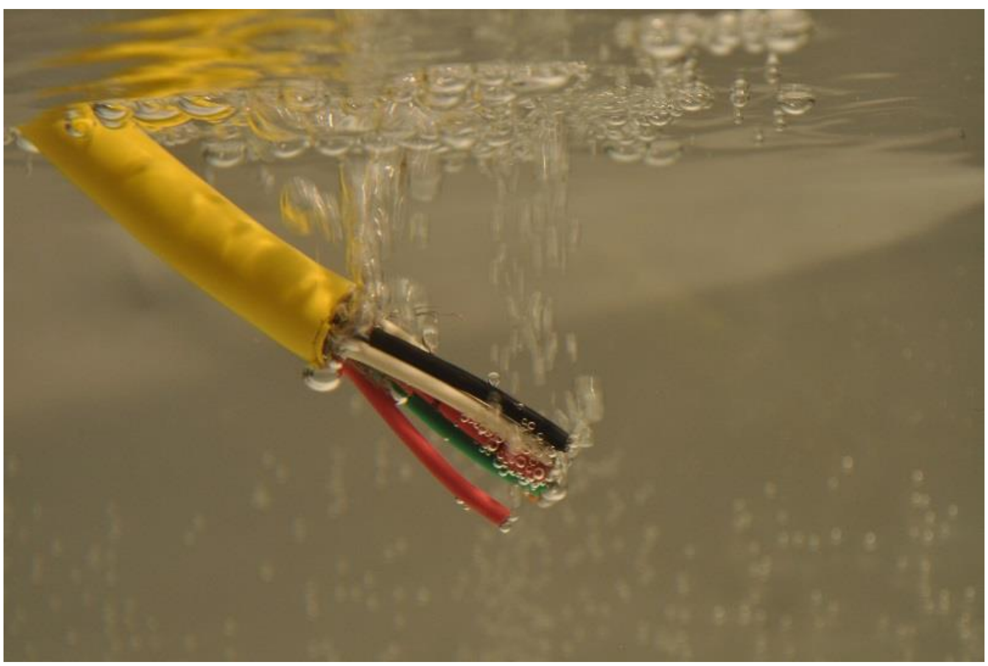
Using Vacuum Impregnation to Fill Quality Gaps for Electronics Manufacturers

Scott Simmons, Business Development Manager, Henkel
Chris Russell, Sales Director, Henkel

ABSTRACT

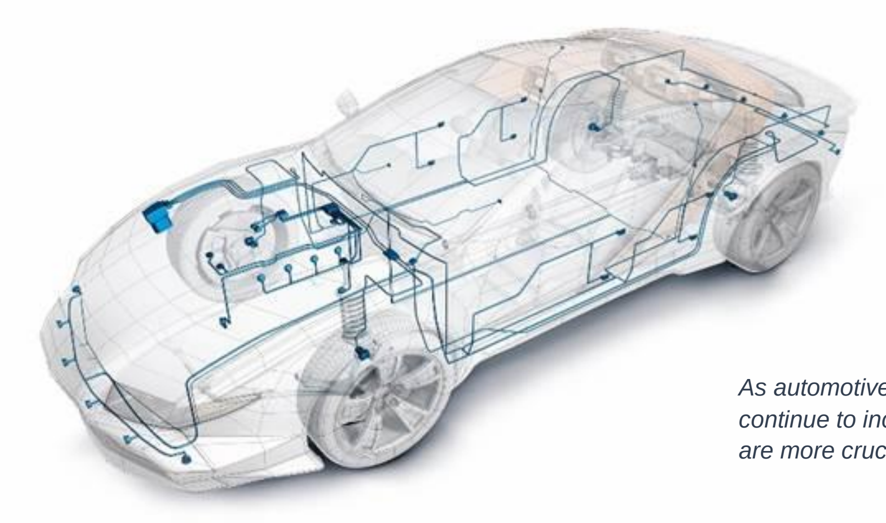
Often the most troublesome and critical problems are those that are least visible. That certainly is true of electronic components, such as connectors, coils and wire harnesses. In the manufacture of these components, tiny voids, leak paths and microscopic holes are unavoidable. These gaps, while often not readily discernable, can be disastrous when electronic products are operated in harsh environments, because moisture and corrosive agents can enter through these voids and spread through to critical components, causing them to fail.

While they may initially be difficult to spot, the presence of these voids can be demonstrated by submerging the part in water and applying as little as 5 psi of air pressure to it. Air bubbles will pour out of the holes and gaps, making the leaks obvious.



Leak paths are uncovered when an electronic part is submerged in water.

The massive expansion of advanced driver-assistance systems and infotainment devices in vehicles has made sealing technologies increasingly crucial in the electronics arena. The problem can cause failures in pin connectors, switches, thermistors, wire assemblies, capacitors, plugs, fuel tank power pass-throughs, coolant sensors, encapsulated coils in fuel injection units, brake actuator assemblies, electronic transmission components, light bulb assemblies and other parts.



