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STOPPING LEAKS BEFORE THEY HAPPEN

SEALING TECHNOLOGY IN ENVIRONMENTAL INTERCONNECT SYSTEMS

Cpl. Christian Hiraldo leads Marines and sailors through a mud pit at the Jungle Warfare Training Center on Camp Gonsalves, Marine Corps Base Camp Smedley D. Butler. (U.S. Marine Corps photo by Lance Cpl. Diamond N. Peden)

Glenair®

STOPPING LEAKS BEFORE THEY HAPPEN

SEALING TECHNOLOGY IN ENVIRONMENTAL INTERCONNECT SYSTEMS

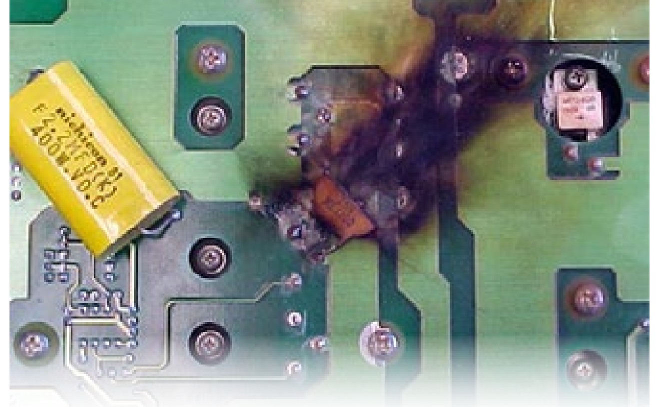
ENVIRONMENTAL BY DESIGN

Every layer of an interconnect system is subject to the forces of nature and the equipment environment in which it serves. From the destructive power of a lightning strike to the cumulative impact of a million flex cycles, interconnects must do battle with the world around them. This special issue of *QwikConnect* presents the story of just one type of environmental stress, the steady drip, drip, drip of invasive fluids. The ability of I/O cabling and connectors to effectively resist the relentless tide of environmental fluids and to reliably seal precious and sensitive electronic systems from damage is a mission-critical element of interconnect system design and material selection.

To say Glenair is an expert in this field is an understatement—on a par with saying we are experiencing a bit of dry weather here in California after several years of serious drought. Glenair's expertise in sealing technology covers all the key areas:

1. Sealed environmental connector designs utilizing resilient grommets, gaskets, and O-rings,
2. Auxillary connector sealing technologies such as hermetic inserts and back potting,
3. Mechanical wire-to-connector sealing technologies such as environmental backshells and shrink boots,
4. Innovative cable jacket formulas that resist even the most destructive and invasive environmental forces,
5. Factory cable and conduit assembly processes, such as overmolding, that ensure long-term, reliable sealing in point-to-point and multi-branch assemblies.

Leak protection is a do-or-die requirement for interconnect systems in many industries. From navy applications, to commercial and military aviation, battlefield and soldier systems, rail and transportation and elsewhere, the failure of an environmental seal can disrupt or even halt an entire operation. Many electronic box / system manufacturers are hyper-sensitive to leak prevention and take precautionary steps to ensure fluid ingress does not occur. But just as frequently, competitive pressures and cost-control measures drive box makers to make compromises that rely on perfectly sealed mating cable plug assemblies—sometimes with dire consequences. The following examples demonstrate how effectively sealed cables *and* boxes play important roles in environmentally sealed applications.



▲ Bad things happen to poorly sealed boxes

MILITARY JET

In the F-16 Falcon, every available square inch of internal wing and body space is used to carry either fuel, ordinance or a critical air borne system. Usable space is at such a premium, that the cable harnesses used to transmit fuel consumption data, control the Fly-by-Wire flight system, and provide connectivity to and from critical avionic devices must travel directly through the jet's internal fuel tanks—a design and engineering challenge of the first order.

These mission-critical cables, called Total Immersion Fuel Tank Air-Borne Cables, or TIFTAC, must exhibit extremely high integrity while fully immersed in jet fuel, lubricating oil, hydraulic fluid and other liquid chemicals. The cables must be able to withstand penetration and degradation from these caustic fluids for their entire lifespan, as any sealing failure or leak could cause a dangerous flight safety condition. This is especially true since the F-16, for efficiency, performance, and resistance to battle damage, carries no mechanical backup to its electronic flight control system. That the F-16 TIFTAC cables must provide such faultless performance under extreme conditions of strain, vibration, shock, and sudden changes of pressure and temperature only adds to the challenge of engineering and building these leak-proof, mission-critical cable assemblies.

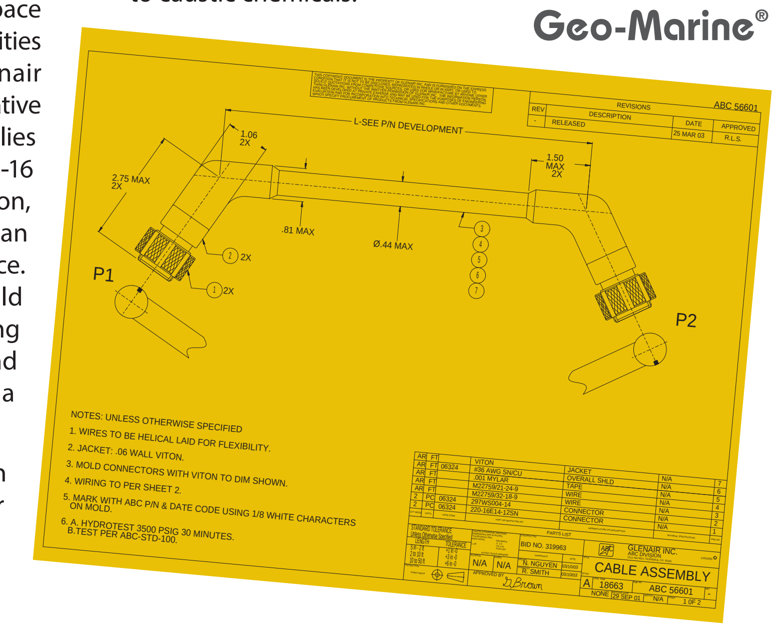
▲ The General Dynamics (now Lockheed Martin) F-16 Fighting Falcon is a single-engine multirole fighter aircraft originally developed for the United States Air Force. Designed as an air superiority day fighter, it evolved into a successful all-weather multirole aircraft. Over 4,500 aircraft have been built since production was approved in 1976.

Glenair has qualified to build some of the most difficult and challenging interconnect assemblies in the aerospace industry and has been manufacturing production quantities of F-16 fuel tank cable assemblies since 1984. Glenair engineers are well-known for their ability to apply innovative solutions to building sealed interconnect cable assemblies for extremely harsh environments. In the case of the F-16 TIFTAC program, this ability resulted in rapid qualification, the on-time fulfillment of thousands of orders, and an impressive 30 year track record of spotless performance. Sealed cables of this caliber require dedicated mold tooling, strict attention to material behavior both during molding and curing, careful preparation, abrading and treatment of cable jacket bonding surfaces, as well as a host of other special techniques.

The procedures developed by Glenair to meet the high quality standards specified by the original manufacturer of the F-16 have been applied successfully to a broad range of harsh-environment cable assemblies for other industries such as industrial mining and energy.

The overmolded Geo-Marine® cable shown below is a perfect example. This sealed, overmolded cable is a unique environmental solution which very few manufacturers in the world would even attempt to build, let alone successfully qualify to the exacting requirements of the application environment, including rough handling, high heat, and resistance to caustic chemicals.

Geo-Marine®

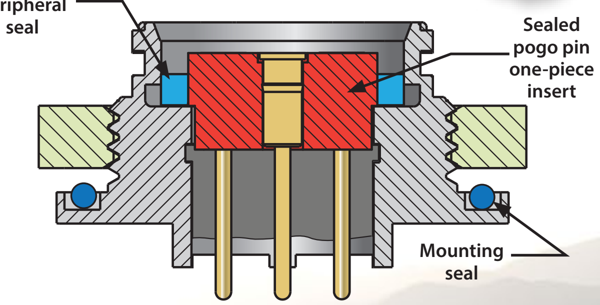


SOLDIER / BATTLEFIELD

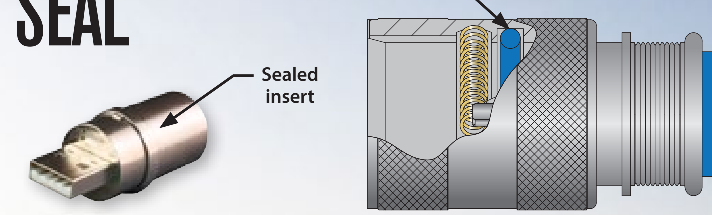
Battlefield communications, computing and other high-performance soldier electronic systems are subjected to continuous environmental stress including temperature extremes, submersion, and abusive handling. C4ISR technologies for battlefield applications require ultraminiaturization and high-speed performance. This is an extremely challenging environment in which to design and deploy successful interconnect technologies. Glenair inspired and designed solutions that support the warfighter—from contacts to connectors, shields, jackets, cables and more—have become the gold standard for both size and weight reduction as well as environmental durability and performance.

