



D.G.O'Brien

High-reliability connection solutions for harsh environments

## Glass-to-Metal Sealing: An Overview

D.G. O'Brien utilizes glass-to-metal sealing technology to provide hermeticity and pressure resistance around our electrical contacts. But just what is this technology and what are its basic benefits? This short review will provide some answers. However, the reader should keep in mind that this technology incorporates much more than can be presented here.

### What is a glass-to-metal seal?

Glass-to-metal seal technology is used extensively to provide a robust hermetic seal between a metal conductor and a metal body. Hermeticity in DGO related applications is defined as a gas-tight seal (as measured by helium leakage rate, typically  $1 \times 10^{-8}$  cc/sec or less), and pressure-tight integrity. A typical glass-to-metal seal consists of the following elements:

- A metal bulkhead (or body) with a hole in it.
- A pin conductor in the center of this hole.
- A piece of glass pre-formed to fit between the pin and the bulkhead.

During processing, these three components are placed on a fixture which holds them in position. This entire assembly is placed in an oven configured to maintain a controlled atmosphere in the firing chamber. The assembly is then heated to appropriate temperatures for the particular set of materials. At the sealing temperature, the glass melts and fills the space between the pin and the bulkhead. The assembly is then cooled.

The type of seal generated by this process is dependent upon the type of glass used and the materials used for the bulkhead and pin. There are two basic types of seals, "matched" and "compression." Most applications, from light bulbs to electronic packaging, rely on a chemical bond between the glass, the conductor and the metal housing to create a hermetic seal that cannot resist pressure. These seals are referred to as matched seals because the glass is selected to have a coefficient of thermal expansion that matches the body. There are literally billions of these seals made every year. While these provide the hermeticity required for the applications, these seals are typically not very strong and cannot withstand large differential pressures across them.

By contrast, DGO manufactures compression seals. These seals are essentially "shrink fits." The glasses used by DGO are selected so that their coefficient of thermal expansion is less than the bulkhead metal surrounding it. As a result, when the metal cools after the firing temperature has been reached, it is shrinking, thus squeezing the glass which has returned to its solid state. Glass is extremely strong in compression; very high compressive forces are generated as a result. The result is a very strong "shrink fit" that can withstand extremely high pressures and physical stresses such as mechanical and thermal shock and vibration.



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## What are the advantages of DGO compression glass-to-metal seals?

**Robust high-pressure integrity:** The first and foremost advantage of these seals is their robust integrity. Of the hundreds of thousands of high pressure glass seals delivered to customers by DGO since 1962, there are no known incidents where these seals have failed to maintain pressure-tight integrity. There have been cases where contact pins have been sheared off due to shock loading, or burned off due to excessive current. But the DGO glass seals have always maintained pressure integrity. This experience covers subsea pressures to 13,500 psig (931 bar) and downhole pressures to 20,000 psig (1380 bar). One customer even attempted to destroy a 38 pin glass sealed insert to test its limits. Upon reaching 38,000 psig, the test fixture sheared in half and crushed all the contact pins in the process. The insert, when tested after this incident, still maintained pressure integrity at the original test pressure of 13,500 psig.

**Structural strength:** This first advantage is particularly helpful in enabling us to create a bulkhead which is an integral part of the structure. Because the compression seal is formed within a bulkhead, this bulkhead can be made an integral part of a structure, reducing the dependency on elastomeric seals, potting or molded components. In critical applications, this helps increase the overall reliability of the pressure barrier.

**Seal integrity unaffected by extreme conditions:** The combination of the above two features makes the DGO glass-to-metals seals very robust. These seals are unaffected by extensive exposure to hydrostatic pressure cycling, shock, vibration, radiation, and thermal cycling from  $-60\text{ C}$  ( $-75\text{ F}$ ) to  $200\text{ C}$  ( $400\text{ F}$ ). Hence, DGO incorporates this technology whenever an application experiences aggressive environmental conditions. It's how we provide the highest level of confidence that the pressure seal will hold up under all conditions.

**Long-term stability:** DGO compression glass seals are also very stable over long periods of time. Because glass is an inorganic material, it is not affected by long-term exposure to elevated temperatures. In other words, it does not age; that is, it does not lose the mechanical properties which affect the seal, as do organic materials such as elastomeric rings or bladders, molded epoxies, potting compounds, and all engineering grade thermoplastics and thermosets. This is critical in applications where pressure integrity over a long life (e.g. 15-40 years) is a requirement. DGO has supplied compression glass seals for use in environments from  $-60^{\circ}\text{ C}$  ( $-75^{\circ}\text{ F}$ ) to  $200^{\circ}\text{ C}$  ( $400^{\circ}\text{ F}$ ).



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## What issues must be considered when using glass-to-metal seals?

**Initial cost:** Compression glass-to-metal sealing process is a tightly controlled and highly repeatable process which uses sophisticated equipment to achieve the desired results. Thus, the initial cost of a product with compression glass seals tends to be more expensive than molded epoxy inserts. However, when viewed in the context of total life cycle costs and reliability, usually DGO products with compression seals are no more expensive, and are often less expensive than any other sealing method.

**Elevated temperature insulation resistance:** The volume resistivity of glass decreases with increasing temperature. We have to take this issue into account when considering operations at elevated temperatures.

## What is the value of using glass seal technology in products?

**Reliability of the pressure seal:** The basic value of integrating DGO glass seal technology into a connection product is the fundamental long-term reliability of the pressure barrier seal. Once processed and tested (all DGO glass seals are 100 percent factory tested prior to shipment), the glass seal is the most stable, secure pressure seal available on the market. It is not affected by the aging process that effects other sealing products where the primary seal is utilizes molded plastics or elastomers. This basic value means a product delivered to a customer will maintain its pressure seal under all the conditions specified for that product over its life. To further maximize the overall reliability, the glass sealed component can be directly welded into a housing, or sealed to the housing using metal seals, providing pressure integrity and absolute hermeticity for the most severe environments.

The risk of failure of a pressure barrier can have significant ramifications in terms of lost life, down time and failed missions. DGO glass seals ensure against these failures. Over the life of a system, their performance can save a customer substantial amounts of money in terms of replacement of lost or damaged equipment, downtime or worse – savings which far exceed the cost premium needed to incorporate this technology.