Conformal Coating vs. Encapsulation – Protecting Electronic Devices, Which Do I Choose?

The electronics industry is one of the most rapidly expanding industries to date, with new applications seemingly endless. Printed circuit boards (PCBs) are found in many domestic, industrial, automotive and military devices, to name but a few. In such applications the environments can cause electrical performance to deteriorate due to the absorption of atmospheric moisture or electrostatic attraction of dust. Under extreme conditions, exposure to corrosive atmospheres or harsh chemicals, are just a couple of examples. In order to ensure reliability of these critical devices it is essential that the PCBs are protected to prevent reduced performance or in the worst case, complete failure. This protection can be offered in the form of a conformal coating or potting and encapsulation resins.

Potting and encapsulation resins offer the highest level of protection for PCBs. By encapsulating the entire PCB the resin provides complete insulation for the unit thereby combining good electrical properties with excellent mechanical protection. Mechanical protection can be identified in a number of ways; superior protection is identified in applications involving prolonged exposure or immersion in harsh chemicals, or those exposed to vibrational, thermal or physical shock, for example. The higher level of protection is achieved through the mass of the resin surrounding the unit. This is different for every application however they will always provide a far more substantial covering than that offered by conformal coatings. Due to the bulk of material surrounding the PCB, potting and encapsulation resins are commonly two-part systems which when mixed together form a solid, fully cured material, with no by-products.

Due to application variances, it is vital that the entire unit is tested in an appropriate environment for its intended end use; this can be exact conditions or carefully planned accelerated testing. The potting and encapsulation resins can also be tested separately in a number of environments, establishing their specifications and suitability for use. These tests typically consist of a cured mass of set dimensions, exposed to controlled atmospheres for a set period of time. The appearance, dimensions and weight of the resin can be measured before and after the test to identify if any changes have occurred. In addition, electrical testing can be performed before and after testing, which again can be generic or specific to the final application.

Conformal coatings can also be utilised to protect the PCBs in a variety of applications, ensuring optimum performance even in harsh conditions. They are single-part materials applied as thin films, typically ranging from 25-75µm. They conform to the contours of the board, providing maximum protection with minimal weight or dimensional change to the PCB. This is possibly the primary advantage of conformal coatings over potting and encapsulation resins. As conformal coatings are only used as thin films, the specification for application is therefore similar in each end-use. It is important to establish the properties required of the conformal coating in order to provide information on both
the standard operating conditions and possible excursions outside of these parameters. This information will then ensure that the correct coating or protection method is chosen.

The most common environment that a coating can be subjected to is standard atmospheric conditions. Initial tests are generally conducted to evaluate both the electrical and mechanical performance of the cured film on substrates governed by each standard test method. Following this the surrounding environment can then be altered to assess the performance of the coating under more severe conditions. Such conditions can include salt mist, high humidity, high temperature and thermal changes either as a gradual rise or decline in temperature or an immediate thermal shock. After exposure to such environments the coating can then be re-tested for its electrical and mechanical properties, determining its suitability for various applications.

There are many types of conformal coating available on the market, as well as a few choices of encapsulation and potting resin chemistries. Each type provides a few characteristic properties which make them suitable for particular applications and additionally, the tests described above can also assist in determining which material is best. For standard atmospheric conditions, most conformal coatings and potting and encapsulation resins will provide the required level of protection and the choice between each will depend on the application processes of the material. For harsher environments the choice may be more detailed, however. For example, acrylic coatings, such as Electrolube Ltd IPC-CC-830B approved TFA, offer good environmental protection with superior clarity and stability following prolonged exposure to UV light. Acrylic coatings do not crosslink and therefore do not provide the required protection against chemicals or high humidity environments where prolonged condensation or periodic immersion in water is likely. In this case, a tougher coating such as Electrolube Ltd UL746 approved DCA or environmentally friendly Non-VOC Coating (NVOC) would be the best option.

Should the environment include greater mechanical stress or prolonged exposure to the extreme environment, potting and encapsulation resins will provide superior protection and therefore optimum performance of the device. Silicone resins offer good clarity in a range of differing products when compared to epoxy and polyurethane systems; optically clear polyurethanes, such as Electrolube Ltd UR5562, are available however. Polyurethane resins offer greater flexibility over epoxy based systems, therefore causing less stress on delicate components, particularly in
environments where the temperature may fluctuate below -30°C. Additionally, polyurethane resins such as Electrolube Ltd UR5041, are ideal for marine applications where the device is immersed and continually operating in salt water. Epoxy resins such as Electrolube Ltd ER2188, are excellent general purpose resins which offer cost effective, high level protection for the PCB including flame retardancy to UL94 V-0. In addition, epoxy resins tend to offer superior protection in environments involving immersion in harsh chemicals.

In summary, both conformal coatings and potting and encapsulation resins offer a full range of solutions for protecting PCBs in a variety of different applications. There are clearly specific applications more applicable for each technology with the most obvious features occurring in some of today’s leading trends; protection in harsh environments, ease of processing and miniaturisation of electronic components. For extreme environmental protection, potting and encapsulation resins provide the confidence that the device will be fully protected throughout the duration of its use, providing the correct resin has been selected and approved in the end application. For ease and speed of processing, conformal coatings will always come out on top. The majority are single part systems which can be modified to cure rapidly in-line with minimal processing. In addition, they provide a high level of protection through only a thin cured film, thereby assisting in the miniaturisation of electronics and reliability of portable devices. For either requirement, Electrolube Ltd are proud to offer excellent technical support for their broad product range, thereby offering many solutions for an extensive range of conditions and processes worldwide.

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