Sealing technology in battlefield cable applications essentially consists of overmolding materials and designs that encapsulate the wire-to-connector interface. Several examples of this technology are shown.

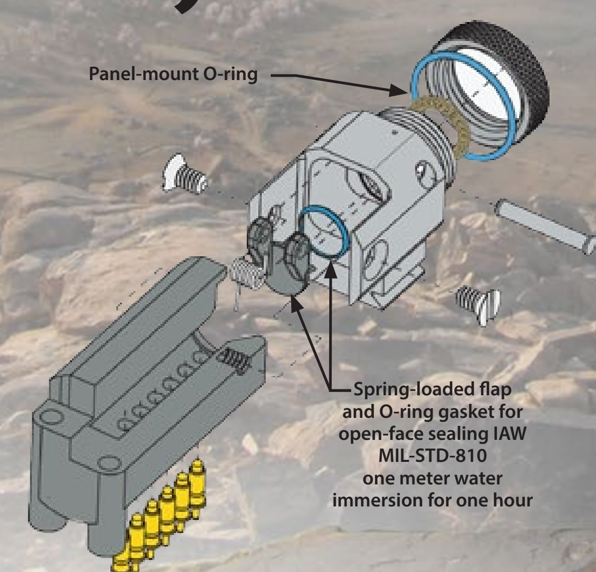
But the key discrete component to target for maximized sealing attention is any receptacle connector mounted to an electronic equipment box, as this is both the most likely and the most costly potential leak path. From our industry-leading Series 80 Mighty Mouse to our nanominiature Series 88 SuperFly™, Glenair has taken every necessary step to ensure reliable, sealed performance of box-mounted receptacle connectors. The following graphics and design drawings illustrate the breadth of sealing technologies incorporated in these small form-factor battlefield receptacles.



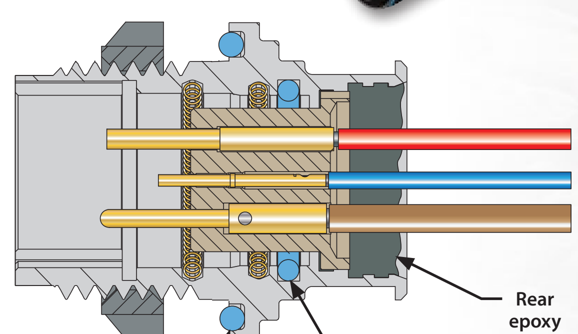
The snap-lock trigger-release Series 860 MouseBud™ incorporates pogo pin type contacts that are ideally suited for open face sealing applications—one meter, one hour water immersion. Receptacle connectors meet MIL-STD-810G, both mated and unmated since the one-piece pogo pin insert is an inherently sealed mechanism. Box-mount sealing is accomplished with a fluorosilicone O-ring, and mated condition sealing is accomplished with an internal peripheral seal.



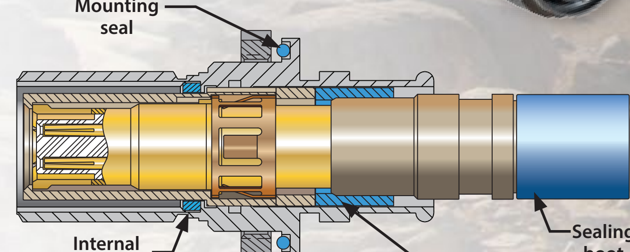
SuperSeal small form-factor RJ45 and USB interconnects are IP67 rated in both the mated and open-face condition. The commercial connector interface assembly is insert-molded and sealed front-to-back. Additional internal peripheral sealing and rear grommet sealing guarantee reliable field performanance and protection of Ethernet and high-speed data switching/hub technology.



The Series 153 SuperJack is an ultra harsh environment unipole for audio, data and power applications. A unique sealing flap in the SuperJack receptacle, combined with an internal O-ring delivers watertight sealing in both the mated and unmated condition.



Sealing on the Series 88 SuperFly receptacle is critical to ensure protection of electronic box elements. Three lines of defense are deployed: A resilient O-ring protecting the mounting interface to the box; a peripheral O-ring for mated-condition sealing; and epoxy backpotting for open-face sealing protection of the box.



The Series 80 Mighty Mouse incorporates the full complement of fluorosilicone mechanical seals. In addition to the interfacial seal on the plug, receptacles incorporate peripheral seals, mounting seals, and rear grommet seals. Special versions of the Mighty Mouse, such as the high-speed variant shown here, may also incorporate additional sealing technologies such as backpotting or a contact sealing boot.

RAIL

Rail and transportation systems represent one of the most challenging environments for the long-term survivability and reliability of interconnect cables and assemblies. From high speed rail transportation systems to heavy railway freight lines, the standard daily fare of the rail industry is one harsh environmental challenge after another. Electrical and signal interconnections in rail car linkages, for example, are subject to significant environmental abuse. Undercar cables, exposed to splashing, mud, diesel exhaust and high heat, require extremely robust environmental protection.

Locomotives are brutal testing grounds for cable systems which are subjected to hot oils, solvents, and fuel spills, not to mention high heat and other environmental stress factors. It's fair to say that the harsh environment of a locomotive engine compartment is where poorly designed or minimally protected interconnect cables go to die.

The art of designing rail industry interconnect cables that provide long-life and value depends on a comprehensive understanding of the environmental stress factors that can, at a minimum, diminish performance, and at their worst lead to complete system failure.

Frequently, Glenair is called upon to redesign and refit rail application interconnect cables that were not adequately designed for robust sealing and harsh-environmental survival. High speed trains throughout the United Kingdom, for example, frequently experience electrical failures in engine governor harnesses. These twenty-year-old (and more) locos are hotbeds of relentlessly high temperatures, vibration and engine oil contamination. In one such retrofit project, the original design for a hard-wired cable assembly required complete re-wiring and significant locomotive downtime every time an individual section of the cable failed. Glenair proposed a braided and jacketed, high performance, high temperature overmolded system with fluid-tight fittings and a simplified installation process. As a result of the change, affected sections can be replaced immediately, cutting train downtime to a minimum and permanently resolving leakage problems in with each harness replacement.

Rail engine harness assembly

(U.S. Navy photo by Mass Communication Specialist 1st Class Gary Keen/Released)

Dramatic photo of USS Anchorage (LPD 23) demonstrates the harsh environment that interconnect and box technology must survive to perform in roll-on / roll-off applications.

NAVY

NAVSEASYSCOM, the engineering service agency of the US Navy has implemented a new Capital Investment for Labor (CIL) program to reduce ship's force maintenance hours and its Total Cost Ownership for a broad range of on board systems.

One of the major program objectives is to find new ways to prevent moisture damage to electronic equipment caused by destructive corrosion, which will in turn reduce sailor work load by eliminating numerous repetitive, and labor-intensive tasks.

The initiative is now well underway, and Glenair is participating in a major effort focused on stern-gate control panels—the exposed communications and electrical control station located on the stern of LSD class ships. The severe corrosion found on stern gate control panel equipment is indicative of conditions on board a wide variety of Navy ships. Such conditions have resulted in the excessive expenditure of manpower and materials in the never ending task of cleaning up and eliminating endemic corrosion problems and its destructive impact on electrical and electronic systems.

Glenair was tasked by the Navy to assist in the complete redesign and retrofitting of LSD class ship stern gate control station consisting of sound-power sets, growler boxes, switches and other controls housed in poorly sealed brass equipment subject to heavy wave and spray action, and severe corrosion.

Glenair designed a completely sealed system built around our composite box technologies and leak-proof jacketed conduit. The systems have now been deployed on multiple ships and have, by the navy's own estimates, already saved thousands of hours of maintenance cycles and system down time.

Bombardier TWINDEXX Express double-deck intercity Electric Multiple Unit high-speed train

Ruggedized, overmolded brake cable

Landing gear photo by Florian Lindner

COMMERCIAL AVIATION

Commercial aviation is a particularly harsh application environment for interconnect cabling. Electrical wire interconnect systems (EWIS) best practices are defined by the FAA, but considerable latitude is granted in the selection and construction of cable and conduit materials. On occasion, OEM manufacturers of commercial aircraft find that some material and construction choices are inadequate for reliable long-term use. One area of particular concern has been wheel well and brake assembly cables and conduits, which are subject to significant vibration, shock and flex mechanical stress factors as well as challenging environmental conditions such as exposure to de-icing solvents and other caustic chemicals.

