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GLASS-SEALED
Hermetic
CONNECTORS

GLENAIR WORLDWIDE HERMETIC CAPABILITIES

Glenair®

GLENAIR WORLDWIDE HERMETIC CAPABILITIES

Military-Grade Hermetic Connectors: From Glendale to to Bologna

Hermetic connectors are principally understood as devices that enable power and signal interconnection across a barrier, even as they keep moisture, vapors, and contaminants away from sensitive electronics. In military and aerospace applications, hermetic connectors are used to safeguard avionics or sensor packages by maintaining an airtight seal between the internal electronics and a harsh external environment. As modern platforms grow more complex and mission profiles more extreme, the role of hermetic connectors has expanded considerably beyond just ingress protection to include the ability to withstand extraordinarily high temperatures, punishing mechanical loads, and chemically aggressive atmospheres—all while preserving the stable electrical performance demanded by mission-critical systems.

At their core, hermetic connectors operate on the principle of glass-to-metal sealing, joining conductors and shells in a leak-tight assembly tested to exacting standards such as MIL-STD-202 or MIL-STD-883. But in certain applications, hermeticity is more of a baseline requirement. Designers increasingly value these connectors as structural, thermal, and reliability elements, entrusted with maintaining performance in environments where connectors equipped with conventional elastomeric sealing might degrade or fail to deliver requisite protection.

Thermal Extremes

One of the most important drivers behind the adoption of aerospace-grade hermetic connectors is the escalating thermal stress present in next-generation military and defense systems. High-speed flight vehicles, missile airframes, engine-adjacent avionics, and spacecraft subsystems all expose their interconnect hardware to temperature extremes that would have been unthinkable in earlier generations of equipment. Under such conditions, environmental-class connectors may suffer from material creep, seal softening, and unpredictable dielectric behavior. Hermetic connectors, by contrast, use carefully matched alloys and sealing glasses—stainless steel or Inconel shells mated to Kovar or similar controlled-expansion pin systems—to maintain their structural and electrical integrity even as temperatures climb dramatically.

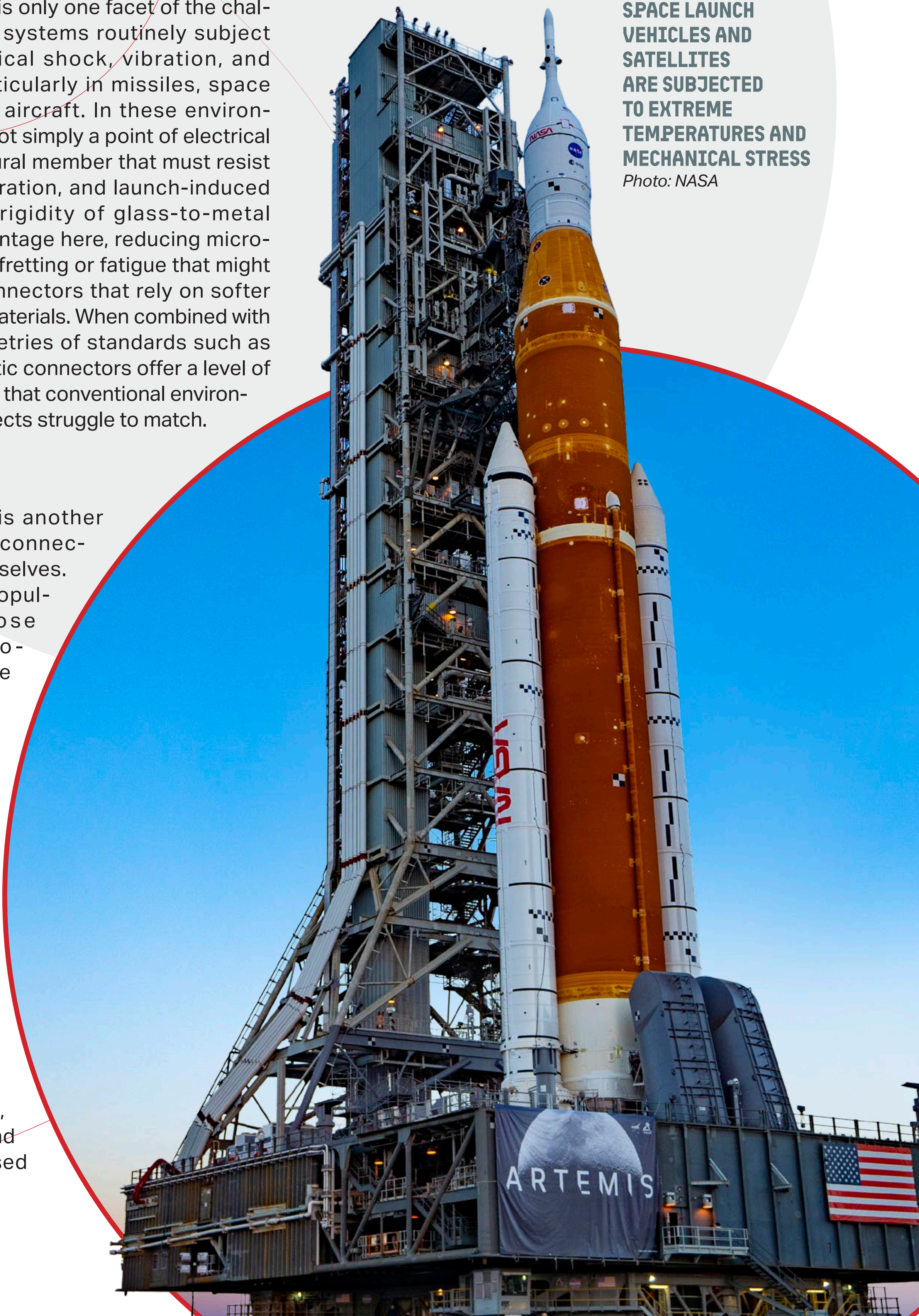
Achieving reliable hermeticity at elevated temperature is no trivial task. Each element of the connector assembly must expand and contract at compatible rates to prevent stress concentrations in the sealing glass. Thermal mismatch can lead to micro-fractures, leakage paths, and long-term reliability concerns. Hermetic connectors designed for high-temperature performance rely on finely engineered material systems that balance thermal stability with mechanical durability. The result is an interconnect capable of surviving propulsion heat, severe radiation of engine components, or rapid shifts between cold-soak and hot-wash environments—all without compromising insulation resistance or leak rate.

HERMETIC CONNECTORS UTILIZE STAINLESS STEEL AND CARBON STEEL OR INCONEL SHELLS, WITH MATCHED OR COMPRESSION GLASS-TO-METAL SEALING

HERMETIC CONNECTORS HAVE EVOLVED FROM SEALING DEVICES INTO MULTIFACETED, ROBUST ENABLING TECHNOLOGIES FOR DEMANDING AEROSPACE APPLICATIONS

Mechanical Stress

Temperature, however, is only one facet of the challenge. High-reliability systems routinely subject hardware to mechanical shock, vibration, and dynamic loading, particularly in missiles, space vehicles, and military aircraft. In these environments, a connector is not simply a point of electrical continuity but a structural member that must resist g-forces, acoustic vibration, and launch-induced shock. The inherent rigidity of glass-to-metal seals provides an advantage here, reducing micromotion and preventing fretting or fatigue that might otherwise occur in connectors that rely on softer insulation and sealing materials. When combined with the robust shell geometries of standards such as MIL-DTL-38999, hermetic connectors offer a level of mechanical survivability that conventional environmental-class interconnects struggle to match.



