

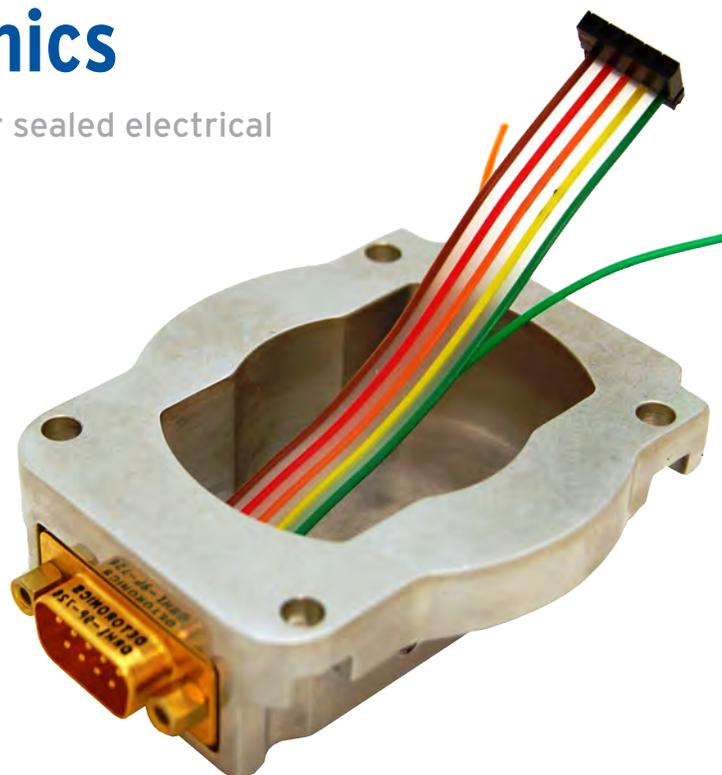
# Hermetic Feedthroughs Safeguard Mission-Critical Electronics

Choosing the right hermetic sealing technology for sealed electrical packages keeps vital applications up and running.

From automotive electronic control units to weather satellites and defense systems, electronics failures can bring communications and critical functions to a sudden halt. Experts specializing in electronics failure analysis can list a host of reasons for various malfunctions, but one of the most common causes is simple moisture. Because water and electronics do not mix well, several strategies exist to protect mission-critical components from moisture and condensation. One of the most successful methods of protecting key components from water hazards involves hermetically sealed electronics cavities—enabled by moisture-blocking component assemblies such as hermetic feedthrough technology.

Sealed cavities are especially important in mission-critical applications such as those found in military and defense settings including power electronics for missiles aboard ships and submarines or those in service aboard high altitude flights. Laser systems, commercial and private avionics GPS units, high voltage power generation and distribution networks, underwater pumps and automotive charging stations represent other important applications where electronics need to be protected from water vapor and condensation.

Reliable sealing involves two major considerations—accounting for moisture sources in the ambient environment and choosing a robust hermetic



D-sub sealed in customer furnished enclosure for use in military flight application.

feedthrough that will keep moisture from wicking into the electronics cavity while allowing power and signal conductors to enter.

## IDENTIFYING WATER VAPOR AND CONDENSATION SOURCES

Electronics failures due to water vapor and condensation can occur in a number of ways. Among the most common are corrosion of solder joints, shorts caused by water droplets, and stress corrosion cracking of seals and electrical interface areas. Glass seals with unseen defects and those under high residual stresses can crack and fail over time, especially in cold temperatures.



Sealed ribbon cable with integrated Schrader valve for vacuum purge.

Water vapor within hermetic packages may arise from several sources, which are important to be aware of. With die attach adhesives, water is often generated as a byproduct of the curing process itself. This is due to certain bonding agent chemistries that produce water during polymerization reactions when adhesives are curing.

To avoid this issue, be sure to finish the curing process before sealing or choose an epoxy formula that does not contain water byproducts. Pre-baking materials can also eliminate any trapped moisture in components.