Glenair has assisted a number of large aircraft OEMs in the redesign of wheel well and brake assembly cables to eliminate leak problems and premature wear patterns. Glenair's approach follows both EWIS best practices as well as leveraging our many years of experience building ruggedized cable assemblies for extreme environments.

In addition to specifying material and construction processes such as overmolded and/or rugged conduit technologies, Glenair's experience has been that these exposed harsh-environment cables should be routed and positioned to avoid chafing against aircraft structures or other components, to eliminate or minimize use as a handhold or support, to minimize exposure to damage by maintenance crews or shifting cargo, and to avoid exposure to corrosive fluids.

Many cable cover material choices are woefully inadequate to protect cabling in landing gear systems. As these assemblies must be protected from impact of rocks, ice, mud, and so on, such protection might include the use of stainless steel metal-core conduit and/or heavy-duty shielded and jacketed overmold technology.

The incorporation of reinforced mounting points directly into the cable design is another key solution to the elimination of wear patterns and subsequent wire damage.

STOPPING LEAKS BEFORE THEY HAPPEN

LEAK PATH DETECTION AND MITIGATION IN ENVIORNMENTAL INTERCONNECT SYSTEMS

LEAK PATH DETECTION AND MITIGATION IN ENVIRONMENTAL CONNECTORS

The sealing of environmental class connectors against fluid ingress in electrical wire interconnect systems is a serious concern, particularly in mission-critical applications where electronic component failure could result in a dangerous safety condition. To assist users of Glenair interconnect technologies to achieve the best possible outcomes in their own system design work, we have prepared the following guidance.

Mated Condition Sealing

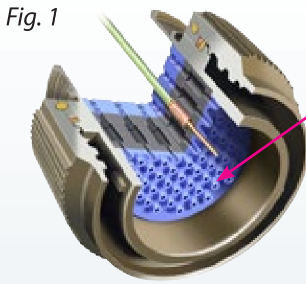
Many references to sealing in Glenair catalogs and technical documentation concern the ability of interconnects to resist water ingress in the mated condition. This is because applicable standards and tests (MIL-STD-810F Method 512.4, water immersion and IP67 IEC-60529, ingress protection) exist to qualify connectors during conditions of actual use, i.e. mated and energized. In practical terms, four mechanical sealing elements are in play in the test and qualification of connectors to these two standards:

1. **Interfacial (AKA "cork-and-bottle") seals** that protect individual contacts and cavities when the two insert assemblies are brought together during mating. As you can see in Fig. 1 and 2, the resilient "cork" half of the seal intermates with the "bottle" side (the front insulator) and, under the pressure of mating, creates a compression seal around each contact pair.
2. **The peripheral seal** (Fig. 3) that encircles and seals the entire array of contacts under the compression of mated connector shell-to-shell bottoming.
3. **The grommet seal** (Fig. 4), with its "triple-ripple" design that seals each individual wire on the back end of the connector, preventing moisture from wicking up the wires and entering the circuit from the rear.
4. **Back-end Epoxy potting** Standard potting on PC and solder-cup receptacles prevents moisture wicking up the contacts during post-solder washdown and provides a splash-proof environmental seal on the receptacle in use (See Fig. 5).

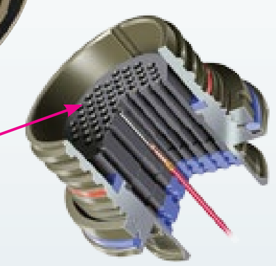
Qualification Testing

To qualify connectors for environmental use, a series of tests are performed on the efficacy of the four seals describe above. These tests include but are not limited to simple low-pressure immersion testing (one meter, one hour) as well as "bubble" testing which subjects a submerged (mated) test cable to pressure for visual evidence of a leak path. Testing is completed under ideal conditions. In other words we use samples that have been carefully examined for defects, prepare test cables using the best practices of our assembly shop, and carefully mate the test samples together using calibrated measurement equipment and O-ring lubrication to ensure optimal mating.

Fig. 1



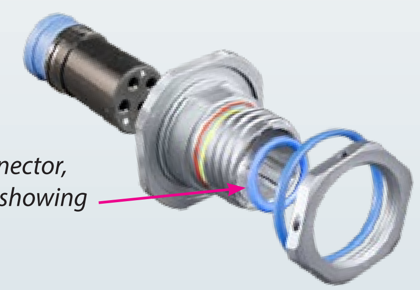
Interfacial seal: note cork-shaped protuberance.



Front insulator (the "bottle" side in cork-and bottle sealing.

Fig. 2

Fig. 3



Receptacle connector, exploded view, showing peripheral seal.

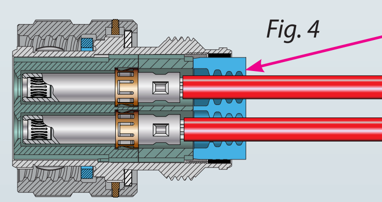


Fig. 4

"Triple-ripple" grommet seal prevents rear-entry leak paths.

Fig. 5

Rear-end epoxy potting is a standard manufacturing process preventing moisture from post-solder washdown entering connector. This caliber of potting does not ensure IP67 level sealing.

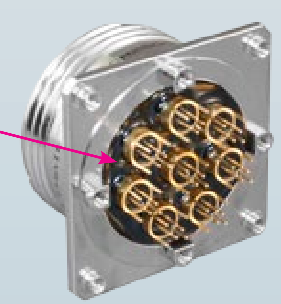
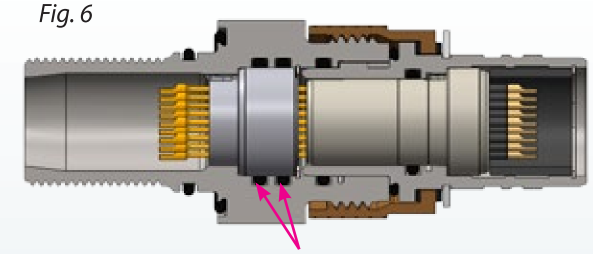


Fig. 6

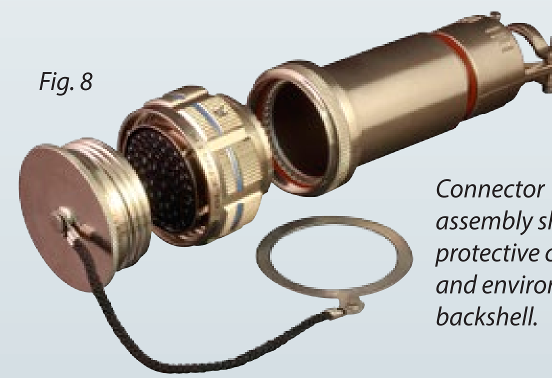


Cross-section of a high-pressure subsea connector showing auxiliary internal compression O-rings that augment open-face sealing capability.

Fig. 7

Hermetically sealed contact inserts ensure sealing in even the harshest environmental applications.

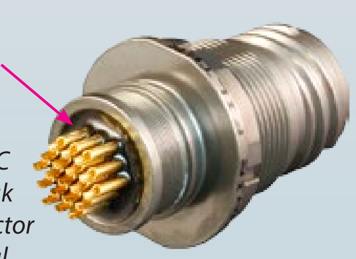
Fig. 8



Connector assembly showing protective cover and environmental backshell.

Fig. 9

Series 80 Mighty Mouse with Mod Code 518 open face sealing. The special Mod Code (ideally suited for fixed solder cup and PC tail contacts) prevents leak paths through the connector even in cases of peripheral seal failure.



Unmated Condition / Open Face Sealing

Obviously an open face or unmated connector, even one properly mounted to a box or bulkhead with an appropriate O-ring or gasket, does not enjoy the full-range of sealing technologies as a mated assembly. While the interfacial seal will still provide a modicum of protection against moisture passing through the connector, without the compression force of the mating connector or the action of the peripheral seal an unmated receptacle invites serious trouble. Connectors subjected to fluids such as sub-sea interconnects in their unmated condition are equipped with additional internal seals and safeguards, including glass-sealed (hermetic) inserts, internal compression O-rings and so on (See Fig. 6 and 7). Typically, designers will also equip connectors with environmental protective covers (Fig. 8) to be applied whenever they are to be left unmated. Finally, some system designers (Fig. 9) will take the precaution of specifying advanced potting, processing and testing of interconnects in certain applications, for example to protect against potential leak paths introduced by damaged or poorly constructed cables or because the consistent use of protective covers is unpredictable or impractical (more on leak paths below).

