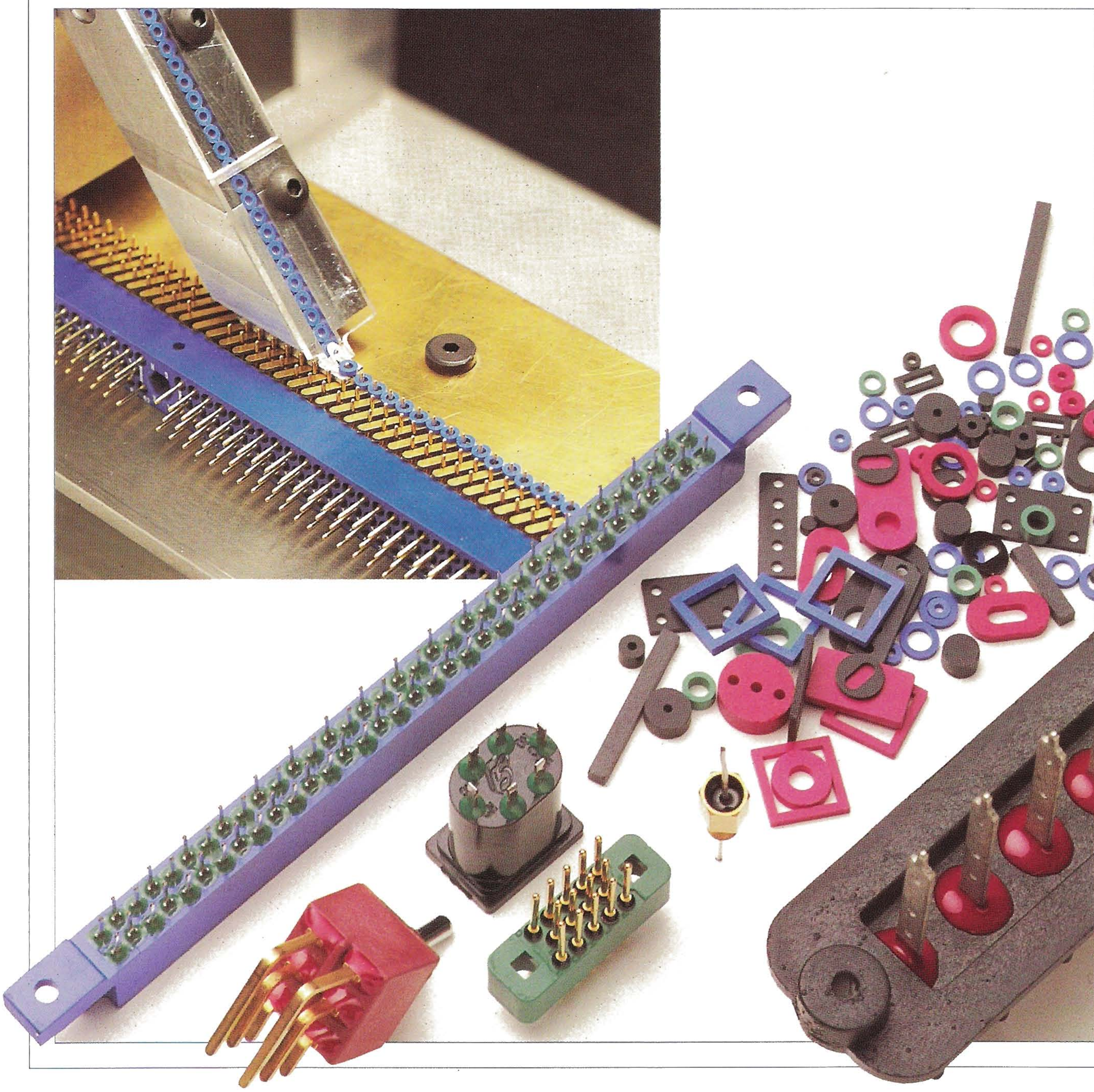
October 1989

CONNECTION TECHNOLOGY



EPOXY PRE-FORMS TO SEAL CONNECTORS

SOCKET BUYERS' GUIDE

SURFACE MOUNT CONNECTOR UPDATE

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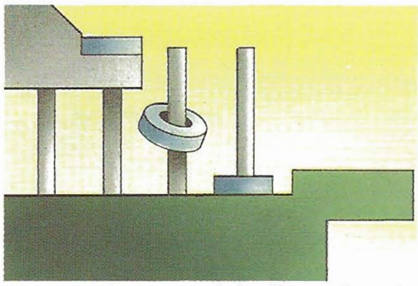