Water issues can also occur during the sealing of gas containers. To attack this potential issue, manufacturers vacuum purge and backfill hermetic cavities before sealing — typically using helium, nitrogen and dry air. However, improper gas control or faulty sealing techniques can lead to water vapor becoming trapped in tanks and cavities. Yet another source of moisture is fine package leaks. This is especially tricky because the pass-fail mark for helium fine leak testing is traditionally set at  $<1 \times 10^{-8}$  atm-cc/sec to prevent moisture ingress, but even smaller amounts of vapor ingress can cause failure in sensitive devices over time. Note that the helium leak rate can be easily converted to a water vapor leak rate by using a 0.469 multiplication factor.

Radial o-ring seal for use in nitrogen filled electrical network switches.



To avoid these water vapor issues in hermetically sealed electronics cavities, it is important to choose the most suitable materials for all components, use careful process control when sealing and specify reliable hermetic feedthroughs such as epoxy-based units. Stringent testing is also important to evaluate the moisture resistance of various components and subassemblies. MIL-STD-883 method 1004 and MIL-STD-750 method 1021 are the most common U.S. military standards used for determining the moisture resistance of electrical components. There's no universal acceptance criteria for internal water vapor content, although MIL-STD-883 method 1018 defines less than 5000 ppm — and many real-world applications require water vapor content of less than 1000 ppm. Whatever the acceptance criteria, end use environment and service life are critical in evaluation of tolerance to moisture.

In addition, MIL-STD-883 method 1014 and MIL-STD-750 method 1071 define various methods for testing hermetic seals, such as dye penetrant, bubble emersion, pressure decay, radioactive testing and mass spectrometry. Pass-fail criteria are typically listed at  $5 \times 10^{-8}$  cc-He/sec. Be sure to ask your component supplier which method they use for hermetic seal testing: The helium mass spectrometer method is widely considered one of the most reliable, sensitive and accurate measurement methods. Further, it is important to keep in mind that overall system leak and moisture permeation must be considered in addition to electrical cavity moisture ingress.

## EPOXY-BASED FEEDTHROUGHS AND SEALING TECHNOLOGIES

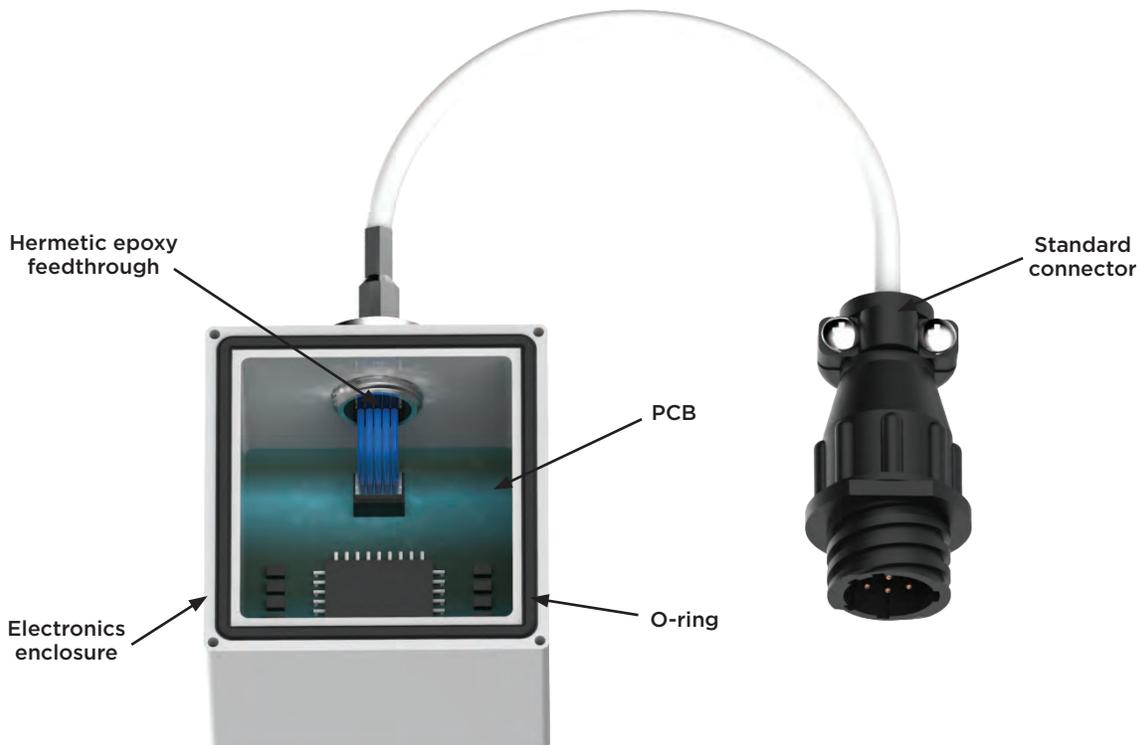
Due to its excellent and robust mechanical properties and resistance to temperature extremes, epoxy is considered an ideal material for creating reliable and long-lasting hermetic seals around wires and connectors that pass into pressure or vacuum systems. For example, Douglas Electrical manufactures epoxy feedthroughs and connectors that withstand stringent performance requirements. These include the vacuum to  $1 \times 10^{-10}$  Torr; pressure to 15,000 psi; temperature ranges from  $-350^{\circ}$  to  $350^{\circ}\text{F}$ ; wire gauges from 38 AWG to 500 MCM; conductor counts from one wire to 3200 in a single feedthrough; and cable lengths to 500m. These hermetically sealed feedthroughs and connectors are widely specified in demanding applications such as advanced weapon systems, downhole oil and gas equipment, medical imaging systems, high-voltage electric switchgear and semiconductor manufacturing equipment.