MOD-518 Open Face Sealing

As described above, high-performance environmental connectors are designed and tested to meet IP67 in the mated condition. But if water immersion is a requirement for environmental, open face, unmated connectors (non-hermetic or sub-sea), then the connector should be specially potted, processed and tested. Modification code 518 specifies layered application of a superior grade of potting material, special curing and processing as well as 100% leak testing. Connectors are 100% tested to meet a leak rate of 1×10^{-4} cc/second of helium at 1 atmosphere pressure differential. Glenair fixed-contact (solder cup or PC tail) connectors may be specified by adding suffix code -518 to the part number to call out this special open face sealing capability.

Leak Paths

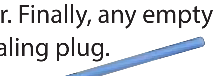
Glenair follows the letter of the law in immersion tests, so when we certify a connector meets IP67 or conforms to the requirements of MIL-STD-810F, we mean it. But it has been our experience that while the environmental failure of a connector may at times be fairly and honestly attributable to a workmanship problem at our factory, it is more often the result of an unforeseen weakness in interconnect system design, an error in user assembly or damage from rough handling and use. Either way, nobody wants a leak. So turn the page for more tips on anticipating and eliminating leak paths in interconnect systems.

STOPPING LEAKS BEFORE THEY HAPPEN

LEAK PATH DETECTION AND MITIGATION IN ENVIRONMENTAL INTERCONNECT SYSTEMS

Leak Path Avoidance in Interconnect System Design

1. **Receptacle Mounting:** Receptacle mounting with O-rings is available in both front and rear mount versions, as well as weld mount configurations preferred for their foolproof sealing. Mounted receptacles may be fully recessed within the face of the box (Fig. 10), which can allow liquids to puddle and collect inside the receptacle cavity. Receptacles that stand proud of the surface of the box, weld-mounted if possible, are recommended for battlefield gear or other applications, where full immersion of the equipment is a possibility. (See Fig. 11)
2. **Cable Routing:** Glenair supplies straight, 45°, 90°, and ultra low-profile "Cobra" connector backshells and boots, to assist designers in reducing the axial load placed on cables exiting a box. Such loads can lead to damage or separation of cable jacketing, boot-to-cable adhesives, or even mechanical damage to the connector itself. (See Fig. 12)
3. **Dissimilar or Inappropriate Material Choices:** Careful consideration must be given to material selection, especially surface platings but also the chemical composition of boots, jackets, overmolding, and adhesives. Dissimilar metal parts, for example, can foster galvanic corrosion which can introduce leak paths at the connector-to-box junction. Non-compatible resilient material choices, such as the wrong boot adhesive or an overmold compound with poor bonding characteristics may also introduce leak paths. (See Fig. 13)
4. **Matched Wire-to-Contact Sizing and Sealing Plugs:** The inability of a rear grommet to properly seal an undersized wire is a common leak-path source. Designers should pay careful attention to using recommended wire gauges for each size of contact used in a system (See Fig.14). The same lesson holds true for asymmetrically shaped wire such as twisted pair which can impact the grommet's ability to seal. Undersized or ill fitting wires may be built up with additional material, such as tape or a sleeve. At other times, the only way to solve this problem is to back-pot the connector. Finally, any empty cavities should always be fitted with a sealing plug.



Don't forget the sealing plug!

Leak Path Avoidance in Assembly

1. **Small Form Factor O-Rings:** Jam-nut and peripheral seal O-rings, particularly in ultraminiature connectors such as Glenair Series 88 SuperFly (Fig. 15) are prone to damage during box mounting and connector mate and de-mate. Glenair recommends the use of Moly-Kote M55 or equivalent lubricant on all O-ring seals. Periodic inspection and replacement of peripheral seal O-rings for wear or damage is a common and recommended best-practice in many industries.

Fig. 10

The fully-recessed receptacle connector configuration in this box assembly would not be a best practice in a harsh environmental application design.

Fig. 11

The configuration of the receptacle connectors on this box for an actual environmental battlefield application is far better suited for the job.

Fig. 12

The planned use of ultra low-profile "Cobra" style 90° backshells and connectors, as well as conventional 45° and 90° connector accessories is an important part of leak path mitigation.

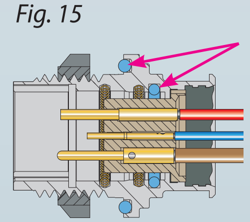
Fig. 13

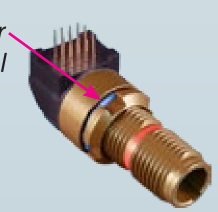
Inattention to both metallic and non-metallic material choices can lead to the introduction of leak paths in interconnect assemblies.

Fig. 14

Left: a correctly sized wire-to-grommet seal assembly (but missing a sealing plug!) Right: undersized wires built up to fit grommet seal openings.

Fig. 15





The small form-factor O-ring and peripheral seals on the Series 88 SuperFly require careful maintenance and handling.

Fig. 16

Damage to rear grommet seal may be avoided with proper contact insertion and removal technique and lubricant.

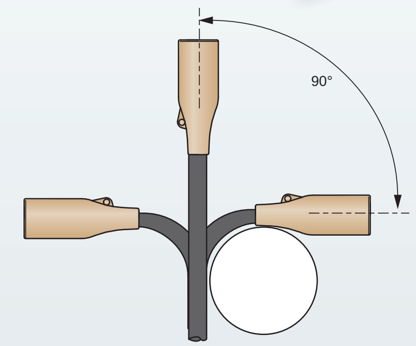


Fig. 17

Jacket surface preparation and cleaning as well as the application of adequate heat prevents leak paths in environmental shrink boot assemblies.

Fig. 18

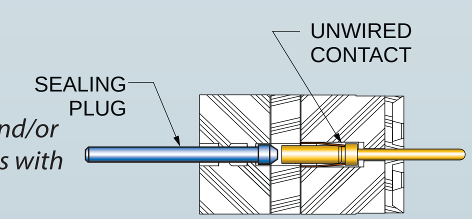
Fully-sealed overmolded cables completely resolve environmental leakage in point-to-point and multibranch cables.

Fig. 19

A series of resilient seals are supplied in environmental backshells to eliminate the potential for moisture to wick up the cable and into the rear wire-to-connector interface.

Fig. 20

Always protect empty cavities and/or unwired contacts with a sealing plug.



2. **Contact Insertion and Removal:** Grommet seals on modern connectors (MIL-DTL-38999, Series 80 Mighty Mouse and others) depend on properly sized wires to compress the material and affect sealing. Damage to triple-ripple grommet seals during crimp-contact insertion and removal (see Fig. 16) may introduce a potential leak path. Glenair recommends (1) damaged or worn tools be discarded, (2) Contact insertion and removal be accomplished without twisting or turning the tool (side-to-side rocking will facilitate entry/release of the retention clip without damaging the grommet), and (3) the use of Isopropyl Alcohol to lubricate the tool/grommet interaction.
3. **Shrink Boots:** Installation of environmental shrink boots requires careful attention to ensure heat-activated adhesives effectively seal the wire-to-connector interface. Complete instructions are found in our boot catalog. The failure to carefully clean and/or abrade cable jacketing is a common source of leakage, as is the failure to apply continuous heat to the work (90 to 150 seconds depending on boot size) after the boot has fully recovered to the cable. Some boots are equipped with a potting port feature to facilitate potting of the wire-to-connector interface. Inspection under axial load (see Fig. 17) is essential as a final check of bond strength.
4. **Overmolding:** The same wisdom applies to ensure proper adherence of molding compounds to cable jackets. Abrade as necessary, degrease with Isopropyl Alcohol and use material combinations known to deliver strong and durable bonds. Overmolding is the "gold standard" when it comes to leak mitigation in environmental cable assemblies. (See Fig. 18)
5. **Backshells:** Environmental backshells exist to manage connector rear-end sealing in assemblies equipped with jacketed cables (see Fig. 19). These backshells are equipped with a coupling nut O-ring that seals against the rear of the connector under compression. In older legacy connectors (such as MIL-DTL-5015 and others), the use of an environmental backshell is absolutely necessary as the wire grommet on the connector is not designed to seal around individual wires. Wire grommets on connectors of this type depend on the compression action of a backshell to affect necessary sealing. Only connectors and backshells from the same manufacturer should be used for legacy connectors of this type due to poor compatibility and interoperability.
5. **Sealing Plugs:** "When installing sealing plug in connector cavities without contacts, the end opposite the knob shall be inserted first and the knob shall be seated against the grommet face. When installing into cavities with contacts, the sealing plugs shall be installed knob end first and shall bottom on the contact wire barrel." (NAVAIR 01-1A-505–1 Inst. manual)(Fig. 20).