As automotive electronic components continue to increase, sealing technologies are more crucial than ever before

Molded electronic components present special concerns in relation to sealing. In connectors, typically metal pins are embedded in a plastic housing. When the connector experiences heat—whether under the hood or in a computer circuit board—the plastic and the metal expand at different rates, creating gaps. Voids in connectors and other portions of plugs and wires can allow moisture and additional corrosives to penetrate the plastic, reducing the life of the part. The gaps can result in complete failure or a poor electrical connection that produces a frustrating intermittent short circuit.

Methods of managing sealing issues

Engineers have tried a number of techniques to resolve this issue, with varying levels of success. The most common method has been the use of potting compounds, which are quick and easy; but they only serve as a patch to the surface of the device. Moreover, they change the dimensions of the component, impacting its specifications.

Another method entails silicone-blocked wire, in which a silicone blocking agent is added to the twisted metal strands to avert the wicking of fluids. This wire can be produced in whole reels; however, some applications do not permit the presence of silicone; and larger-gauge wire—which requires a significant amount of silicone—can allow silicone to leach and cause other problems, such as contamination of transmission fluid.

Thermal expansion results in gaps that can lead to part failure. Potting compounds (left) and silicone blocking agents (right) have been used to resolve this issue, with varying levels of success.

Simply applying silicone around connectors on the surface exposes the silicone to the elements and doesn't resolve the issue of different coefficients of thermal expansion for the silicone and the metal components within it.
Gaskets and O-rings can be used; they're easy to install and can be replaced. However, they seal only the top surface. Moreover, the rings can become dry and brittle over time and begin cracking. Form-in-place gaskets and cure-in-place gaskets may be employed to form a durable interface between two components, but they leave other areas of the components unsealed.

One solution that has proven to be largely successful is vacuum impregnation. The auto industry has used this methodology for 60 years to seal porosity in engine blocks, transmission cases and other components that are required to maintain a pressure. In the early 1990s, engineers began applying vacuum impregnation to seal electronic components and wires that also faced pressure retention requirements.

Ultimately, vacuum impregnation began to be used for sealing a wide variety of electronic components to meet corporate policies of zero-fault tolerance. Today, this technique is applied to everything from computer cables to windings for electric motors and portable wireless applications, where mechanical shock can cause connection failures.

The vacuum impregnation process

As its name indicates, vacuum impregnation employs a vacuum to draw a resin into cables or components, completely filling any voids throughout the entire length of a harness or the complete volume of a part. It does so without changing any of the dimensions of the component, since the resin only resides in the holes and leak-path gaps and excess resin is removed during the process.

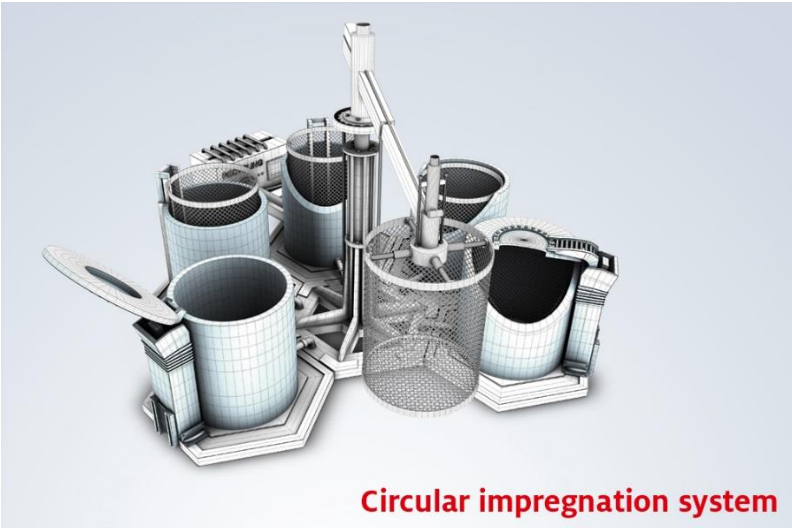
Vacuum impregnation for electronic parts seals leak paths between metal and plastic materials in electronic components

Vacuum impregnation is a batch process for sealing electronic components that is highly effective and at the same time inexpensive, robust and volume friendly. It is especially applicable to sealing voids between dissimilar materials in over-molded connectors and encapsulated coils. It also fills voids through the jacket, between the jacket and conductor and between strands of the conductor of a wire or wire harness.

Several variations of vacuum impregnation techniques are in use today. The most common method is called dry vacuum pressure (DVP).

- This process begins by placing a batch of parts, such as wire harnesses or other components, into a basket.
- The basket is loaded into a vacuum impregnation process tank. There, a vacuum is created to draw air out of all the voids in the part, opening the fine leak paths in the component.
- Once the air has been removed, resin is transferred from a storage tank, submerging the basket of parts.
- The vacuum is released and the process tank is pressurized with compressed air to drive the resin sealant into the voids in the parts.
- Subsequently, excess sealant is transferred back to the storage tank, and the basket of parts—each of which now is impregnated with resin—is removed.
- The basket is transferred to a centrifuge to spin off excess resin, and the parts then are washed with water and a mild detergent to finish removing resin from the exterior of the component. Systems are available to recover some types of resins from wash water for further savings.

