Primer on Hermetic Sealing For Connectors

Various techniques have been successful for providing a gas-tight connection for electrical leads passing through an interface.

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It is often of primary concern that electrical interconnections such as RF connectors and feed throughs be sealed from the external environment. This is accomplished by providing a hermetic interface. The sealing methods include glass-to-metal, O-ring, metal-to-metal and soldering or brazing.

Hermetic is defined as completely sealed, especially sealed against the escape or entry of air. In reality, nothing can be completely hermetic, since all materials are permeable and will allow gases to pass through them over time. For this reason, hermetic packages and connectors are defined with maximum permeability rates, better known as leak rates. The typical leak rate for hermetic connectors is measured in cubic centimeters per second per atmosphere, at one atmosphere with helium (cc/sec/atm).

Glass-to-metal seals are formed by fusing a glass dielectric between two metal conductors at temperatures greater than 1000°C. This processing temperature makes the glass-to-metal seal the most mechanically and environmentally reliable method used to create a hermetic seal. Glass-to-metal seals can be used to create vacuum-tight seals with leak rates of less than 1×10^{-8} cc/sec/atm. There are two types of glass-to-metal seals: matched and compression.

Matched seals rely on a chemical oxide bond for sealing and primarily use outer and inner conductors of Kovar (trademark of Carpenter Technology), an iron-nickel-cobalt alloy, with borosilicate glasses as dielectrics. Economics makes manufacturing Kovar connector housings unrealistic; therefore, tube shaped Kovar eyelets are used to produce drop-in seals. These seals are then soldered or brazed into connector or package housings. The similar coefficients of thermal expansion between components of matched seals gives them high reliability over temperature.

Compression seals are produced using center conductors of iron-nickel alloys, outer conductors of 303 stainless steel and alkali barium glasses as dielectrics. Unlike matched seals, compression seals primarily depend on the compression of the outer conductors' higher coefficient of thermal expansion upon the lesser coefficient glass, and the glass upon the lower coefficient center conductor. Due to the smaller surface area of the center conductor, a chemical bond alone is typically enough to create a durable glass-to-metal bond without compression. The variation between the coefficients of thermal expansion places the seal in compression. The wall thickness of the seal must be of sufficient thickness to equalize the stresses at the glass-to-metal interface.

It is always best to consult with the connector manufacturer

Since compression seals use the connector housing as the outer conductor and radial compressive forces to achieve hermeticity, any radial torque applied to the connector housing may stress the seal joint and degrade the level of hermeticity. For this reason, connector applications that use compression glass-to-metal seals are usually mounted to packages with either screwed-in flanges, mounting nuts and lock washers or solder.

Rubber O-ring seals are used as moisture barriers and form an environmental seal when enough axial force is applied to deform the O-ring cross-section between a connector housing and package housing. The O-ring seal's biggest advantage is its ability to be easily and economically removed and replaced without damaging the connector or the package.

Typically, O-ring seals are hermetic to 1×10^{-5} cc/sec/atm. They should not be used in applications where long-term leak rates of less than 1×10^{-5} cc/sec/atm are required. In order to obtain these hermetic values, an O-ring is required on both the center contact and the dielectric material of the connector. The applications of specific O-ring materials are described in various manufacturer's handbooks and must not be overlooked when matching the proper hermetic connector to a particular application.

Metal-to-metal seals are produced by applying a clamping force to metal gaskets and deforming either the gasket or connector package. The clamping force is achieved by torquing a connector into a threaded mounting hole with the properly calibrated torque tool. They are exclusively used to seal connectors to package housings and can achieve leak rates of $1 \times 10^{-}$ cc/sec/atm, or better, with proper installation.

Factors such as poor sealing surface finishes, improper tooling and large variations in coefficients of thermal expansion between the connector housing, package housing and gasket material will degrade the integrity of metal-to-metal seal.

Metal-to-metal seals are comprised of three basic types: knife-edge, compression and formable.

Knife-edge gaskets seal by cutting into both the connector and package housing during installation. If the connector is removed from a package after initial installation, a circular indent