STOPPING LEAKS BEFORE THEY HAPPEN

BREAKTHROUGHS IN HIGH-PERFORMANCE JACKETING AND WIRE PROTECTION MATERIALS

JACKETING MATERIAL SCIENCE

Jacketing and other resilient materials used in interconnect systems play a key role in environmental sealing. Much of the discussion centers around the mechanical properties of these thermoplastic and thermoset materials, or in other words their ability to physically block water ingress. But other key attributes, such as caustic chemical or fire resistance, are significant factors in material selection for effective, long-term environmental protection.

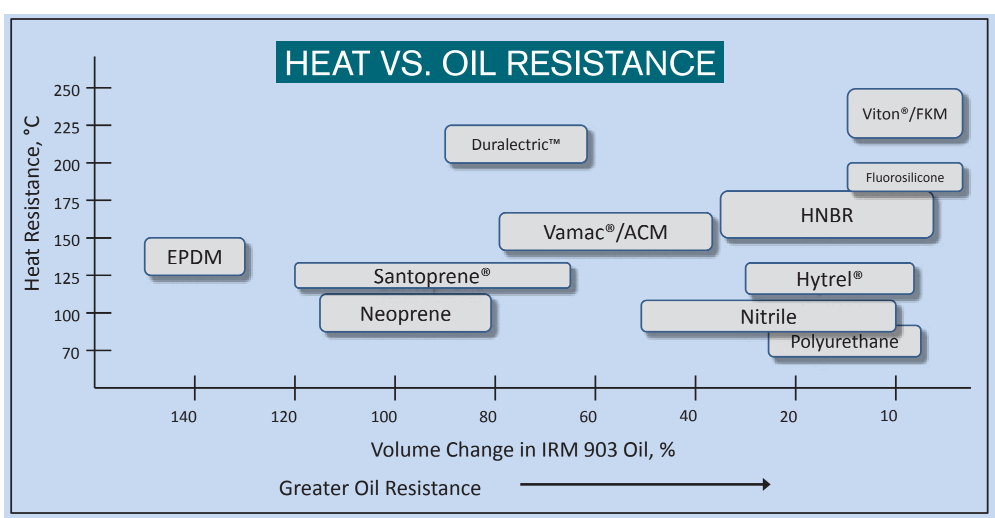
Cable jackets are principally deployed to protect wires and connectors from fluids, heat, abrasion and cuts, electric arc, and fire—all while remaining flexible and resilient. This is a tall order for most low-grade materials, which is why mission-critical interconnect systems design-in higher-grade, higher performing thermoplastics and thermoset materials.

These two classes of materials, thermoplastics and thermosets are found throughout interconnect applications. Both types are complex chemical compounds and hybrid mixtures that may be fine-tuned for different requirements. Thermoplastics, such as Ultem, PEEK, PFA, Estane, Santoprene, Hytrel and others, are characterized by their makeup of matrix polymer, fiber strength members and performance-based chemical additives. Thermoplastics are melted in high-heat molding machines and formed into desired shapes using dedicated tooling.

Thermosets such as Viton, EPDM, Neoprene and Duralectric are typically used to fabricate extrusion molded jacketing and other highly flexible sealing members. Thermosets are “set” to their final shapes with heat in a curing process.

Whether the materials will be used in overmolding, jacketing or as a component piece, such as an O-ring, there are a couple of key starting points for down-selection. Glenair application engineers typically start with the expected temperature service range to begin the selection process. Temperature is both a measure of external or ambient sources as well as internally generated heat from energized wires and cables. Next, we look at fluid exposure to determine which materials would or would not be good candidates for the application. Neoprene, for example, is a popular cable jacket choice with decent temperature tolerance up to 125° C. But the material is rated poor in its resistance to common hydraulic fluids used in aerospace applications. The last key question we consider in the initial analysis is fire resistance. This is because so few resilient materials demonstrate excellent levels of fire resistance. If fire resistance is a must, the list of available material choices gets real short, real fast.


Thermoset material extrusion equipment



Another important qualification benchmark is the ability of a material to perform its sealing and wire-protection role after prolonged exposure to a combination of environmental stresses. This graphic plots out the performance of various materials when subjected to both high heat and oil. Reading from left to right we see that EPDM, a widely used material in interconnect cable assemblies, is only a moderately successful material in terms of heat and oil resistance. At the other extreme, Viton demonstrates outstanding resistance against these two key stress factors.

OVERMOLD AND JACKET MATERIAL PROPERTIES

Common Name	Viton®	Duralectric™	Vamac®	HNBR	EPDM	Neoprene	Santoprene®	Polyurethane	Hytrel®
Technical Name(s)	fluorocarbon FKM	PDMS	ethylene acrylate ACM	hydrogenated nitrile	ethlyene propylenediene EPR	polychloroprene	TPV TPE	TPU	TPC-ET
Service Temp. Range	-25°C to 235°C	-60°C to 260°C	-25°C to 175°C	-50°C to 175°C	-50°C to 150°C	-50°C to 125°C	-55°C to 135°C	-40°C to 90°C	-75°C to 125°C
Abrasion Resistance	Very Good	Good	Fair	Very Good	Very Good	Good	Good	Excellent	Very Good
Fire Resistance	Excellent	Excellent	Fair	Good	Fair	Good	Fair	Fair	Fair
Ozone/Weathering Resistance	Excellent	Excellent	Fair	Excellent	Excellent	Very Good	Very Good	Very Good	Very Good
Fluid Resistance									
Lubricating Oils	Excellent	Very Good	Very Good	Excellent	Poor	Good	Fair	Very Good	Good
Drilling Fluids	Excellent	Poor	Fair	Excellent	Poor	Good	Fair	Fair	Fair
Fuels & Solvents	Excellent	Very Good	Good	Excellent	Fair	Fair	Good	Fair	Fair
Skydrol® / HyJet™	Poor	Very Good	Poor	Poor	Very Good	Poor	Poor	Poor	Poor
Hot Water	Excellent	Excellent	Very Good	Excellent	Excellent	Very Good	Fair	Good	Good

This summary of available overmold and jacket material choices is a handy tool in benchmarking performance and application suitability. These materials have a clear role in the interconnect system: keep it sealed up tight, protect wires and cables from physical damage and deliver long-service life with the same flexibility and handling characteristics they had at the start. This is a tough assignment. And it is no wonder that many a system failure is directly attributable to a resilient material failure. By way of example, Glenair was recently given the opportunity to redesign a problematic interconnect assembly on a commercial jet. The original cable design, largely due to inappropriate material choices, was responsible for a host of system failures and costly maintenance cycles. In our analysis, the original shrink-boot equipped, Neoprene jacketed assembly was no match for the environmental and mechanical rigors of the job. Our overmolded Duralectric replacement assembly, on the other hand, is specifically designed for the exact conditions of the application (service temperature, flex modulus, chemical/fluid resistance, vibration and shock and so on).

DURALECTRIC®

- -65°C to 225°C
- Excellent fire resistance
- Very good resistance to oils, fuels, acids, and solvents
- Very good resistance to Skydrol® and HyJet™
- Special grades in development:
  - 260°C service, 315°C for 3 days max
  - Ultra-low temperature flexibility, -100°C to 200°C
  - Extreme fire resistance (20 minutes of direct flame, no penetration)

Viton

MADE WITH GENUINE VITON — DuPont Performance Elastomers — Viton® fluoroelastomer

- Viton® = Fluorocarbon Elastomers
- -25°C to 235°C
- Excellent resistance to oils, fuels, acids, and solvents
- Excellent fire resistance
- Special grades: -45°C (Viton® GLT)
- Extreme chemical resistance such as oil field drilling fluids (Viton® ETP)
- Resistance to hydrogen sulfide, amines, and strong bases (Aflas®)

NEOPRENE

- Neoprene = polychloroprene
- -50°C to 125°C
- Resistant to lubricants and hot water
- Very good weathering and ozone resistance
- Very durable and tough
- Widely used by Glenair in complex cable assemblies

Polyurethane

- Polyurethane (TPU)
- -40°C to 90°C
- Resistant to lubricants,glycols, and fuels
- Very good weathering and ozone resistance
- Best abrasion resistance of all compounds
- TPU is great for coil cords

The Riddler

WHAT ALWAYS RUNS BUT NEVER WALKS,
OFTEN MURMURS BUT NEVER TALKS
HAS A BED BUT NEVER SLEEPS
HAS A MOUTH BUT NEVER EATS?

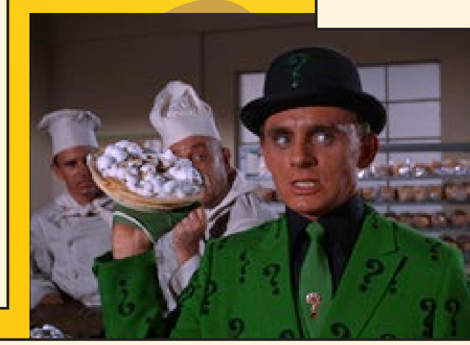
WHAT HAS RIVERS BUT NO WATER, FORESTS BUT NO TREES, AND CITIES WITH NO BUILDINGS?