SPACE LAUNCH VEHICLES AND SATELLITES ARE SUBJECTED TO EXTREME TEMPERATURES AND MECHANICAL STRESS
Photo: NASA

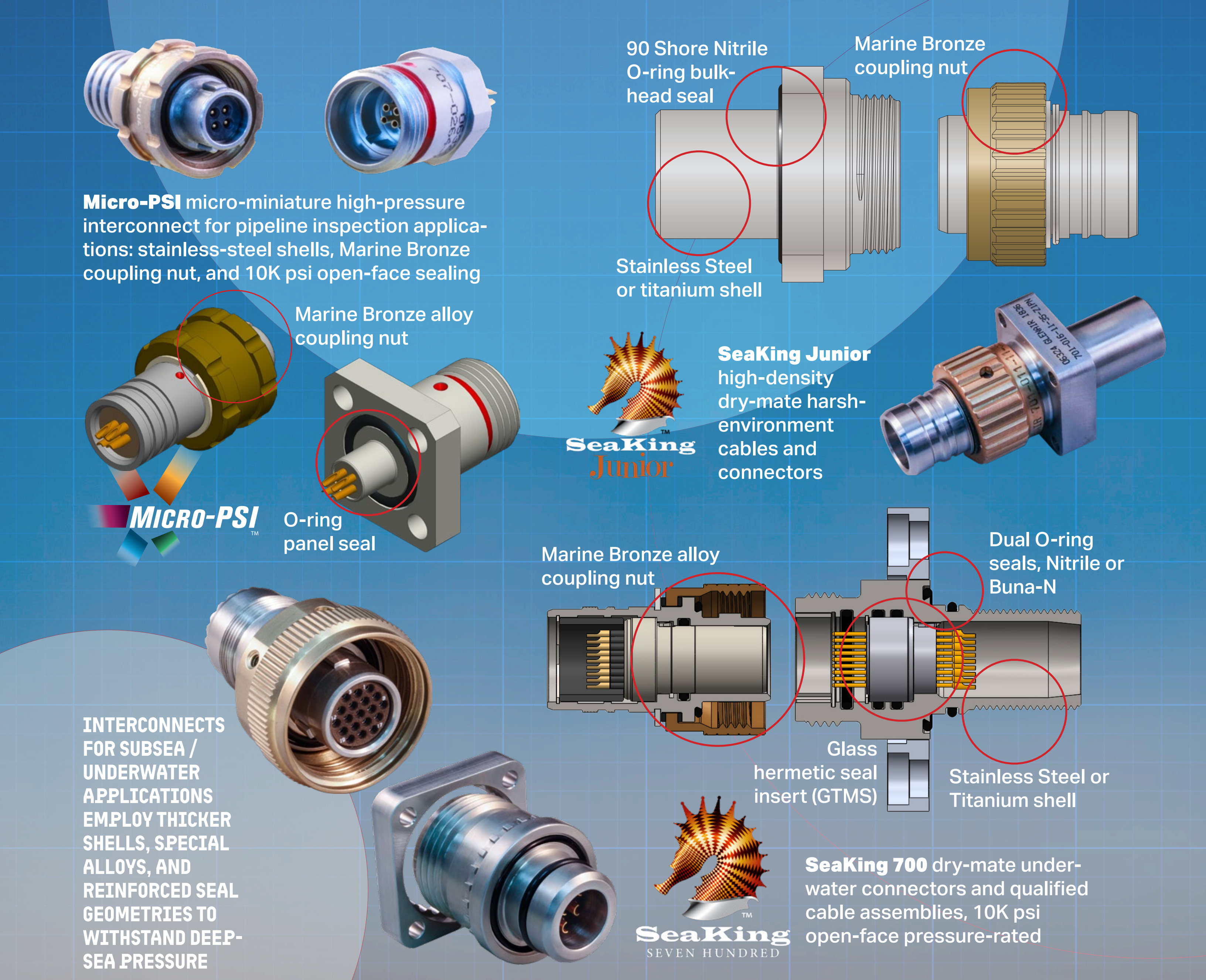
Chemical Resistance

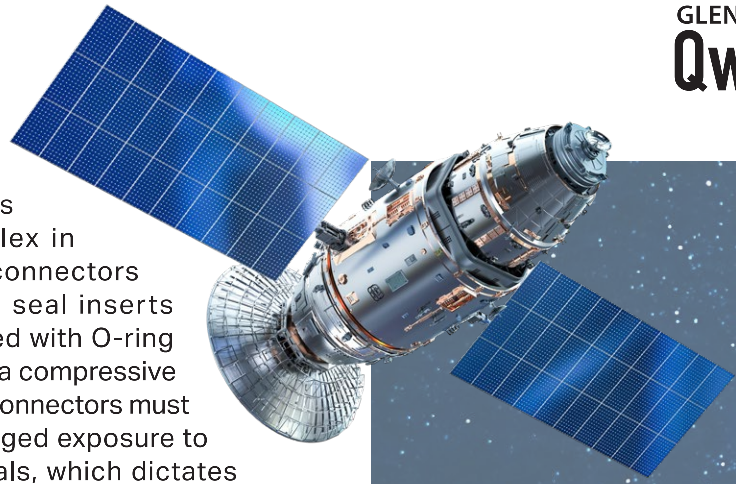
Chemical resistance is another area where hermetic connectors differentiate themselves. Modern aerospace propulsion systems expose surrounding components to a volatile cocktail of fuels, oxidizers, hydraulic fluids, and airborne particulates. High-performance aircraft operating in maritime environments must additionally contend with salt fog and corrosive moisture cycles. This makes glass-to-metal sealed hermetic connectors a preferred option for applications involving fuel system electronics, engine control units, and environmentally exposed naval platforms.

Hermetic Connectors: Atmospheric vs. High-Pressure Subsea Applications

So, in aerospace and space systems, glass-to-metal sealed connectors primarily serve to maintain controlled internal environments and withstand harsh mechanical and environmental stress factors. By contrast, hermetic connectors used in subsea or deepwater applications must contend with extremely high ambient pressures, hydrostatic forces, and aggressive saline chemistry. High-altitude vacuum sealing, in other words, prevents outgassing and inward leakage under low external pressure, while subsea high-pressure sealing resists external hydrostatic forces that drive fluid intru-

Subsea "Hermetic" Connectors: a Special Class of Rugged, Sealed Interconnects

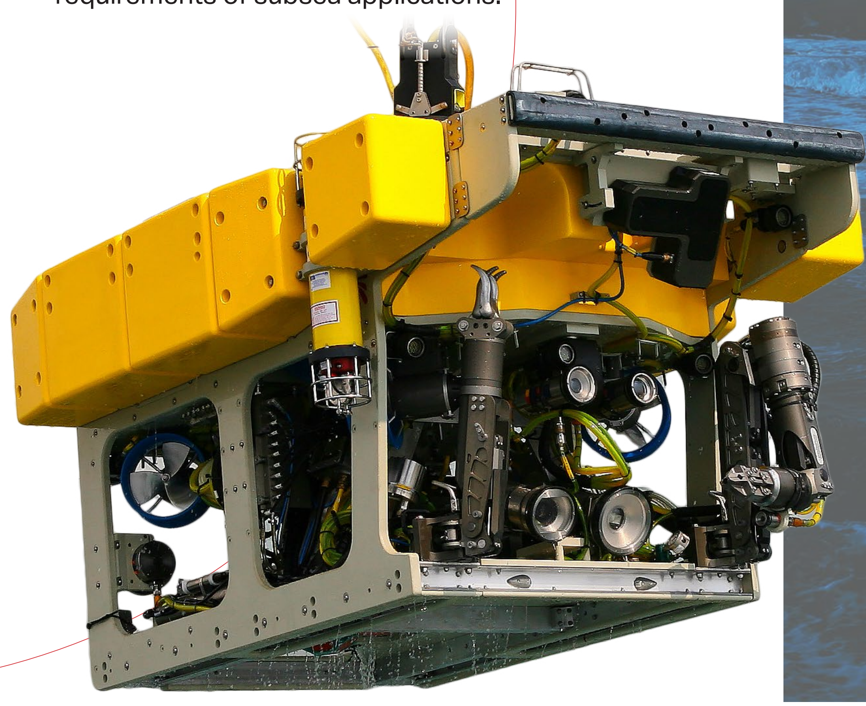




sion into the enclosure. The structural requirements are therefore more complex in subsea applications, with connectors employing glass hermetic seal inserts (GTMS) which are augmented with O-ring sealing to withstand deep-sea compressive forces. As mentioned, these connectors must resist corrosion from prolonged exposure to electrolytic marine chemicals, which dictates different material choices and shell geometries.

Functionally, the priorities differ as well. Aerospace hermetic connectors focus on precision electrical performance in thermally dynamic, controlled atmospheres, whereas subsea hermetic connectors are optimized for mechanical robustness and long-term environmental isolation under extreme hydrostatic pressure. While both classes rely on glass-to-metal hermetic sealing, subsea variants, again, incorporate O-ring-seal design strategies, and high-pressure performance testing to guarantee long-term reliable performance.

Understanding these differences—driven by the unique nature of the two domains—is critical for engineers specifying hermetic connectors for each respective environment. Glenair is uniquely positioned to bring its hermetic sealing expertise—perfected in rugged aerospace and space environments—to meet the high-pressure sealing requirements of subsea applications.



SPECIFYING HERMETIC CONNECTORS FOR AIR AND SPACE SYSTEMS

- Enable power and signal interconnection across a barrier
- Keep moisture, vapor, and contaminants away from sensitive electronics
- Maintain an airtight seal between internal electronics and the external environment
- Perform at high and low temperatures
- Withstand mechanical stress
- Resist harsh chemical exposure
- Conventional glass-to-metal sealing

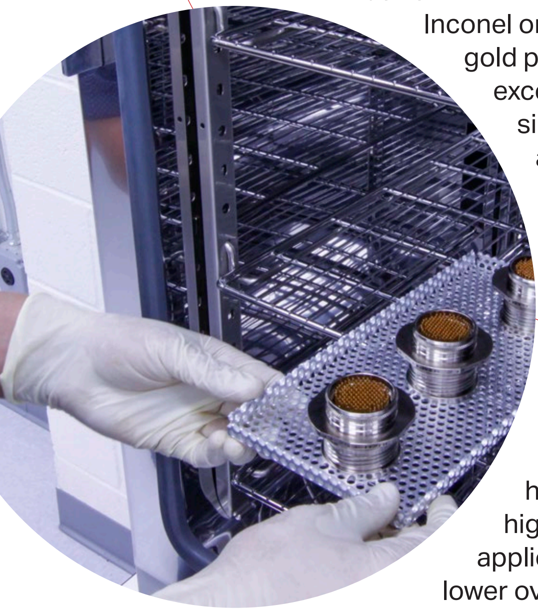
SPECIFYING HERMETIC CONNECTORS FOR UNDERWATER / SUBSEA APPLICATIONS

- Enable power and signal interconnection across a barrier
- Prevent seawater ingress into internal electronics
- Resist high ambient pressure and hydrostatic forces
- Resist long-term exposure to salt water
- Glass hermetic seal inserts augmented with O-ring sealing

Encapsulant vs. Glass-to-Metal Sealed Hermetic Connectors: Electrical Performance and Material Advantages

As described, hermetic connectors have traditionally relied on rugged glass-to-metal seals to achieve leak-tight performance. These seals are highly reliable, capable of maintaining vacuum or pressurized environments under extreme thermal and mechanical stress. However, the metallic contact and shell materials used in glass-to-metal hermetics—stainless steel, Inconel, and Kovar—impose some limitations on electrical performance. In particular, steel alloy contacts have higher resistivity than copper-based alternatives. As a result, high-current or low-resistance applications sometimes face constraints in signal fidelity or power delivery.