Circuitseal used to detect humidity in transformer.

With regard to military applications, defense contractors regularly use Douglas Electrical's hermetic feedthroughs, potted mil-spec connectors and custom cable harnesses. These components and assemblies are both electrically and hermetically tested for quality control, as well as compliant with ITAR, DDTTC, DFARS, Conflict Minerals and ROHS. Typical applications include antenna feedthroughs for aircraft; hermetic sealing for rigid, flexible and hybrid circuit boards for bomb fuses; hermetic sealing of cable harnesses to keep moisture out of

## Sealed Electronics Cavity



missile and munition control systems; and power and signal leads for military fuel pumps. All of Douglas Electrical's epoxy seals easily meet the MIL-STD-883 definition of hermetic with a typical overall assemble leakage rate of  $<1 \times 10^{-9}$  cc-He/sec. In addition, Douglas provides the hermetic seal to an OEM that manufactures extremely high accuracy moisture sensors capable of 0.1 ppb sensitivity levels.

## **UNDERSTANDING MANUFACTURING AND USAGE VARIABLES**

Being proactive about moisture control is critically important to keeping sensitive electronic systems up and running, especially in demanding environments such as high humidity, temperature extremes and salt spray that can lead to corrosion concerns. In fact, electrochemical migration caused by corrosion often results in spotty performance and short circuits. In order to avoid failure issues, it is important to pay attention to the assembly environment and hermetic packaging materials. Ambient air containing moisture can become

trapped in electronic devices and cavities during assembly. Further, temperature drops during shipping or storage can also cause water condensation within devices.

One way to prevent—or at least reduce—water ingress is to work with an experienced electrical component supplier. This can go a long way towards minimizing electronics failures associated with moisture. Finally, selecting a reliable hermetic feedthrough technology and minimizing ambient moisture sources will help keep mission-critical applications in peak operating condition with minimal downtime.

**For additional information on hermetic feedthroughs, please visit <http://www.douglaselectrical.com>.**

**For sales information, contact Chris Rempel by phone at (973) 627 8230, or by e-mail at [crempel@douglaselectrical.com](mailto:crempel@douglaselectrical.com).**