YOU ARE RUNNING A RACE AND YOU PASS THE PERSON IN 2ND PLACE. WHAT PLACE ARE YOU IN?

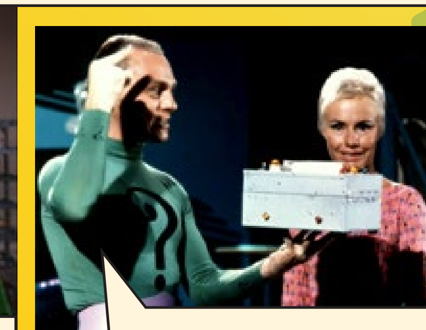
DURING WHAT MONTH DO PEOPLE SLEEP THE LEAST?

TAKE ME FOR A SPIN AND I'LL MAKE YOU COOL...
BUT USE ME IN THE WINTER AND YOU'RE A FOOL.
WHAT AM I?

IN THE DARK THEY ARE FOUND WITHOUT BEING FETCHED, IN THE LIGHT THEY ARE LOST WITHOUT BEING STOLEN. WHAT ARE THEY?

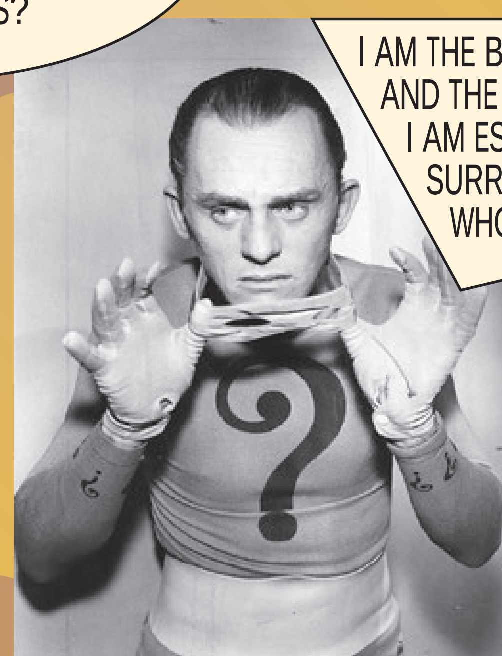


YOU CAN EASILY TOUCH ME BUT NOT SEE ME.
YOU CAN THROW ME OUT, BUT NOT AWAY. WHAT AM I?

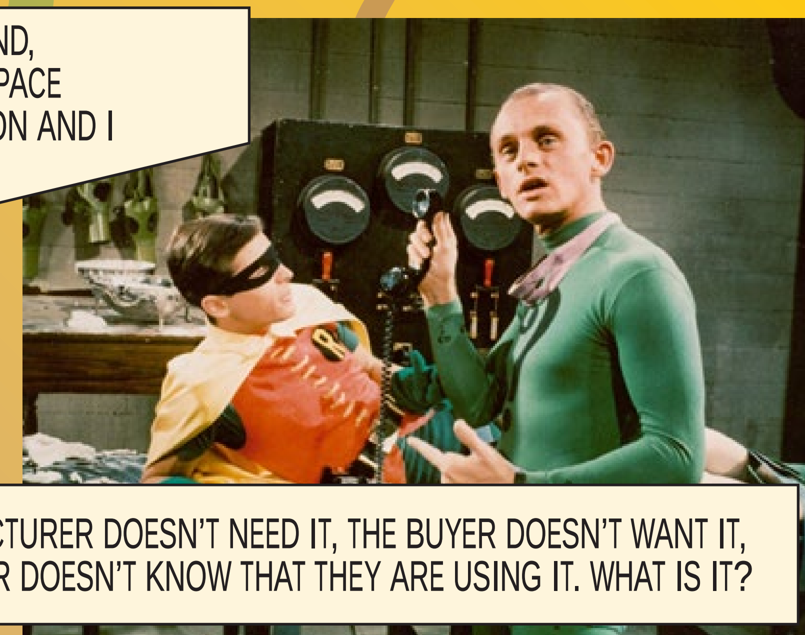


YOU BURY ME WHEN I'M ALIVE,
AND DIG ME UP WHEN I DIE.
WHAT AM I?

YOU LEAVE HOME, MAKE THREE LEFT TURNS AND RETURN HOME WHERE YOU FIND TWO MEN WEARING MASKS.
WHO ARE THEY?



I AM THE BEGINNING OF THE END,
AND THE END OF TIME AND SPACE
I AM ESSENTIAL TO CREATION AND I
SURROUND EVERY PLACE.
WHO AM I?



THE MANUFACTURER DOESN'T NEED IT, THE BUYER DOESN'T WANT IT,
AND THE USER DOESN'T KNOW THAT THEY ARE USING IT. WHAT IS IT?

MANY HAVE HEARD ME, BUT NOONE HAS SEEN ME.
AND I WILL NOT SPEAK BACK UNTIL SPOKEN TO.

SAY MY NAME,
AND I DISAPPEAR.
WHO AM I?

ANSWERS PUBLISHED NOVEMBER 15TH • WWW.GLENAIR.COM/QWIKCONNECT

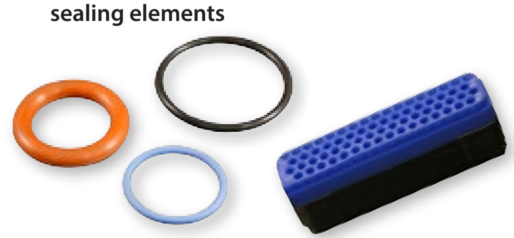
STOPPING LEAKS BEFORE THEY HAPPEN

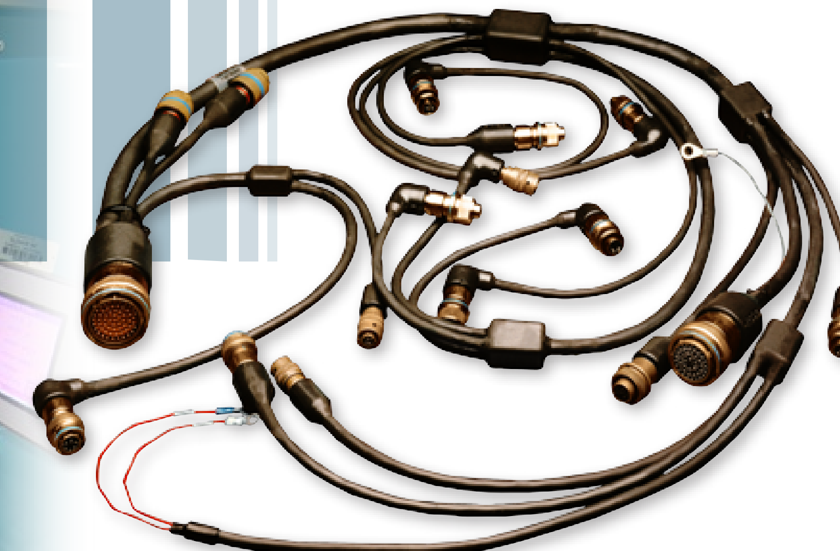
MANUFACTURING PROCESSES FOR ADVANCED SEALING APPLICATIONS

Special-purpose overmold tooling and fixtures for small form-factor sealed Mighty Mouse cable assemblies

High-volume production overmold and cable encapsulation tooling and equipment for Duralectric™ cable assemblies

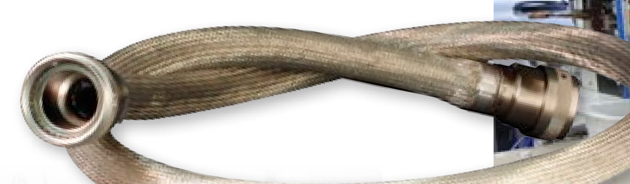
Injection molding, tooling and equipment for in-house production of O-rings, gaskets, grommets, interfacial and other mechanical sealing elements





Volume production overmolding equipment and tooling for complex multibranch cable assemblies, utilizing Viton® and other specialty materials

Induction welding equipment and fixtures for fabrication of sealed metal-core conduit wire protection and routing assemblies



In stock quantities of high-performance extruded cable jacketing

Vacuum-assisted long run conduit and/or cable jacketing

STOPPING LEAKS BEFORE THEY HAPPEN

THE ULTIMATE SOLUTION TO ENVIRONMENTAL SEALING OF INTERCONNECT CABLES: OVERMOLDING

Let's turn the discussion now to overmolded type cable assemblies. Overmolded terminations and transitions provide the ultimate environmental seal. The encapsulating material vulcanizes with the cable jacketing to form a total seal against liquid or dust incursions.