Encapsulant-sealed hermetic connectors, such as Glenair CODE RED, address this limitation by combining proven hermetic isolation with lightweight polymer encapsulants—a construction methodology that does not require high-temperature furnace processing. In these designs, sealing materials deliver true hermetic performance while allowing the use of low-resistance gold-plated copper contacts. Copper's electrical conductivity is more than an order of magnitude better than Inconel or Kovar, and the gold plating provides excellent corrosion resistance and long-term contact durability. The result is significantly improved insulation resistance, lower contact resistance—particularly in high-density or high-speed signal applications—and lower overall weight due to the ability to swap out heavier steel alloy shells for lightweight aluminum.



Aluminum shell CODE RED hermetic connectors and copper contacts reduce weight and improve electrical performance compared to heavier-duty glass-to-metal seal hermetic solutions.

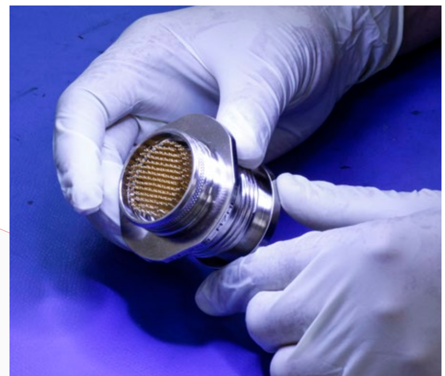
From a structural perspective, encapsulant-sealed hermetics can achieve the necessary environmental protection without the mass and thermal expansion constraints imposed by glass-to-metal seals. While glass-to-metal connectors remain superior in extreme-temperature or high-shock applications, encapsulant-sealed designs excel in scenarios where weight reduction, improved electrical performance, and dense signal routing are primary considerations. These connectors are particularly advantageous in advanced avionics, UAV systems, and other aerospace platforms where minimizing mass without compromising reliability is critical.

The Lightweight Hermetic Challenge

The interconnect industry has searched long and hard for an alternative to glass-to-metal hermetic sealing that can still meet the $1X10^{-7}$ helium leak-rate standard but do so with better electrical performance including better current-carrying capacity and lower contact resistance.

The interest in a lighter weight solution is also significant, particularly for air and space applications. Unfortunately, glass-to-metal seal furnace temperatures are far too extreme for lightweight aluminum shells and low-resistance copper contacts.

Historically, manufacturers have attempted to use epoxy potting compounds as a replacement process for glass, but conventional epoxy sealing lacks the strength and mission-critical durability that is the benchmark of mil-spec hermetic connector standards.



CODE RED IS A GLENAIR SIGNATURE ENCAPSULANT MATERIAL FORMULATED IN-HOUSE AND APPLIED TO THE HERMETIC ASSEMBLY IN A RIGOROUS MULTI-STAGE PROCESS.

CODE RED is the Glenair branding for our signature, encapsulant-to-metal hermetic sealing technology that delivers 1 X 10^{-7} leak rate performance at a fraction of the weight of conventional glass-to-metal seal products—52% weight savings has been demonstrated with a CODE RED hermetic D38999 shell size 9-35 connector versus the same size connector with standard glass-to-metal sealing. CODE RED is an innovative encapsulant sealing and application process that far surpasses historically poor epoxy sealing results.

Further, CODE RED hermetic connector configurations facilitate the construction of hermetic-class products in rectangular and other non-circular shapes (see Glenair HiPer-D and Series 79 Micro-Crimp designs), significantly improving the long-term durability of the hermetic seal. The material and processing have been subjected to the same qualification tests and benchmark standards as our gold-standard glass-to-metal seal connectors, including 100 cycles of thermal shock, and Highly Accelerated Life Testing (or HALT).

CODE RED

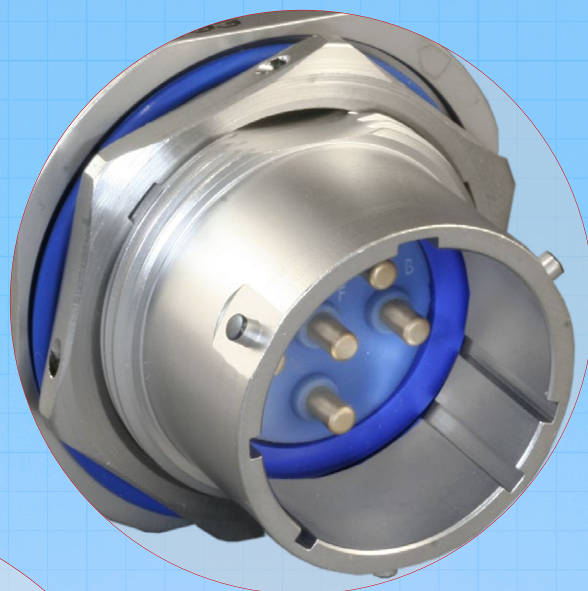
LIGHTWEIGHT HERMETIC ENCAPSULANT-SEAL TECHNOLOGY FROM GLENAIR

Lightweight hermetic encapsulant sealing solution with 1X10^{-7} leak rate performance. Available in Glenair Signature connector packaging including HiPer-D, Micro-D, Series 79, Series 806, and SuperNine.

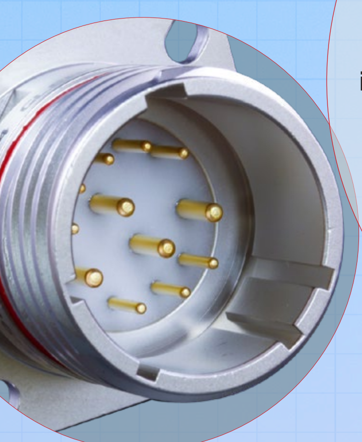
Hermetic "Classes" in MIL-DTL-38999: Understanding Material and Finish Differences

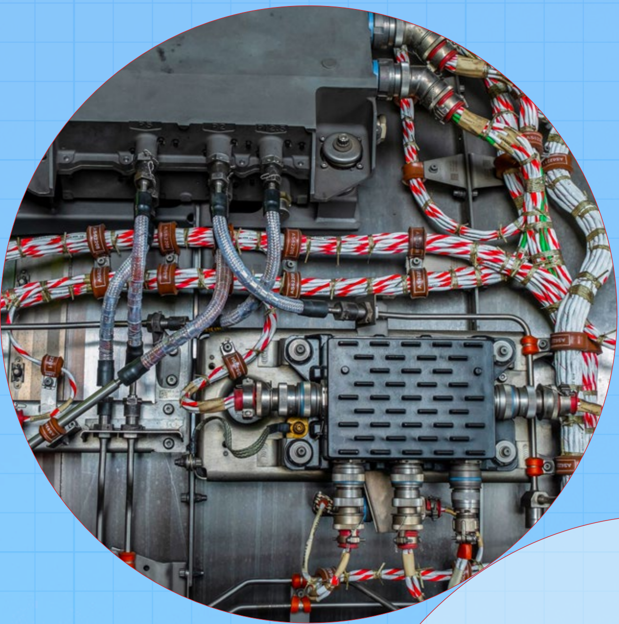
In the MIL-DTL-38999 connector specification, the hermetic class designator identifies the shell material, sealing method, and finish used to achieve leak-tight performance. Although all hermetic D38999 connectors deliver requisite $1X10^{-7}$ leak-rate sealing, the different classes are engineered for distinct operating environments, corrosion profiles, and thermal demands.

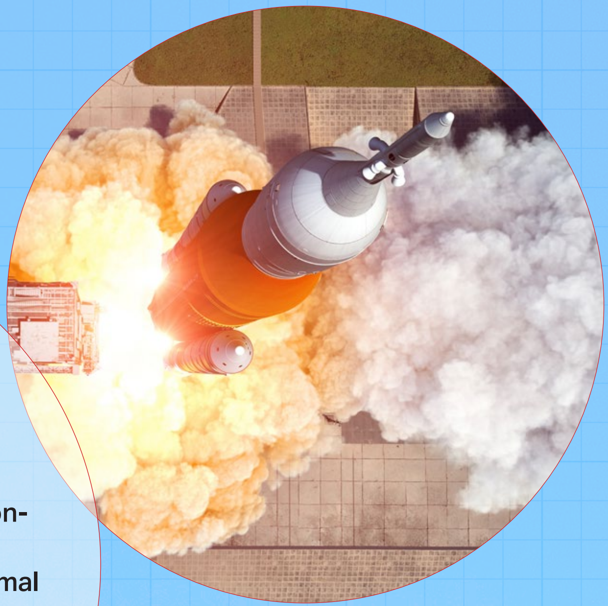
Class Y the most common variant, built with stainless-steel shells and fused glass-to-metal seals. This construction provides excellent corrosion resistance and stable hermeticity across typical aerospace temperature and vibration ranges. Class Y is widely used for avionics enclosures, sensors, and pressurized electronics bays where stainless steel offers an optimal balance of strength and environmental robustness.



Class N hermetic connectors employ stainless-steel shells with nickel plating, offering a different combination of corrosion resistance and surface hardness. Class N has improved shell-to-shell conductivity, and may also be chosen when nickel finish is required for galvanic compatibility with adjacent hardware or application-specific corrosion requirements.







Class H connectors include NASA space outgassing, and are designed for space applications and other extreme aerospace environments such as propulsion-adjacent electronics, or applications where glass seals may crack under sustained thermal stress. Other applications include space telescopes and high-precision optics where damage from outgassed materials could compromise the mission.

Selecting the correct hermetic class is as important as choosing the shell size or insert arrangement. Interconnect engineers must match the class to the environmental demands—whether the priority is corrosion protection, high-temperature performance, mechanical resilience, or long-term dielectric stability—to ensure the connector maintains its hermetic integrity throughout the mission profile.