Figure 1, using automatic loading equipment, epoxy preforms may be loaded onto pins at rates up to 600 ppm.

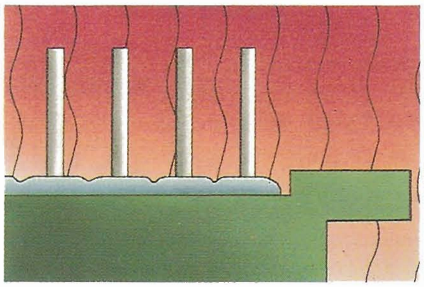

Figure 2, the loaded connector is subjected to cure temperatures of between 140-210°C. Full cure takes 5-60 min.

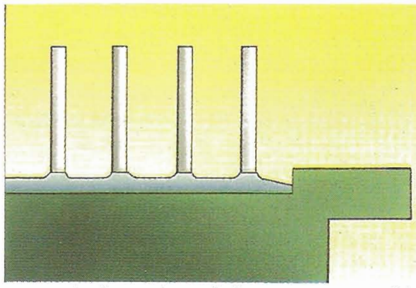

Figure 3, the end result is a connector with extremely uniform, consistent seals from pin to pin.

Using Epoxy Pre-forms to Environmentally Seal Connectors

By David B. Anderson, President
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During the past decade, the demand for sealed electro-mechanical devices has increased dramatically, especially the demand for sealed electrical connectors used for printed circuit (PC) board applications. Sealing the PC board component offers protection against internal damage caused by conformal coatings, flux-removing solvents, dust, dirt, and other environmental contaminants. Consequently, connector manufacturers are beginning to produce sealed versions of some of their standard PC board product lines.

Unfortunately, most current connector designs lack the necessary features to ensure proper sealing. Addressing the design requirements for sealing early in the product development cycle will maximize the efficiency of the sealing process regardless of whether epoxy preforms or liquid epoxies are used.

Considerations When Sealing Connectors

There are several areas of concern associated with applying epoxy material around each pin of a connector without violating the specifications of the connectors. The epoxy may "ride up" too high on the contacts and exceed the stand-off height of the connector and/or change the overall height dimension or specification of the connector. In addition, the epoxy may spread to the contact area inside the connector, thereby interfering with the operation of the contact. Further, the application of some epoxies can be difficult to incorporate into the manufacturing process, require the attention of highly skilled labor and can result in errors and scrapped product.

Epoxy Preforms

The traditional method of sealing PC board components has been the manual or automatic dispensing of liquid epoxies. This carries with it its own set of problems, such as:

- Delicate and time consuming mix-

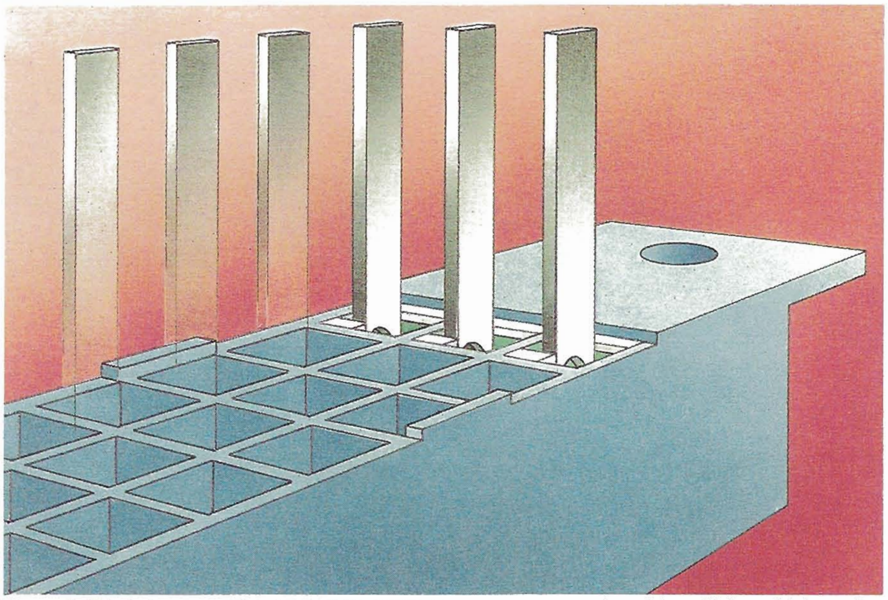


Figure 4, this is an example of a typical connector that is not designed for efficient, high-quality sealing: (a) the stand-off height is too low to allow the epoxy to cure into an acceptable seal without interfering with the placement of the connector onto the printed circuit board; (b) the pin cavity is too large to permit a reliable, uniform seal; and (c) pin-locating projections or holding features outside the pin cavity create conditions that can make the sealing process more difficult and expensive.

ing procedures for two-part epoxies. Mixing must be precise, or the quality of the seal will vary or be impaired.

• Time and/or labor intensive manual dispensing.

• Inconsistent seal quality due to variations in the viscosity of the liquid epoxy and inaccurate or varying dispensing methods. This can lead to excessive epoxy build-up around some pins, overlapping of seals, and spots or drips of epoxy in unwanted areas causing rejected product.

• Slow dispensing that can require costly clean-up and wasteful shut-down procedures.

• Inflexible application and cure requirements (once dispensed, liquid epoxy cannot easily be removed from unwanted areas and, as it starts to cure, reworking becomes increasingly difficult).

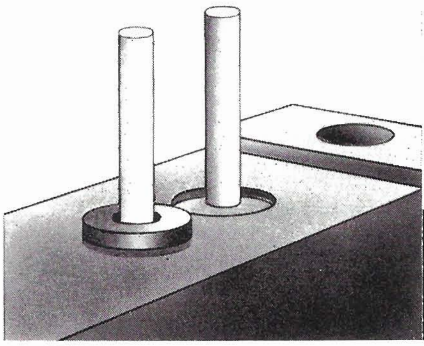
• Poor epoxy inventory control. The exact amount of liquid epoxy required to seal a given batch of components may be unknown or inaccurately estimated. Often, up to 50% of liquid epoxy ends up as waste due to misdispensing, clogged needles, operator errors, and improper mixing.

An Alternative to Liquid Epoxy

Epoxy preforms can be an alternative to liquid epoxy. Epoxy preforms are solid shapes of one-part epoxy, stable at room temperatures. When exposed to elevated temperatures, they melt to form a rigid seal. The exact shape of the preform is predetermined for use on a specific product. Epoxy preforms can be designed according to most symmetrical shapes. However, the most common shape for an epoxy preform for connector applications are rings. The dimensions of the preform are held to a standard of ±0.002" with tighter tolerancing available for more critical applications.

Each preform is manually or automatically loaded onto the terminals of the connector. The preform falls to the base of each terminal where it emerges from the connector housing. The loaded connector is then subjected to cure temperatures between 140 to 210°C. Full cure will take 5 to 60 minutes, depending on the specific cure temperature.

Epoxy preforms are made from several epoxy systems. Although similar in chemistry make-up, the viscosity of each system is different and highly controllable. A specific epoxy system is chosen after the requirements of the finished seal have been assessed.