Mold tooling is highly specialized to accommodate the precise application. Integration of mounting brackets and other hardware enhances the utility of the assembly. Overmolding is extremely tamper resistant.

Overmolding is ideal for applications that place cable assemblies in harsh chemicals, such as jet fuel. Jacketing and mold materials can be specified from a range of options (including IAW MIL-M-24041) to afford maximum protection for even the most complex multi-branched assembly.

Overmolded cable assemblies are by far the best solution for systems that require maximum levels of environmental and mechanical protection.

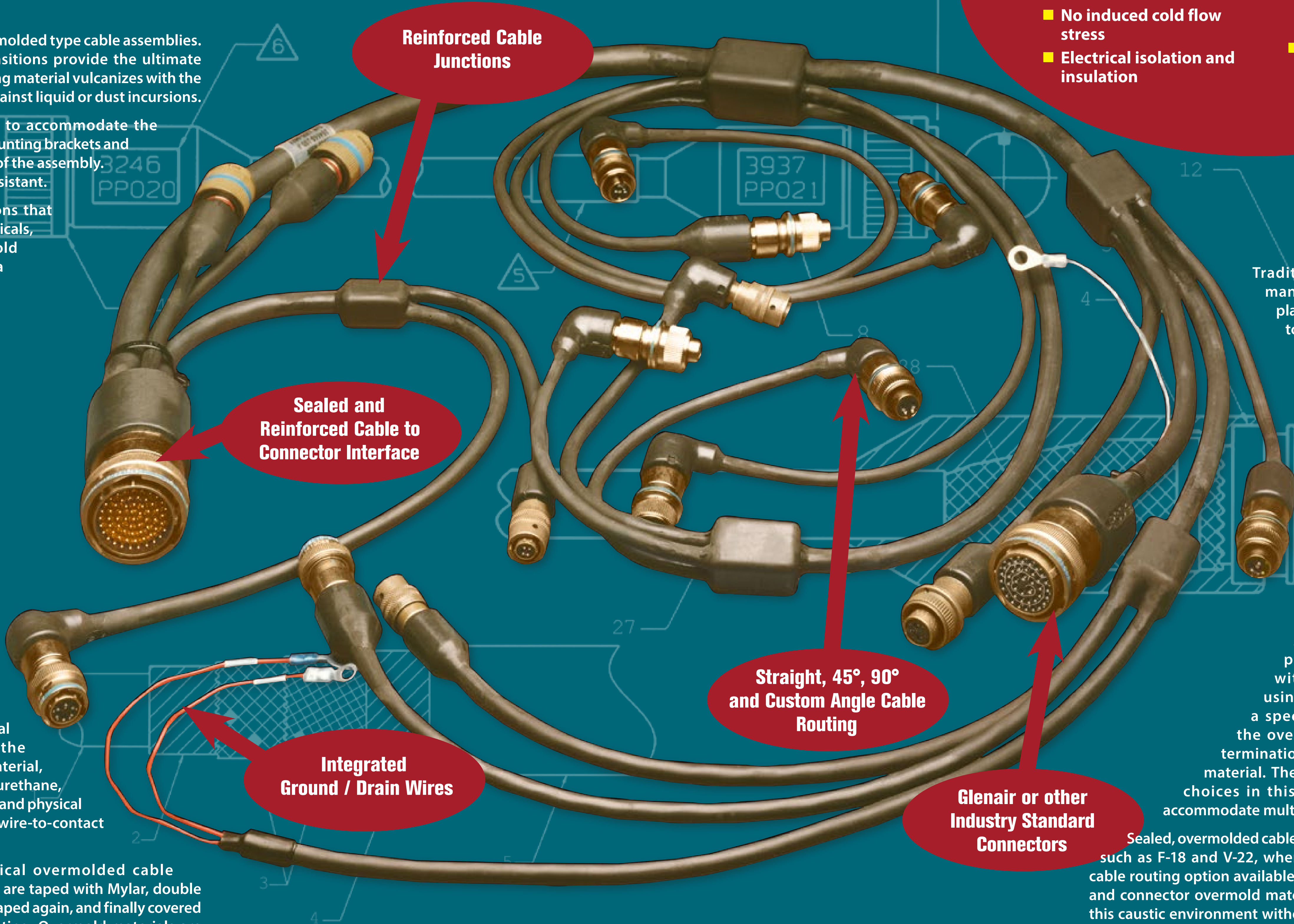
The connectors and cable junctures of this aerospace assembly are protected and sealed with ruggedized injection overmolding. Note the conical cross-sections of the overmold provides outstanding strain-relief and eliminates stress risers.

In the typical assembly, a shield termination backshell provides a bonding point for the molding material and a termination platform for the EMI shielding. The overmolding material, whether Viton®, Duralectric™ or polyurethane, provides outstanding environmental and physical protection of circuits at the critical wire-to-contact juncture.

At the innermost layer of a typical overmolded cable construction, wound insulated wires are taped with Mylar, double overbraided with braided shielding, taped again, and finally covered with a thin-walled elastomeric jacketing. Overmold materials are carefully selected to vulcanize with the elastomer jacketing.

KEY ADVANTAGES OF OVERMOLDING

- Waterproof sealing
- Robust mechanical protection
- Protection of terminations
- Chemical resistance
- No induced cold flow stress
- Electrical isolation and insulation
- Reduced wear damage
- Flexible routing/cable entry
- Superior sealing performance compared to virtually every other form of aerospace cabling
- Tamper proof



Traditional overmold tooling requires manual injection of heated, liquefied plastic material into the closed, heated tool. The material is pumped in until the cavity is completely filled. Heat is continuously applied to tooling for a prescribed period. The tool is dismantled, the overmold workpiece removed and flash, if any, is carefully trimmed away.

Automated overmold machines reduce cycle time significantly, enhance reliability and allow use of even more materials such as polyamide which is less expensive but with performance that is adequate for many applications. Large quantity overmolded cable assemblies that principally utilize standard connector and accessory products can be quoted and delivered with extremely rapid turnarounds using equipment of this type. Often, a special banding backshell is used in the overmolding process for easy shield termination and attachment of the molding material. There are a wide number of potential choices in this area, including backshells that accommodate multiple shield terminations.

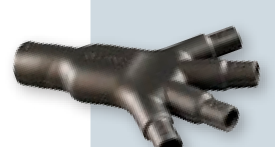
Sealed, overmolded cables are ideal for aerospace applications, such as F-18 and V-22, where space is so limited that the only cable routing option available is through the fuel cell. Viton jacket and connector overmold materials allow harnesses to perform in this caustic environment without risk of damage for the life of the aircraft. Glenair has built tens of thousands of interconnect cables for extreme environmental applications of this type.

SERIES 77 BOOTS

Robust environmental sealing / strain relief for connector-to-cable transitions

- Standard, short, long and 90° lipped and lipless boots
- Choice of six boot materials and a complete range of high-performance adhesive types
- A wide range of colors including desert tan
- The industry's largest selection of metal and composite shrink boot adapters
- All popular part numbers in stock and ready for same-day shipment

Standard Lipped or Lipless Boots



Transitions

Convoluted Boots

SERIES 77

Full Nelson

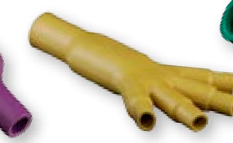
Environmental Shrink Boots

COLOR-CODED BOOTS FOR SPECIAL PURPOSE APPLICATIONS

Red straight boot with eyelet

Desert Tan widebody Y transition

Right-angle adapter, purple



4–1 widebody transition, yellow

Green long-tail boot

High-ratio right-angle adapter, grey

Low-profile 3–1 adapter, white

Material Color Options for Type 1 High Performance Elastomer Boots and Transitions					
Mod Code	Color	Similar to (Reference)	Mod Code	Color	Similar to (Reference)
632 B	Blue	PANTONE 3005U	632 R	Red	PANTONE 1797U
632 E	Grey	FED-STD-595; #36270	632 T	Tan	FED-STD-595; #33446
632 G	Green	PANTONE 355U	632 W	White	FED-STD-595; #37875
632 P	Purple	FED-STD-595; #37100	632 Y	Yellow	PANTONE YELLOW U
632 O	Orange	FED-STD-595; #32300	Standard	Black	FED-STD-595; #37038