COMPARISON TABLE: D38999 HERMETIC CLASSES

Hermetic Class	Shell Material and Finish	Seal Type	Advantages	Typical Use
Y	Stainless Steel, Passivated	Glass-to-metal	Balanced performance, excellent corrosion resistance, high availability	Avionics enclosures, IMUs, sealed electronics bays, navigation and control hardware
N	Stainless Steel, Electrodeposited Nickel finish	Glass-to-metal	Durable, conductive nickel finish for grounding or mating compatibility	Systems requiring conductive finish, mixed-material assemblies, specific corrosion-control environments
H Space-Grade	Stainless Steel, Passivated	Glass-to-metal	Best for extreme temperature applications; highly stable dielectric properties, best leak-tight performance under thermal cycling	Propulsion systems, high-heat sensors, spaceflight hardware with rapid or wide-range thermal cycling

GLENAIR WORLDWIDE HERMETIC CAPABILITY OVERVIEW

Hermetic seal connectors are used to resolve potential gas, moisture, and particle ingress problems in high-pressure, high-altitude, and vacuum barrier applications to prevent moisture and other contaminants from damaging sensitive electronic instruments and equipment.

Hermetic seal connectors produce a condition commonly referred to as "airtightness" and are fabricated via a glass-to-metal or lighter weight encapsulant-to-metal sealing process. Both technologies deliver outstanding airtight performance for high-reliability applications and may be specified in a broad range of both circular and rectangular connector packaging.

MATCHED SEAL VS. COMPRESSION SEAL

Glass-to-metal seal hermetic connectors are constructed in two basic formats:

In **Matched seal** hermetics, the glass material coefficient of thermal expansion closely matches that of the metal body or shell material. In other words, while a strong seal is created between the two materials, it is not under dynamic compression.

In **Compression seal** hermetics, the glass coefficient of thermal expansion is less than that of the metal shell surrounding it. As a result, when the metal cools after the final firing temperature has been reached, it squeezes tight against the glass, which has already returned to its solid state.

Compression seals are considered ideal for circular connectors, while matched seal technology is more appropriate for rectangular connectors with their oddly-shaped form-factor. Compression glass seals are generally more stable over longer periods of time, demonstrating robust integrity and structural strength.

MEASURING HERMETIC SEALS

Helium leak testing is the methodology used in our industry to determine the exact degree of airtightness delivered by a particular hermetic device. The extent of any leak—the degree to which connector materials and sealing methodologies still allow gas to pass through the hermetic seal—is referred to as the leak rate. The leak rate is measured by the volume of a tracer gas (such as helium), which can

Hermetic interconnect technology overview

pass through the interconnect, each second, with a pressure differential of 1 atmosphere. The unit of measure which is commonly used in such testing is “atmospheric cubic centimeters per second of helium.” Various DLA mil specs define a leak rate measurement in the range of 1 x 10^{-7} cubic centimeters of helium per second as the modern acceptable leak rate for our industry, and that any current-day technology that can maintain that standard over the service life of the connector, is considered to have met the hermetic seal standard.

Glenair hermetic offerings include qualified, mil-standard connectors as well as signature designs with “better-than-QPL” features such as special PCB standoffs and integrated banding platforms.

MIL-STANDARD AND GLENAIR SIGNATURE HERMETIC CONNECTOR PACKAGING

The process of building a hermetically-sealed connector may be applied to virtually any connector series, given suitable shell materials and wire terminations. Glenair offers hermetic-class connectors in every military standard connector series we manufacture, from legacy power and signal cylindricals such as 26482, 5015, and MIL-DTL-83723 types, to higher-density aerospace interconnects such as the D38999 Series III and IV.

Rectangular connector series available in the hermetic class—again, typically matched-sealed—include the micro miniature MIL-DTL-83513 and the M24308 D-Sub. We also supply many non-standard mil-spec connector derivatives including designs with crimp-removable contacts, wire shield termination band platforms, hybrid shielded and RF contacts, bulkhead feed-thrus, connector savers, and many more. We offer both glass-to-metal and encapsulant-to-metal seal hermetics in all our Signature Series connectors. These are the many small form-factor and specialized harsh-environment connectors that have been developed by Glenair to meet specific customer requirements not addressed in mil-series connectors.

ThermaRex™
CRYOGENIC • HIGH-TEMPERATURE

EXTREME-TEMPERATURE HERMETICS: THERMAREX

All hermetic connectors, both glass-to-metal seal and encapsulant-to-metal-seal, utilize standard interfacial and grommet seal component parts. For applications that require either cryogenic performance to -196°C, or high-temperature performance to +300°C, Glenair supplies ThermaRex series connectors with temperature-tolerant interfacial seals and O-rings.

Glenair signature ThermaRex™ extreme-temperature hermetics utilize temperature-tolerant interfacial seals and O-rings

Hermetic Connector Capabilities

Hermetic interconnect technology overview

GLENAIR ITALIA: NEW CAPABILITIES

The hermetic department in Bologna has implemented these same capabilities and processes with new equipment sets and lines for thermal processes including pre-oxidation of metal components prior to glass sealing, a process step formerly only available in Glendale but now duplicated in our EU hermetic operation. Descaling and passivation steps are completed in Bologna in a fully automated line in preparation for gold plating of hermetic contacts.

The hermetic group in Bologna is also moving forward with the in-house production of the glass multiforms integral to hermetic connector production, as well as ultimately bringing glass and ceramic marking in house.

As a result of these changes, hermetic connector production capabilities in Bologna now extend to processing any design for compressed sealing with stainless steel or Inconel material, matched sealing with Kovar for rectangular connector form factors, and both high-production belt furnace and vacuum/static furnace production lines for lower-volume custom work. The operation is fully staffed with a team of experienced personnel.

Glenair hermetic solutions are always subjected to 100% visual and helium leak testing, electrical testing (IR and DWV) and, depending on application type, in-house pressure testing or lab-based pressure testing.

Glenair Italia capabilities and processes include thermal pre-oxidation of metal connector components prior to glass sealing, automated descaling and passivation, and contact plating.

Hermetic connector production capabilities in our Italian factory include all compression-seal designs for circular connectors and matched-seal for rectangular connectors.

Hermetic interconnect technology overview

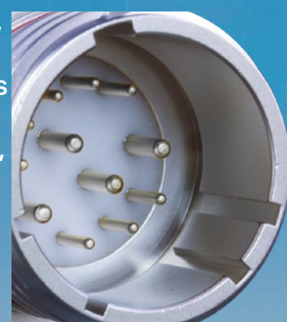
Glass Hermetic Sealing Process

① The heart of a glass-sealed hermetic connector is a pre-form disc made of refined glass—analogous to the rigid dielectric in a standard environmental connector, and fabricated in accordance with the insert arrangement for the connector's specified number and size of contacts.

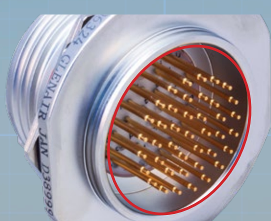
② The pre-form is loaded with its contacts and positioned inside the metal connector shell. Carbon fixture plates are used to hold the contacts in their specified positions.

③ The assembly is then run inside a controlled temperature furnace and subjected to a gradually increasing temperature of approximately 1700° Fahrenheit.

④ At the sealing temperature, the glass melts and fills all voids between contact pins and shells, forming an extremely robust mechanical chemical bond, due to both thermal expansion properties and molecular-level interactions between the glass and metal. The assembly is then gradually cooled.

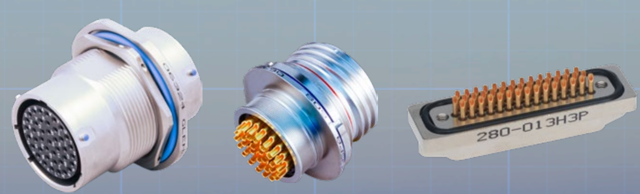


⑤ Next, the assemblies are suspended with wiring on racks, based on their size and configuration, and run through a series of cleaning and descaling processes designed to remove oil, oxidation, and other impurities. Then the work goes through a passivation process to arrest any additional oxidation of the metal parts.



⑥ Gold plating is applied to the connector contacts. Without the benefit of surface plating, contacts would not be conductive enough to reliably transmit data or power.

⑦ Then comes final assembly: conversion to socket face, red banding and part marking, second machining operations and so on. All Glenair hermetic connectors go through a detailed final inspection step before leaving the factory.



I Wonder What They Were *Really* Singing About?


SEALED WITH A KISS
NEW YORK 19 N.Y. • MADE IN U S A
GLASS-SEALED ONION
Words and Music by JOHN LENNON and PAUL McCARTNEY
MACLEN MUSIC INC.
OHIO PLAYERS
AIR-TIGHT
THE FIRST METAL CONNECTOR TO EVER HIT #1! FEATURES THE HITS "KOVAR FEEL THE NOIZE" AND "BANG YOUR FLANGE"
Glenair
Glenair
Glenair
10^-7 sealing
100% tested
tight rope
BILLY JOEL
GLASS HOUSINGS

A Practical Guide to Specifying and Installing Hermetic Connectors in Aerospace Interconnect Applications

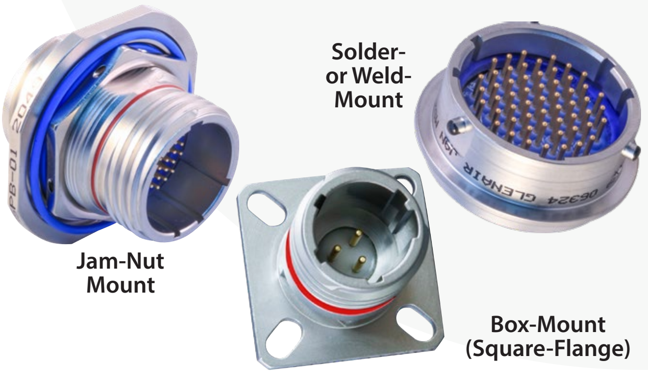
Hermetic connectors in aerospace are essentially pressure boundaries, and are selected for each application based on mounting style, sealing strategy, and electrical performance. There are three principal connector mounting styles for use on boxes and bulkheads:

- **Jam-Nut Receptacles:** Designed for rear mounting through a single hole, they use a hex nut and an O-ring to provide a tight environmental seal and reduce the number of openings in the sealed enclosure.
- **Box-Mount (Flange) Receptacles:** These use a standard four-hole flange and require a separate sealing gasket to ensure an airtight seal between the panel and the receptacle shell.
- **Weld- or Solder-Mount Receptacles:** These have a reduced flange designed to be soldered directly into a mounting panel, ideal for limited spaces or high-density layouts.