Once all the resin is removed from the exterior of the component, the resin remaining in the internal leak path is cured through a brief heat cycle. Depending upon the complexity of the part, the process may include additional steps such as a post-heat cure and/or ultrasonic cleaning. The component is now dimensionally unchanged - but completely sealed.



Henkel's Circular Impregnation System uses dry vacuum pressure to draw air out of all the voids in a part.

Benefits of vacuum impregnation

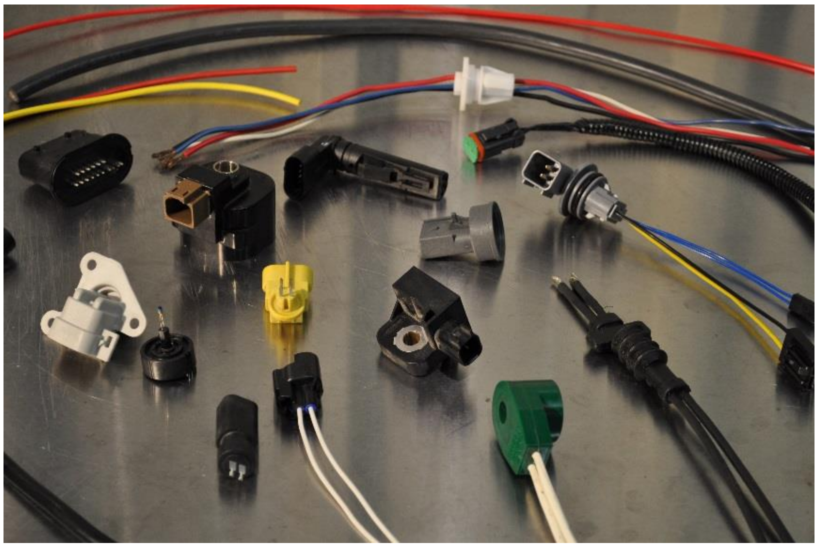
The advantages of vacuum impregnation are impressive. The most obvious is that an untreated part and a properly vacuum-impregnated part, when placed side by side, look exactly the same. All the resin is inside the component in the areas that previously formed gaps. This consideration is especially important for components designed with very tight dimensional tolerances.

The entire batch process requires only about one hour, which means that a very large number of parts can be sealed quickly and very economically. For example, a batch may consist of as many as 2,500 wire harnesses, resulting in a sealing cost of just 10 to 15 cents per harness. Consequently, production rates are higher than with other sealing methods, and costs plummet. Moreover, when the entire harness is sealed, the resin fills openings within bundled wire strands and at locations where wires touch connectors or grommets, in addition to covering the harness ends that are exposed to outside elements.

1 batch = 1 hour of processing time

Production rates increase
2,500 wire harnesses
In one batch

Costs plummet
Only 10 to 15 cents per harness instead of entire replacement cost



Electronic components commonly sealed with vacuum impregnation

Equally important is the fact that vacuum impregnation creates a permanent seal that will not crack or degrade. The resin contains a fluorescent tracer; so, under a UV light, the resin-filled voids and leak paths will appear blue, verifying they have been sealed. Manufacturers thus can have 100 percent confidence in the integrity of their products.

Labor costs and the incidence of faulty parts drop with vacuum impregnation—the sealing is done correctly the first time, eliminating rework. Scrap decreases, improving profitability.

Of particular importance is that effectively sealing electronic parts can avert the failure of a larger component. A faulty fuel pump can disable an entire vehicle.

Vacuum impregnation achieves all these benefits without impacting dimensional attributes, electrical properties, terminals, leads or pins.

The reasons for resins from Henkel

Clearly, the most important aspect of the vacuum impregnation process is the resin used to fill the voids in components. This resin must be able to manage the induced stress caused by heating cycles that the product will experience, maintaining the contact between plastic and metal parts. It must be sufficiently flexible and chemical resistant.

The most common materials used today are methacrylate monomers, such as those in LOCTITE IS 5100/5110TM from Henkel Adhesives. These are thermoset materials that crosslink into a solid, yet flexible, substance that allows the resin to move with the contraction and expansion of two dissimilar materials. The resin completely washes away from the outside of the part during the final stages of the vacuum impregnation, enabling the component to keep its original dimensions and keeping critical surface contacts clean.

When cured, the Henkel resins are flexible and durable. They will not develop cracks from thermal expansion—they tolerate temperatures as high as 450 F—and they are unaffected by oil, glycol, caustics or acid.

Other Henkel formulations allow for adjusting the resin to make it harder or softer to meet the needs of the application.

Henkel today is developing new resins with even greater flexibility and chemical resistance. To be introduced in 2018, this next generation of products will provide continued reassurance for electronics manufacturers as more devices and wiring are incorporated into vehicles for automated and semi-automated driving, electric cars and trucks, safety and infotainment, and as consumers continue to fill their pockets and handbags with more personal devices.

Henkel makes the vacuum impregnation process practical for the electronics industry. It helps to fill potential voids in quality that once were inherent in equipment manufacturing but that today can be resolved with Henkel resins.