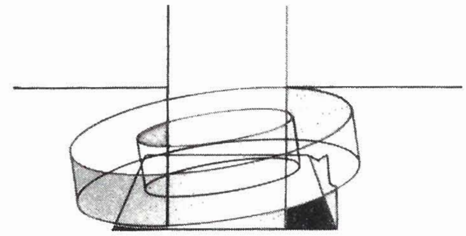


Figure 6 (left), if increasing stand-off height is not feasible, a recess can be designed.
Figure 7 (above), molding features that "tilt" the epoxy preform ring on the sealing surface should be minimized or eliminated.

Since epoxy preforms are manufactured to precise dimensions and are made from highly controlled raw materials, epoxy preforms generate uniform and consistent seals, pin-to-pin, connector-to-connector.

Sealing with epoxy preforms eliminates processing variables such as mixing, metering, operator expertise, operator fatigue, and equipment maintenance. Because of strict tolerancing on viscosities and preform dimensions, a high level of consistency of each seal, pin-to-pin, connector-to-connector is possible.

Solid epoxy preforms can be handled with automatic loading equipment. The "seal" can be treated as a component of the PC board product and can be handled accordingly. The rate at which epoxy preforms can be loaded onto pins of a multi-pin device depend upon the geometry of the preform and the pin design. Typical loading rates range from 200 to 600 ppm.

Other advantages are that clean-up procedures, including the use of toxic solvents are eliminated, epoxy waste and associated disposal is eliminated and any residue left from the preforms can merely be swept up; handling equipment need only be wiped down once or twice a week.

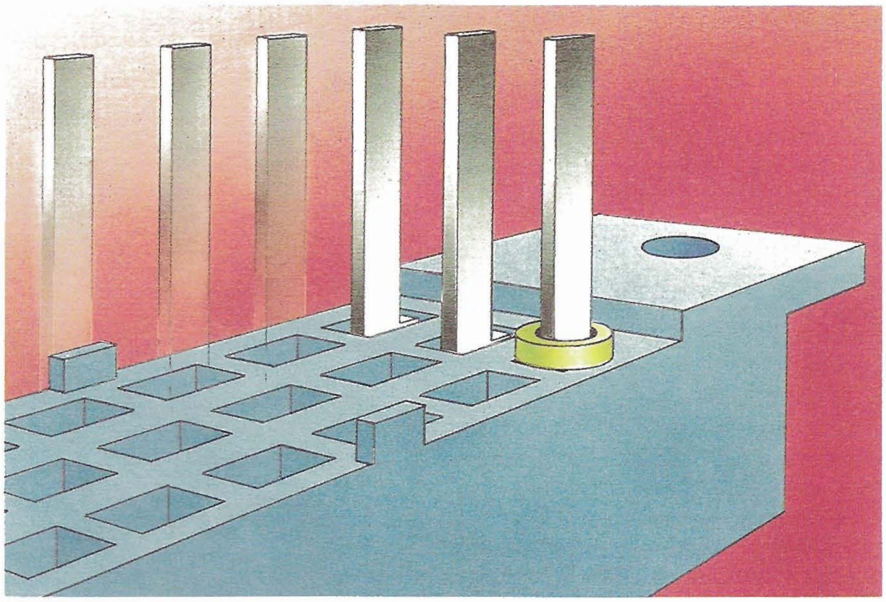


Figure 5, by comparison, this is an example of a connector that is designed for efficient, high-quality sealing: (a) the stand-off height has been raised to allow the epoxy to cure into an acceptable seal, without interfering with the placement of the connector onto the PC board; (b) the pin cavity has been minimized to permit complete, uniform sealing; and (c) projections and features inside the pin cavity have been lowered from the 'transition' area, enabling the epoxy to cure evenly around the pin.

Connector Design Guidelines for Sealed Connectors

When designing a connector or PC board device that is to be sealed, it is important to keep in mind the sealing operation and how it will fit into the manufacturing process of the product. There are certain features that should be included in the design of the product to allow for the repeatable application of the sealing material and that will create a reliable high quality product. These considerations should be addressed in the design stage of the product as it is often difficult, without sacrificing quality, to simply seal an existing unsealed version of that product.