Front- or Rear-Mounting: for vacuum systems, it is generally recommended to mount the hermetic feedthrough against the flange from the high-pressure side. The vacuum on the other side then helps "suck" the connector tighter against the sealing surface, enhancing the seal's integrity.

Physical attachment to boxes and bulkheads

For most aerospace bulkhead penetrations, single-hole jam-nut receptacles are preferred. They minimize panel penetrations, reduce fastener count, and limit potential leak paths to a single circular interface. Jam-nut designs also lend themselves well to controlled face-seal compression using an integrated O-ring. They are compact, lightweight, and easy to qualify for leak testing after installation. For pressurized enclosures, vacuum housings, and avionics bays, this is often the default choice.



Square-flange or box-mount receptacles still have a role, particularly where connector density, low mating/demating frequency, and on-site penetration or drilling of bulkheads is performed. However, every fastener hole is a potential leak path, and flange mounts depend heavily on gasket quality, surface finish, and fastener torque consistency. They are best reserved for applications where the ability to mount multiple connectors in close proximity is required, or, as mentioned, when simplified on-site drilling of connector through-hole and fastener points is to be performed.

Weld-in or solder-mount hermetic feedthroughs and receptacles offer the highest possible assurance of long-term hermeticity. By eliminating elastomeric panel seals entirely, they remove aging, compression set, and permeability from the equation. These mounts are commonly used in deep-space hardware, high-vacuum instruments, and permanently-sealed pressure vessels. The tradeoff is irreversibility: once installed, replacement requires cutting or re-welding the pressure boundary.

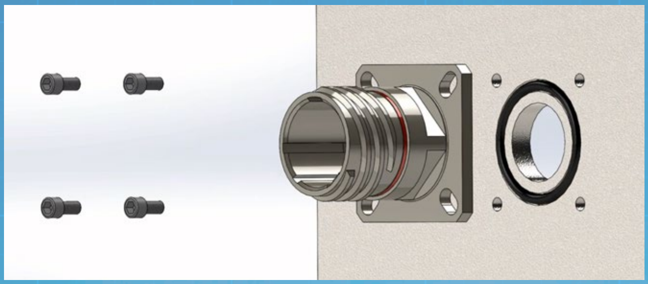
Internal hermetic seals vs. panel seals

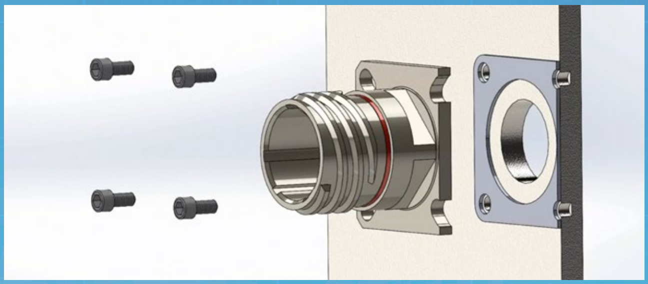
It is important to distinguish between two different seals in a hermetic connector:

1. The **internal hermetic seal** (typically glass-to-metal or epoxy encapsulant), which isolates the contacts from the connector shell and delivers the requisite hermetic sealing of the insert.
2. The **external panel seal**, which prevents leakage around the connector body at the bulkhead. In the case of jam-nut mount connectors, this would be an O-ring. Square-flange mount connectors may utilize O-rings or form-fitting gaskets.

Internal seals define the connector's intrinsic leak rate and are typically qualified to fine-leak levels suitable for high vacuum and long-duration service.

The external seal, however, is a significant potential source of system-level leakage and requires attention during installation and maintenance.





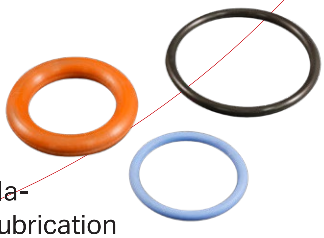
PANEL SEALING FOR BOX-MOUNT / SQUARE FLANGE HERMETIC CONNECTORS
Square flange hermetic connectors may be mounted to a panel or box using O-rings (diagram on left) or a form fitting panel gasket (right). In both cases, blind holes are used for mounting to minimize potential leak paths.

O-Ring Hardness vs. Pressure

In jam-nut mount hermetic connectors, O-ring material selection is a critical design variable because the elastomer must complement the primary glass-to-metal or encapsulant hermetic seal without becoming the limiting factor in environmental performance. Unlike face-seal or gasketed flanges, the jam-nut O-ring is typically compressed radially against the panel cutout and axially by the connector shoulder, where it is exposed to installation torque, panel finish variability, and long-term compression set. The selected material must maintain elasticity across the full operating temperature range, resist permanent deformation under sustained preload, and tolerate differential thermal expansion between the connector shell and the mounting panel—typically aluminum or stainless steel in aerospace applications.

Material choice is driven by temperature capability, fluid and fuel exposure, outgassing requirements, and resistance to aging in sealed or partially evacuated environments. Fluorosilicone is commonly specified where fuel, oil, or hydraulic fluid exposure is expected, offering broad chemical compatibility and flexibility at low temperatures, albeit with reduced tear strength. Subsea applications typically specify Nitrile or Buna-N O-rings for life-of-system durability.

O-ring lubrication: helpful, or harmful?



O-ring lubrication is one of the most misunderstood aspects of hermetic installation. Used correctly, O-ring lubrication improves sealing by reducing friction, preventing twisting or tearing during compression, and promoting uniform seating. Used incorrectly, it can compromise vacuum performance or contaminate sensitive systems. Best practices include:

- Use only lubricants approved for the pressure and cleanliness class of the system. For vacuum and aerospace work, this typically means thin films of vacuum-compatible greases (e.g., PFPE).
- Apply lubricant sparingly. The O-ring should appear slightly glossy, not wet. Excess grease increases outgassing and can migrate.
- Never use hydrocarbon greases in oxygen systems or high-vacuum environments unless explicitly approved.
- For Ultra-High Vacuum (UHV) or contamination-sensitive instruments, dry installation with polished sealing surfaces may be preferred.

Panel preparation and installation discipline

Hermetic connectors are intolerant of irregular interfaces. Panel flatness, surface finish, and hole geometry matter.

- Mating surfaces should be smooth (typically 16–32 μin RMS) and free of scratches across the panel interface.
- Blind-tapped holes are preferred over through-holes to reduce secondary leak paths.
- Jam-nut torque must follow specifications precisely. Over-torque can distort the seal or crack internal glass; under-torque leads to incomplete compression.
- Anti-rotation D-flat hole geometry should be used to prevent connector body twist during mating.

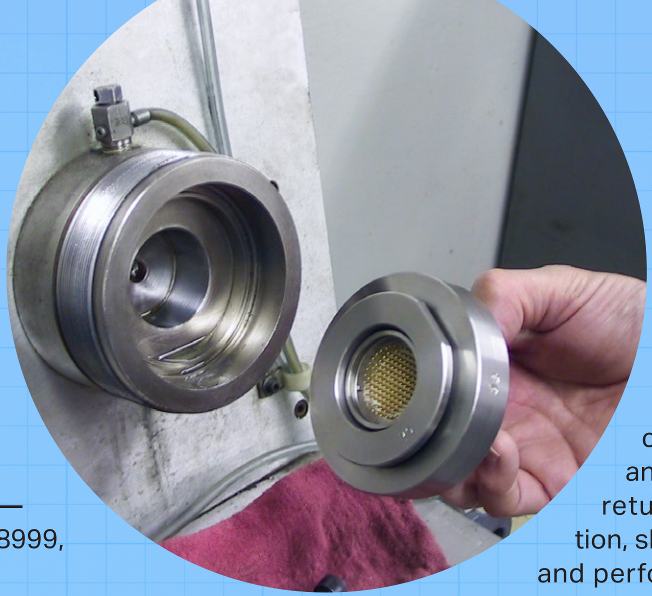
Hermetic Leak Rate Testing Limits and Qualification for Connectors Used in Mil-Aero Applications

Hermetic sealing is central to the long-term reliability of military and aerospace electronics. Hermeticity—defined simply as the condition of being airtight—prevents the ingress of moisture, outgassing products, and contaminants that can degrade electronics or lead to failure over the life of a system. While interconnect engineers can partially mitigate moisture risks through conformal coatings, backpotting, environmental cable-to-connector sealing, and other protective design strategies, the most robust approach remains the use of true hermetically-sealed interconnects. Glass-to-metal sealed connectors, including rectangular, circular, and RF coaxial styles, ensure that internal cavity moisture remains below the threshold at which condensation can occur, even after decades of thermal cycling and pressure differentials. These same attributes make hermetic connectors indispensable in vacuum chambers, cryogenic assemblies, high-altitude payloads, and enclosures filled with inert gases.