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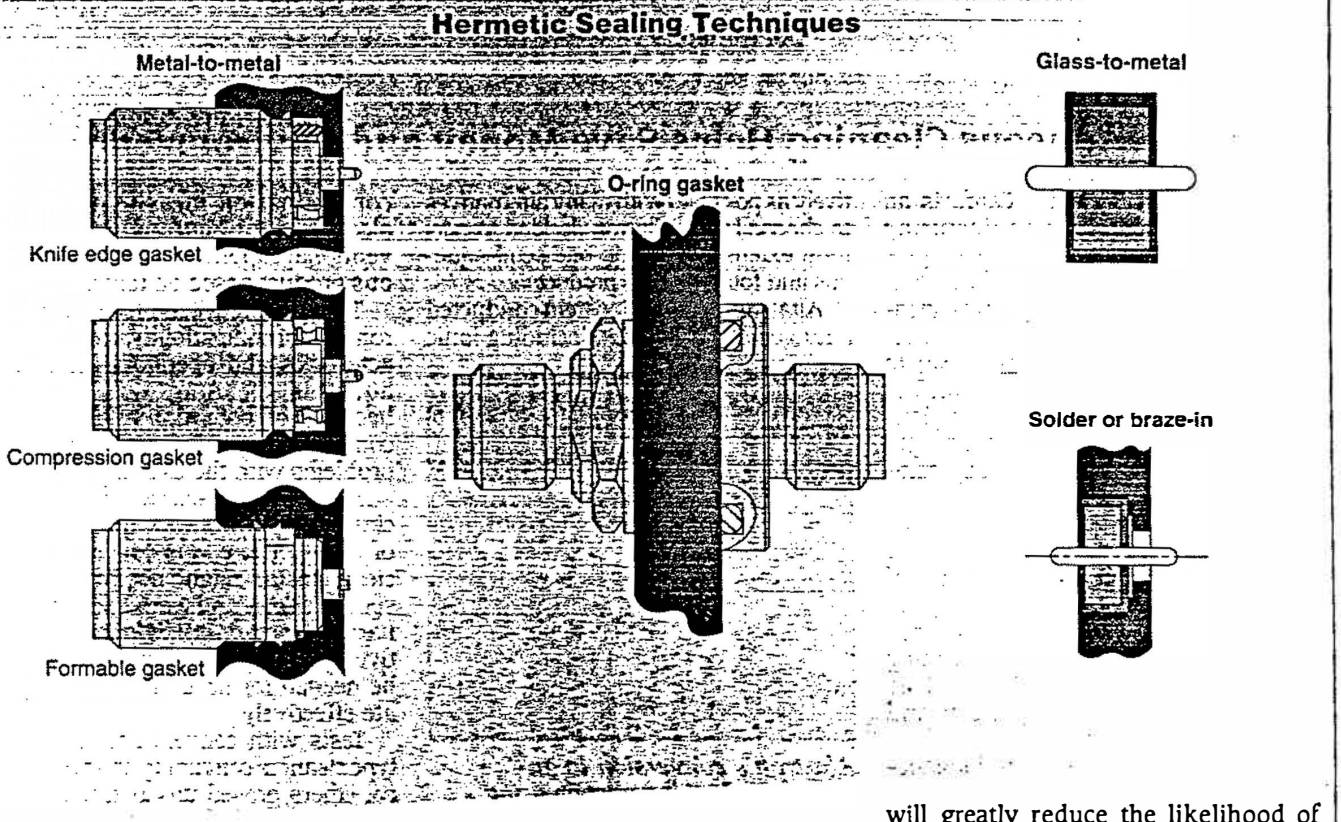

tion from the gasket may be seen on the connector and/or package housing. Due to the destructive nature of this type of seal it is difficult to reseal the package once disassembled.

The sealing surface finish is also not as critical as the sealing wall thickness and coefficients of thermal expansion variations. Softer package materials, such as aluminum, may need to be as much as twice the thickness as required for harder package materials. This will prevent bowing of the package wall and cracking of sensitive internal circuitry. Large variation in thermal expansions between the cold-rolled steel gasket and the package material may create leak paths at temperature variations, and may damage the package housing and internal circuitry.

Compression metal gaskets use the same theory as the knife-edge gasket but do not damage either the connector or package housing when sealing. These gaskets are made in various cross-sectional shapes and materials such as aluminum and Kovar. This form of gasket is best used with package materials with coefficients of thermal expansion similar to the gasket materials.

To obtain leak rates of 1×10^{-6} cc/sec/atm or better, the metal surfaces touching the metal gasket must have a surface finish of at least 32 μin. rms. Since only surface pressure is used to create a seal, tool marks and rough surface finishes between the gasket and package surface create leak paths for gases. Connectors using the rigid and compression gaskets often share the same mounting hole.

Formable metal gaskets are the most versatile of the metal seals and achieve leak rates of 1×10^{-6} cc/sec/atm with proper installation. Similar to the two previous metal-to-metal seals, the soft copper gasket is deformed between the package and connector housing and a hermetic seal is formed.

Hermetic is defined as completely sealed

Formable gaskets can be used with any type of material and allow the connector to be resealed within the package. Neither the connector nor the package is damaged. A new gasket will be required to reseal the package. The disadvantage is that it does not share the same mounting hole as the rigid and compression gaskets, making connector substitution impossible.

Soldered and brazed seals are the most reliable, difficult and expensive assembly methods used to obtain a hermetic seal. Careful attention must be paid to such issues as types of solder or braze, housing material, plating, design, proper tooling and equipment. Overlooking even one of these factors will greatly reduce the likelihood of producing a proper seal.

Brazing is typically done at temperatures above 800°C and has the same variety of material options and configurations as that of solder sealing. Brazed seals are not as popular as solder seals, but the diffusion process that occurs through brazing differentiates it from soldering and makes brazing the superior mechanical and environmentally durable sealing method. For example, assembly methods such as vapor phase and IR reflow soldering may reflow solder seals, whereas the brazed joint will remain unaffected.

It is evident that there are many factors that require consideration in choosing hermetic connectors; factors which will affect both the product's performance and final cost. Brazing vs. soldering, or matched vs. compression seals, or vacuum vs. moisture seals, and the various metal-to-metal sealing options all must be considered to assure that the connector and application are matched. Therefore, it is always best to consult with the connector manufacturer to discuss the suitability of a chosen connector for a given application.

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