The design features that are discussed in the following paragraphs are all aimed at achieving a very important goal in the production of a sealed product; *TO MINIMIZE THE AMOUNT OF EPOXY NECESSARY TO FORM THE SEAL.* Most, if not all, problems associated with sealing operations could be eliminated if the sealed product is designed with this in mind.

The following guidelines are written in response to the most common problems experienced in the sealing of connectors.

Epoxy "rides-up" too high on the connector pins and/or spreads into the contact area of the connector. A major requirement of the epoxy sealant is that it not be allowed to "ride" or "wick" up along the surface of the terminals beyond the stand-off height of the connector. This would obviously violate the function of the stand-off.

However, it is important to realize that the sealing operation must, inevitably, include the addition of a thin layer of material to the surface of the connector. Therefore, the sealed connector must be designed with an adequate amount of spacing for this additional amount of epoxy. There must be space for the epoxy to accomplish the seal without exceeding the stand-off heights or other critical dimensions of the connector.

The thicker the layer of epoxy needed to produce a seal, the greater the amount of spacing that must be allocated on the connector for the epoxy. Again, the more you can reduce the amount of epoxy required to make a seal, the better.

One solution to this problem is to increase the distance between the stand-off and the sealing surface, which can be accomplished by either increasing the stand-off height or by designing a recess or counter bore into the body of the connector where the sealing will take place. This recess feature will effectively increase the stand-off height of the connector relative to the sealing surface without increasing the overall height of the connector. A layer of epoxy can then be added to the surface of the connector without extending beyond the stand-off height.

This recess feature has been successfully integrated on a large number of PC board components such as switches and relays and recently on a number of connectors. Some of these connectors have been designed with circular recesses around the base of each pin, specifically to hold a ring-shaped epoxy preform.

When using epoxy preforms, one can expect the height of the epoxy to reach 0.30" to 0.60" up the pin. A good "rule of thumb" is that the epoxy will ride-up 0.015" above the layer of epoxy placed on the connector. This is caused by the capillary effect during the cure cycle as the preform melts to a liquid. In other words, if a 0.020" thick preform is needed to create the seal, the epoxy will ride up the pin to a maximum height of 0.035" above the plane on which the preform is loaded.

Another solution to this problem is to minimize the size of the cavity which holds the pins of the connector. If the clearances around the pin are large, a greater amount of epoxy will be necessary to fill the gaps to produce an adequate seal. As the amount of epoxy needed increases, the spacing requirement between the sealing surface and the height of the stand-off will also increase.

A third solution is to optimize on the pin configuration to minimize the amount of epoxy. Avoid the use of solder-cup contact designs when possible. This channeled feature draws the epoxy up the pin. Choose or design a pin configuration that reduces or minimizes the effective opening around the pins of the connector. "Retention barbs" or "contact flaps" will accomplish this and will reduce the amount of epoxy necessary to produce the seal.

There is difficulty incorporating a consistent, efficient method of sealing into the manufacturing process. Many of the operational and quality controls problems associated with sealing connectors can be eliminated by using solid epoxy preforms.

Today's connectors are sophisticated, highly engineered components. Connectors must be manufactured by methods that will ensure the highly reliable nature of the product. Epoxy preforms can provide a precise amount of epoxy material in component form for simple loading. The process is neat, clean, and repeatable.

When designing a connector for use with epoxy preforms, keep in mind that the rings of epoxy must fall to the base of each pin and come to rest on the sealing surface of the connector before the epoxy is cured. The following features should be considered in the design of the sealed connector.

One recommendation is to minimize molding features on the sealing surface of the connector that could interfere with the loading and seating of the epoxy preforms.

Raised lettering, knock-out pin marks, gate projections, mold insert lines, mold flash and other raised characteristics on the sealing surface of the connector could prevent the epoxy preform from being properly seated or oriented on the connector prior to the curing process. If the epoxy preform is not correctly oriented on the part, the epoxy may melt and solidify in an unusual way causing the seal to be incomplete or nonuniform.

In addition, it helps to provide enough space at the end of a row of pins for an epoxy preform ring to drop around the pin without interfering with the stand-off.

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