Moisture management is a persistent challenge in sealed electronics. Even modest levels of water vapor can condense during variations in temperature and altitude, causing corrosion, dielectric breakdown, and electrical shorts. High-frequency systems can be particularly sensitive: small changes in dielectric environment or corrosion at contact interfaces can alter insertion loss or return loss performance. Glass-to-metal seals provide a stable, impermeable barrier that is far more resistant to moisture diffusion than conventional environmental connectors. This extremely low permeability is essential not only for aircraft-borne equipment with 20– to 30–year service expectations but also for spacecraft assemblies where maintenance is impossible after launch.

Because hermeticity is integral to performance, every aerospace-qualified hermetic connector is verified through helium leak testing prior to shipment. Helium is used because its atomic size allows it to pass through extremely fine defects in a seal, its inert nature prevents interaction with connector materials, and its scarcity in the atmosphere makes it easy to detect with a mass spectrometer. A typical test applies a one-atmosphere vacuum to one side of the connector while helium surrounds the opposite side. If helium penetrates the seal, the mass spectrometer will register the leakage rate. Depending on connector configuration, fine-leak testing may be performed using either a vacuum method or a "bombing" technique, both of which are described in MIL-STD-883, Method 1014. Gross-leak testing may also be performed to screen out catastrophic sealing failures, employing the overpressure or fluorocarbon-immersion methods outlined in the same standard.

A variety of U.S. military, NASA, and international standards govern hermeticity requirements and test methods. MIL-STD-883, Method 1014 remains the most widely referenced specification and defines the acceptable leak-rate limits and procedures for fine and gross leak testing. Although originally written for microelectronics, its methods are routinely applied to hermetic connectors. MIL-STD-202, Method 112 provides an additional framework for sealing tests on passive components and connector assemblies,



especially under mechanical or environmental stress. Many connector detail specifications—including MIL-DTL-38999, MIL-DTL-24308, and MIL-DTL-83513—reference hermeticity verification as part of qualification. NASA workmanship and reliability standards, such as NASA-STD-8739.14 and NASA-HDBK-8739.23, reinforce similar requirements for spaceflight hardware. EU programs often rely on ECSS-Q-ST-70-02, which incorporates hermetic leak limitations into broader thermal-vacuum qualification guidance.

Leak-rate limits vary depending on connector style and expected mission duration, but typical aerospace practice calls for fine-leak thresholds of 1×10^{-7} atm-cc/sec helium or better. Spaceflight hardware and high-reliability avionics assemblies often require even lower values—on the order of 1×10^{-8} atm-cc/sec—to ensure negligible moisture accumulation over many years. Gross-leak failures are not permissible under any conditions; a connector must demonstrate an absence of detectable leakage when subjected to gross-test procedures. Designers sometimes apply volume-based moisture-ingress models such as the Airborne Moisture Content (AMC) method to confirm that the total water vapor entering a sealed cavity over the system's lifetime remains below condensation limits.

Because hermeticity is integral to performance, every aerospace-qualified hermetic connector is verified through helium leak testing prior to shipment.

Qualification of hermetic connectors for military and aerospace platforms involves more than a single leak test. Mechanical and environmental stresses—thermal cycling, vibration, shock, altitude exposure, and corrosive atmospheres—are typically applied before and after hermeticity testing to verify that seals remain stable under mission-representative conditions. For RF coaxial connectors such as SMA, TNC, and BNC, qualification also incorporates return-loss and insertion-loss verification, shielding-effectiveness measurements, and performance checks after thermal shock or mechanical load. The stability of glass-to-metal seals depends heavily on compatible coefficients of thermal expansion among the shell, glass, and conductor materials. Qualification regimens therefore pay close attention to metallurgical factors, glass chemistry, plating thickness, and the torque or clamping loads applied during assembly.

Despite the robustness of hermetic connectors, failures can occur when processes or materials deviate from specification. Common issues include micro-cracks in glass resulting from thermal mismatch, voids or inclusions within the seal, plating porosity that enables moisture migration, or shell deformation caused by excessive installation torque. Glenair addresses these issues through intensive process control including optimized furnace profiles, intensive material analysis and certification, enhanced optical inspection methods, and 100% leak testing for all production parts.

Hermetic connectors remain one of the most effective tools for protecting mission-critical electronics from moisture and contamination. Helium leak testing, grounded in well-established military and NASA standards, provides a reliable and repeatable means of certifying hermetic performance. For aerospace system engineers, selecting connectors built to stringent leak-rate thresholds and ensuring that they are qualified under relevant environmental conditions is essential for achieving the long-term reliability demanded of modern aircraft, spacecraft, and other high-reliability defense systems.

Hermetic Interconnect Glossary

AIR LEAKAGE
The measure of gas ingress across a hermetic barrier. Total air leakage is the sum of the gas which passes through the seal itself, the permeable shell materials or via cracks or gaps in the mounting area.

BONDING
In hermetic glass-to-metal sealing, the permanent fusing of the constituent connector parts —contacts, connector body and glass seal—to one another using surface preparation techniques and high-heat.

COEFFICIENT OF THERMAL EXPANSION
A mathematically derived value describing the dimensional change of a material when subjected to a measured change in temperature. Factored into hermetic connector fabrication to ensure the glass and metal materials return to a known state of compression after the heating and cooling process is completed.

COMPRESSION SEAL
The most effective glass-to-metal sealing method. It is created by using metal shell and contact materials that expand at a greater rate than the glass during heating. During cooling, the metal materials contract back into the already solidifying glass to form a robust compression bond.

ENCAPSULANT-SEAL HERMETIC CONNECTORS
A type of hermetic electrical connector that uses a specialized polymer or epoxy-based compound (CODE RED encapsulant) to achieve an airtight and moisture-proof seal, instead of traditional glass-to-metal sealing. These connectors offer reliable hermetic performance while reducing weight and improving mechanical durability. Used in applications where size, weight, and thermal stress resistance are critical, encapsulant-seal designs leverage advanced materials to maintain long-term integrity in harsh environments.

ENVIRONMENTALLY SEALED
A class of interconnect components that are sealed against moisture ingress through the use of gaskets, O-rings, grommets, or other means. Many applications that could use costlier hermetically- sealed connectors can be adequately protected using simpler environmental sealing techniques. The decision to use hermetics is generally made when the ability to withstand high-pressure differentials (32psi and up) is added to the application performance specifications.

FEEDTHROUGH
A double-sided receptacle connector device, mounted in a bulkhead or wall, used in interconnect systems to pass wires through barriers without creating an entry point for moisture, dust, or chemical pollutants. Hermetic feedthrough connectors are used when the compartments on either side of a bulkhead must be maintained at different pressure levels.

FLANGE
A flat rim projection extending from or around the periphery of a receptacle connector designed to house O-ring sealing devices, fasteners, or other mounting hardware. A flange may also be used to provide a greater surface area of metal material to aid in weld- or solder-mount attachment of receptacle connectors to bulkheads.

HERMETICITY
The measure of a connector's permeability to gas ingress. In general terms, it means how "airtight" the device is when measured using a helium mass spectrometer leakage test. Since all materials are ultimately permeable to gas ingress at some point, hermeticity ratings are used to define acceptable performance levels as required by each individual application.

HERMETIC CONNECTOR
Any of various forms of interconnect devices that are outfitted with specialized seals to prevent moisture and gas from passing through the connector and damaging sensitive electronic equipment. Glass-sealed hermetic connectors are the most effective, with compression-glass sealed connectors providing the highest levels of protection.

KOVAR®
An iron-nickel-cobalt alloy with a coefficient of thermal expansion closely matched to certain glass seals commonly used in both connector bodies and contacts.

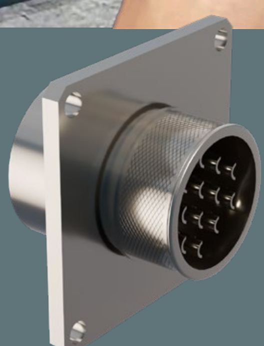
MATCHED SEAL
A category of glass-to-metal sealing. In matched seals, the coefficient of thermal expansion for the glass seal, contacts, and connector body are relatively the same, resulting in a finished product with little or no built-in stress between the constituent parts.

MISMATCHED SEAL
Also known as compression sealing, the different material coefficient of thermal expansion values in the glass and metal materials result in a hermetic seal that is under significant compression stress after cooling. Hermetics of this type can withstand higher-pressure differentials than matched seals.

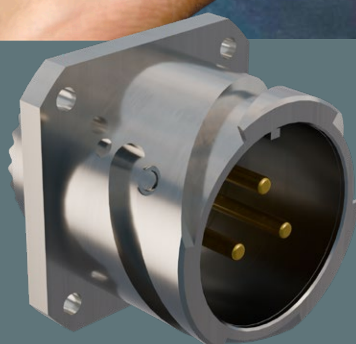
SOLDER- OR WELD-MOUNT
One of the most common mounting configurations for hermetic connectors, especially for electronic equipment such as switches and transducers. Unlike jam-nut mounted connectors, weld-mount hermetics are permanently attached to the pressurized bulkhead, typically with laser, TIG, or MIG welding technology.

Vertically-Integrated Hermetic Capabilities

From connector contact fabrication to machining, hermetic preform production, firing, plating, and assembly – all under one roof



GLI-HE-7087 – Bulkhead hermetic feedthrough designed for wire-to-wire and PCB flex-to-flex connections. Versatile solution does not require a mating plug. Designed for applications such as ground vacuum testing where wires and flex are directly connected to test equipment and instrumentation.



HE-ITS-7088 – Hermetic ITS reverse bayonet receptacles. A proven standard reverse-bayonet interface with glass hermetic sealing. Allows high-power applications to use rapid disconnect/connect coupling. Meets requirements and layouts of AS50151.

GLI-24042-1 – Weld-mount glass-sealed Micro-D receptacle. Designed to take minimal panel space. Small form factor is lightweight and provides excellent sealing performance.

GMMD-HFR4T – High-speed rectangular hermetic feedthrough with shielded twinax contact layout.

GLENAIR ITALIA

Vertically-Integrated Hermetic Capabilities

From connector contact fabrication to machining, hermetic preform production, firing, plating, and assembly – all under one roof

TOTAL VERTICAL INTEGRATION

Includes in-house rubber and thermoplastic injection molding.

ADVANCED HERMETIC-SEAL CONNECTOR FACILITY

Rugged reverse-bayonet hermetic connectors, unique feedthru configurations, glass-seal Micro-D rectangular designs.

Vertically-Integrated Hermetic Capabilities

From connector contact fabrication to machining, hermetic preform production, firing, plating, and assembly – all under one roof

HIGH-CAPACITY CNC MACHINING CENTERS

Allow Glenair BLQ to provide lightning-fast turnaround on small and custom orders as well as large production runs, all with superior surface finishes and better part quality.

ADVANCED CONNECTOR AND CONTACT PLATING CAPABILITIES

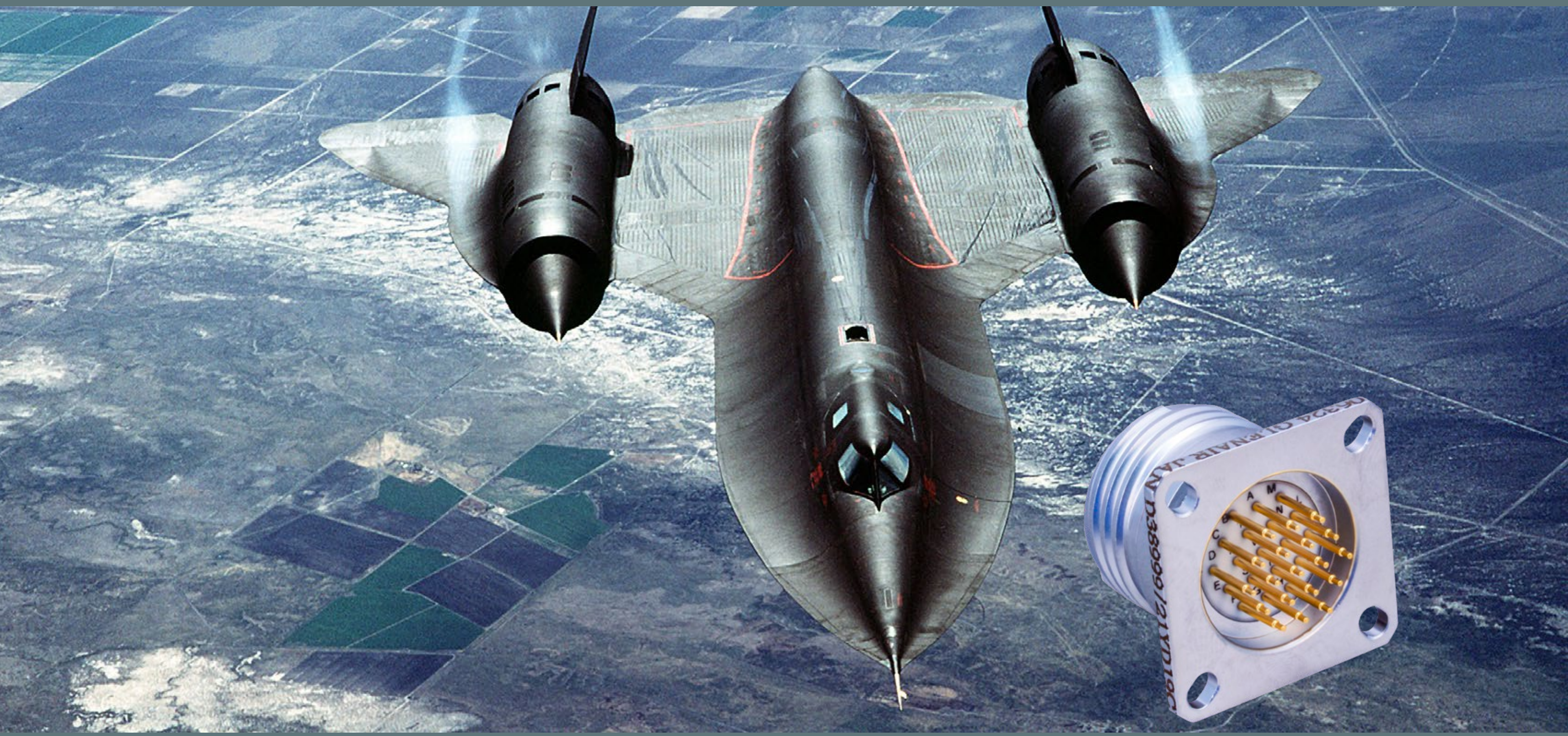
Gold, nickel, and other Glenair signature plating classes performed in-house.

OPTIMIZED FOR USE WITH MIL•STAR™

HIGH-PERFORMANCE HOOKUP WIRE AND CABLE

GLASS-SEALED Hermetic CONNECTORS

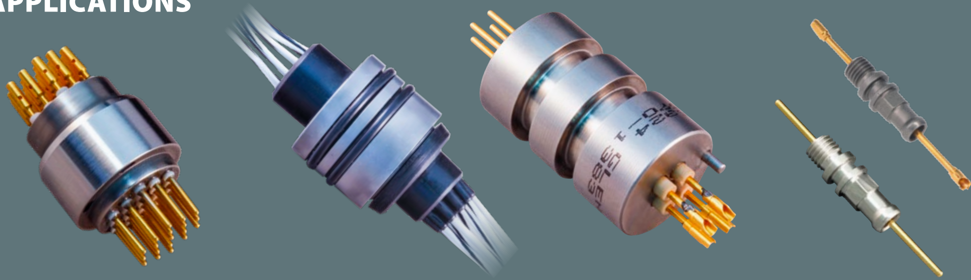
Mil-qualified and Glenair signature hermetic-class connectors



Resolve gas, moisture, and particle ingress problems with gold-standard glass-to-metal seal hermetic interconnects for aerospace, space, subsea, and downhole applications.

- **Superior pressure resistance to 32,000+ psi**
- **Higher resistance to extreme operating temperatures to +260°C**
- **Superior mechanical strength**
- **No metal or glass material breakdown or aging over time**
- **Helium leak rate <1X10^{-7} cc/sec to 1X10^{-10}**

HIGH-PRESSURE / HIGH-TEMPERATURE (HPHT) HERMETIC CONNECTORS FOR LWD AND MWD APPLICATIONS



HPHT multipin and single-pin hermetic feed-thrus and high-pressure penetrators rated to 25,000 psi and hermeticity of <1 X 10^{-8} ccHe/sec @ 1 atmosphere differential for downhole instrument interconnection

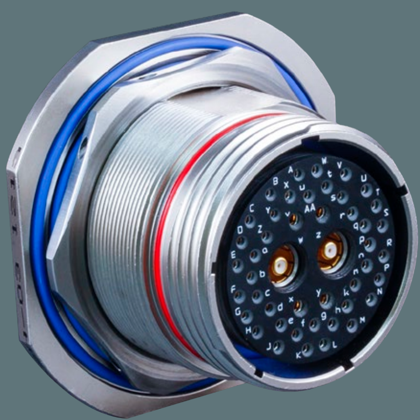
AEROSPACE-GRADE

Hermetic Connectors Glass-to-Metal Seal Type

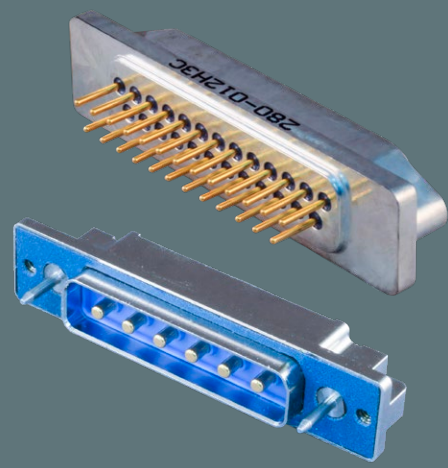
GLENAIR QwikConnect

Receptacles · bulkhead feedthroughs · penetrators · Sav-Con® adapters

UNIQUE HERMETIC OFFERINGS AND CATALOG (COTS) SOLUTIONS



Coax, Triax, Quadrax, and hybrid-contact layouts

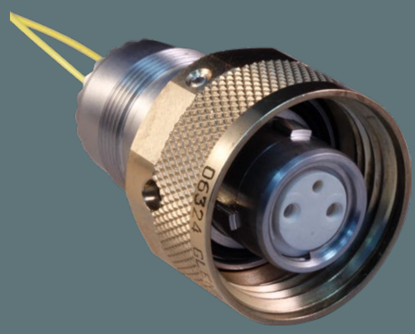


Rectangular hermetics including Series 28 HiPer-D and Series 79

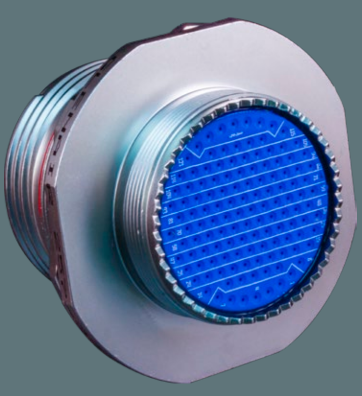
El Ochito high-speed octaxial contacts in a lightweight CODE-RED sealed bulkhead feed-thru

Triax hermetic

Hermetic Sav-Con feedthroughs and gender changers



Subsea 10K psi SeaKing with glass-sealed hermetic insert



Hermetic with crimp-removable contacts

Hermetic bulkhead penetrators

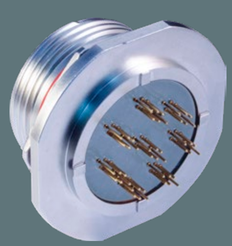
Hermetic receptacles with integrated banding porch

OPTIMIZED FOR USE WITH MIL-STAR™
HIGH-PERFORMANCE HOOKUP WIRE AND CABLE

GLASS-SEALED Hermetic CONNECTORS

Hermetic connectors in lightweight, low-electrical-resistance packaging with 1X10^{-7} leak-rate performance

Hermetically-sealed interconnects used in vacuum or high-altitude applications prevent moisture and other contaminants from damaging sensitive electronic equipment. Glass-to-metal hermetic sealing has been the gold standard in the aerospace and petrochemical industries for decades due to the strength and long-term durability of the materials used. But glass-to-metal seal hermetics come with a big price tag in both weight and electrical resistance. CODE RED is an innovative sealing encapsulant and application process invented by Glenair that provides durable hermetic sealing in a lightweight aluminum package. CODE RED allows for the use of gold-plated copper alloy contacts, significantly improving electrical performance. CODE RED hermetic connectors are available in SuperNine® (D38999 Series III type metal and composite), Mighty Mouse, M24308 D-Sub and HiPer-D, and Series 79; and deliver reliable, life-of-system 1X10^{-7} max leak-rate hermetic sealing. Special non-magnetic (zero residual magnetism) versions are also available, consult factory.

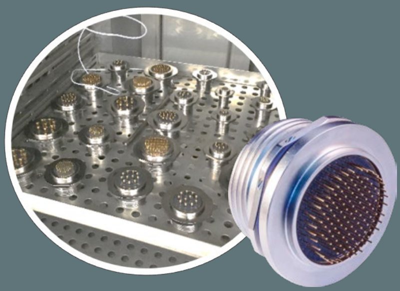


- **1X10^{-7} hermetic sealing in a lightweight aluminum shell**
- **Low-resistance gold-plated copper contacts**
- **Passed full D38999/23 qualification testing**
- **Meets NASA outgassing and aerospace temperature/corrosion resistance standards**
- **Operating temperature -65°C to +200°C**
- **Up to +50% weight savings**
- **Improved current carrying capacity and electrical resistance compared to Kovar/ Inconel solutions**

CODE RED
Hermetic Connectors Encapsulant-to-Metal Seal Type

Lightweight, low-resistance hermetic sealing solution

CODE RED LIGHTWEIGHT HERMETIC CONNECTOR TESTING AND VALIDATION



Connectors utilizing CODE RED hermetic encapsulant sealing underwent a grueling qualification test and validation process to prove material durability and hermeticity. Validation testing including 100 cycles of thermal shock IAW EIA-364-32 Test Condition A -65°C to +200°C while maintaining hermeticity followed by 1000 hours of thermal aging at 200°C. Additional tests included:

- DWV, DWV at altitude
- IR, IR at temperature
- Highly Accelerated Life Testing (HALT)
- Insert and contact retention
- Mating durability
- Random vibration at temperature IAW MIL-DTL-38999
- Hermetic seal at 1 atm differential pressure

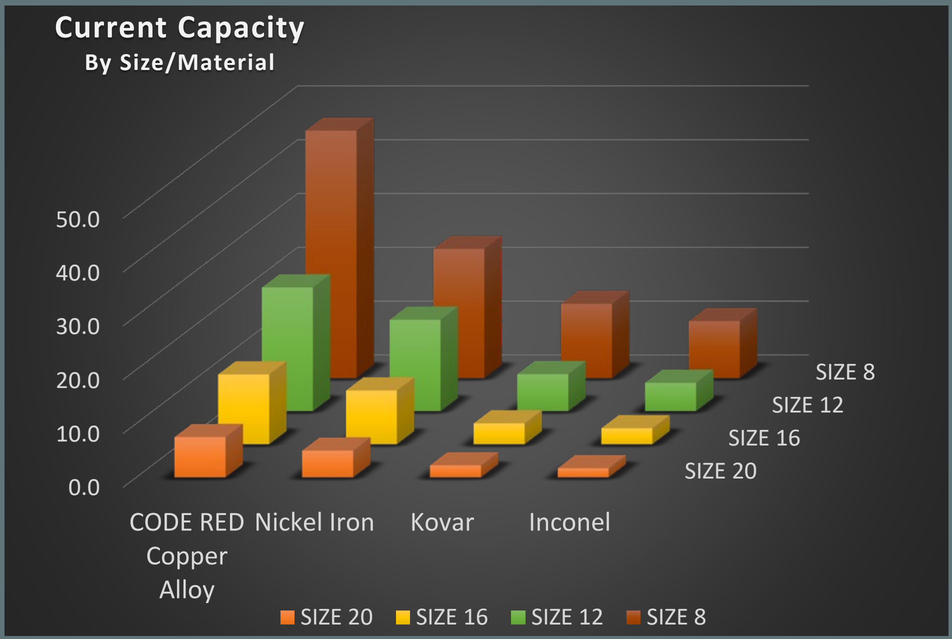
The entire qualification test cycle was repeated successfully with new parts to validate complete reliability.

CODE RED USES PROVEN-PERFORMANCE CONNECTOR AND CONTACT MATERIALS

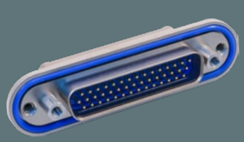
CODE RED MATERIALS / FINISH	
Sealing Adhesive	Proprietary Glenair compounds
Contacts	Gold-plated copper alloy
Insulator	Rigid high-temp plastic
Seals	Blended fluorosilicone/ silicone elastomer
Receptacle Shell and Jam Nut	Aluminum alloy
Finish	Multiple mil-spec finishes
zero residual magnetism materials also available	

PERCENTAGE WEIGHT SAVINGS CODE RED VS. GLASS-TO-METAL MIL-DTL-38999 SR. III	
Shell Size/Insert Arr.	Weight Reduction
9-35	52%
11-98	47%
13-35	47%
15-97	42%
19-32	40%
21-11	32%
23-21	28%
25-08	43%

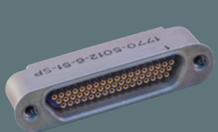
Graph illustrates Current Carrying Capacity of CODE RED copper alloy contacts compared to the Inconel, Kovar, and nickel iron contacts used in conventional glass-to-metal seal hermetics.



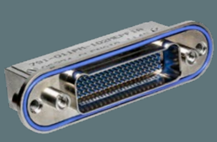
AVAILABLE CONNECTOR PACKAGES



HiPer-D advanced-performance D-Sub

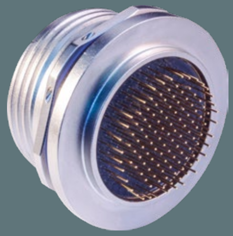


Micro-D M83513-intermateable



Series 79 Micro-Crimp

Sr. 806 Mil-Aero micro miniature



SuperNine "better-than-QPL" D38999

RF and high-speed

Outlook

The True Cost of Ownership

Warren Buffett likes to say, *"Price is what you pay. Value is what you get."* In our line of work, I can't think of a truer statement. I've been in this business long enough to know that nobody ever blows a program because the connector cost a few dollars more. Programs get derailed when a shipment shows up late, when a quality issue sends people scrambling, or when "good-enough" customer service turns out not to be good enough at all. The real cost of ownership lives in all the little things around the edges—the things Glenair has spent decades quietly building into our culture.

Take delivery speed. A connector is never just a part number on a bill of materials. It's a key component that can determine, for example, whether a satellite gets finished in time to meet a launch date, or whether a production line gets ground to a halt or keeps on spinning. Every time we make a shipment from stock, or turn a modification in days instead of weeks, we're not simply helping a customer—we're saving them real money.

The same goes for quality. A field failure or rework will eat up the budget ten times faster than the cost of the original hardware ever could. That's why we put so much emphasis on our testing labs, our documentation discipline, and our vertical integration. When you control your machining, plating, molding, assembly, and test—every last step—you eliminate surprises and improve quality. And doing both is the best path to cost savings there is.

And then there's customization. Most programs don't fail because a catalog part was too expensive. They fail because nobody could make the right part fast enough. Glenair's "tell us exactly what you need and we'll build it" mentality—plus free fit-check samples and no minimum order requirements—has saved more schedules than most people will ever know. When engineers get 3D models the same day, when they can talk to a real application expert instead of a ticketing system, when they can fit-check a flex assembly in their mockup before they ever cut a PO, those are the moments when cost of ownership really becomes visible.

And here's something we don't brag about enough: capacity and stability. Being made in America, being truly vertically integrated, and keeping ample machine time and headroom in every department is not an accident. It's a philosophy. It means our supply chain doesn't wobble when the world does. It means that when a customer suddenly needs twice as many assemblies, we don't tell them, "sorry, see you in 52 weeks." That reliability—steady, predictable, no-drama reliability—is worth its weight in gold in our industry.

When you add it all up—speed, quality, customization, documentation, engineering support, capacity, and the ease of doing business that comes from working with a manufacturer that has been delivering the goods for over 70 years—you start to see why the cheapest unit price is almost never the best value. In our experience, customers who choose Glenair aren't looking for a bargain-bin part; they're looking for peace of mind. They're looking for the value-rich solution that won't become the expensive problem later.

As we head into a new calendar year, I want to thank everyone here who makes Glenair the lowest cost-of-ownership interconnect supplier on the planet—not by cutting corners, but by building value into every step of what we do. That, as Mr. Buffett might observe, is a beautiful thing.

Chris Toomey

QwikConnect

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