PIGGYBACK SHRINK BOOT ADAPTERS

GLENAIR'S COMPLETE VERTICAL INTEGRATION ENSURES HIGH-AVAILABILITY HEAT-SHRINK BOOTS FOR ALL CONNECTOR TYPES

D38999 type Fiber Optic connector boot

SuperFly® boot

Micro-D boot

Universal backshell boot

SHRINK BOOT ADAPTERS SELECTION GUIDE

Series 310 Shrink Boot Adapters

Series 311 EMI/RFI Lamp-Base Thread/Boot Adapters

Series 319 Shield Sock/Boot Adapters

Series 440 Band/Boot Adapters

SAE-AS85049 QPL Shrink Boot Adapters

Composite Thermoplastic Band/Boot Adapters

SERIES 77
ENVIRONMENTAL
SHRINK BOOTS

Glenair Environmental Shrink Boots Now TACOM Approved, In-Stock and Ready for Immediate Shipment

High-performance Series 77 "Full Nelson" environmental shrink boots manufactured by Glenair in Glendale, California are now approved by the US Army Tank-Automotive Command (TACOM). Manufactured from high-temperature crosslinked elastomeric polymer material and/or caustic chemical-resistant Viton polymer, Glenair straight and right angle long-tail shrink boots, Y and T transitions, convoluted strain-relief boots and heat-shrinkable adapter shims have been added to the following source control documentation:

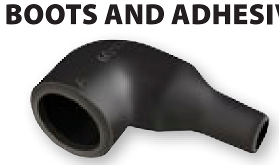
Glenair Series 77 "Full Nelson" TACOM APPROVED Shrink Boots

Description	Military Part Number	Glenair Part Number	Raychem Part Number	Hellermann Part Number
Heat Shrinkable Low Profile 3-Entry "Y" Transition	12273148-1**	770-009Y*05	381A301-**	492H412-*
	12273148-2**	770-009Y*06	381A302-**	492H413-*
	12273148-3**	770-009Y*07-01	381A303-*01	492H414-*01
	12273148-4**	770-009Y*08-01	381A304-*01	492H415-*01
	12273148-5**	770-009Y*07	381A303-**	—
Heat Shrinkable Low Profile 3-Entry "T" Transition	12273162-1**	770-012T*01	301A511-**	412H622-*
	12273162-2**	770-012T*02	301A512-**	412H623-*
	12273162-3**	770-012T*03	301A513-**	412H624-*
	12273162-4**	770-012T*04	301A514-**	412H625-*
Heat Shrinkable Low Profile 4-Entry 3:1 Transition	12273163-1**	770-014*09	462A421-**	573H532-*
	12273163-2**	770-014*10	462A422-**	573H533-*
	12273163-3**	770-014*11	462A423-**	573H534-*
	12273163-4**	770-014*12	462A424-**	573H535-*
Heat Shrinkable Adapter Shim Boot	12273164-1**	770-019SB*01	202E334-**	313E445-*
	12273164-2**	770-019SB*02	202E344-**	313E455-*
	12273164-3**	770-019SB*03	202E336-**	313E447-*
	12273164-4**	770-019SB*04	202E346-**	313E457-*
Heat Shrinkable Convoluted Strain Relief 2-Entry Boot	12273242-1**	770-022C*01	202C611-**	313C722-9
	12273242-2**	770-022C*02	202C621-**	313C732-9
	12273242-3**	770-022C*03	202C632-**	313C743-9
	12273242-4**	770-022C*04	202C642-**	313C753-9
	12273242-5**	770-022C*05	202C653-**	313C764-9
	12273242-6**	—	202G621-**	—
	12273242-7**	—	202G632-**	—
	12273242-8**	—	202C642-**	—
	12273242-9**	—	202C653-**	—

Description	Military Part Number	Glenair Part Number	Raychem Part Number	Hellermann Part Number
Heat Shrinkable Straight Lipped 2-Entry Long Tail Boot	12273147-1**	770-020S*02	202F211-**	313F322-*
	12273147-2**	770-020S*03	202F221-**	313F332-*
	12273147-3**	770-020S*04	202F232-**	313F343-*
	12273147-4**	770-020S*05	202F242-**	313F353-*
	12273147-5**	770-020S*06	202F253-**	313F364-*
	12273147-6**	770-020S*07	202F263-**	313F374-*
	12273147-7**	770-020S*08	202F274-**	313F385-*
Heat Shrinkable 90° Lipped 2-Entry Long Tail Boot	12273176-1**	770-021A*02	222F211-**	333F322-*
	12273176-2**	770-021A*03	222F221-**	333F332-*
	12273176-3**	770-021A*04	222F232-**	333F343-*
	12273176-4**	770-021A*05	222F242-**	333F353-*
	12273176-5**	770-021A*06	222F253-**	333F364-*
	12273176-6**	770-021A*07	222F263-**	333F374-*
	12273176-7**	770-021A*08	222F274-**	333F385-*

VG QUALIFIED SHRINK BOOTS AND ADHESIVES

DIN



VG Standards are established by the Deutsches Institut für Normung (DIN) and are widely used in European defense programs. Glenair Type 2 shrink boots are qualified to VG95343 Part 28, and our adhesives are qualified to VG95343 Part 18. Consult Glenair UK for price and delivery.

TACOM-Approved Environmental Shrink Boots

FULL NELSON

Expanded Cross-Reference: TACOM-to-Glenair Shrink Boot Part Numbers

TACOM #	GLENAIR #	TACOM #	GLENAIR #	TACOM #	GLENAIR #
12273147-120	770-020S602	12273162-110	770-012T601	12273176-120	770-021A602
12273147-220	770-020S603	12273162-210	770-012T602	12273176-220	770-021A603
12273147-320	770-020S604	12273162-310	770-012T603	12273176-320	770-021A604
12273147-420	770-020S605	12273162-410	770-012T604	12273176-420	770-021A605
12273147-520	770-020S606	12273162-120	770-012T501	12273176-520	770-021A606
12273147-620	770-020S607	12273162-220	770-012T502	12273176-620	770-021A607
12273147-720	770-020S608	12273162-320	770-012T503	12273176-720	770-021A608
12273147-130	770-020S502	12273162-420	770-012T504	12273176-130	770-021A502
12273147-230	770-020S503	12273163-110	770-014609	12273176-230	770-021A503
12273147-330	770-020S504	12273163-310	770-014611	12273176-330	770-021A504
12273147-430	770-020S505	12273163-410	770-014612	12273176-430	770-021A505
12273147-530	770-020S506	12273163-120	770-014509	12273176-530	770-021A506
12273147-630	770-020S507	12273163-220	770-014510	12273176-630	770-021A507
12273147-730	770-020S508	12273163-320	770-014511	12273176-730	770-021A508
12273148-110	770-009Y605	12273163-420	770-014512	12273242-110	770-022C601
12273148-210	770-009Y606	12273164-110	770-019SB601	12273242-210	770-022C602
12273148-310	770-009Y607-01	12273164-210	770-019SB602	12273242-310	770-022C603
12273148-410	770-009Y608-01	12273164-310	770-019SB603	12273242-410	770-022C604
12273148-510	770-009Y607	12273164-410	770-019SB604	12273242-510	770-022C605
12273148-120	770-009Y505	12273164-120	770-019SB501	12273242-120	770-022C501
12273148-220	770-009Y506	12273164-220	770-019SB502	12273242-220	770-022C502
12273148-320	770-009Y507-01	12273164-320	770-019SB503	12273242-320	770-022C503
12273148-420	770-009Y508-01	12273164-420	770-019SB504	12273242-320	770-022C503
12273148-520	770-009Y507			12273242-420	770-022C504
				12273242-520	770-022C505

TACOM Approved Shrink Boot Material Properties

Property	Viton® Fluoroelastomer Blend (SPEC-01417-SC-X15111)	High Performance Elastomer Blend (SPEC-01417-SC-X15112)
Flexibility	Flexible	Flexible
Operating Temperature Range	-55°C to +150°C	-55°C to +135°C
Shrink Temperature (min.)	135°C	135°C
Tensile Strength (psi)	2200	1500
Elongation (% min.)	400	300
Heat Shock	4 hrs, 225°C	4 hrs, 220°C
Heat Aging	168 hrs, 150°C	168 hrs, 150°C
Dielectric Strength (V/mil)	200	200
Volume Resistivity (ohms-cm)	10^{10}	10^{10}
Water Absorption (%)	0.5	0.5
Flammability	Burn Time <120 sec Burn Length <25mm	Burn Time <120 sec Burn Length <25mm
RoHS Compliant	Yes	Yes

Approval:
Project Manager, Heavy Brigade Combat Team (PM-HBCT),
US Army Tank-Automotive Command (TACOM)

Glenair®

For more information contact Glenair at **818-247-6000** or visit our website at **www.glenair.com**
U.S. CAGE code 06324

turboflex
THE ULTRA FLEXIBLE RUGGED POWER CABLE

Ultra-flexible rugged power cable

TurboFlex™ power distribution cables are constructed from highly flexible conductors and high-performance insulation to produce cables ideally suited for applications where flexibility, durability, and weight reduction are required. Amazingly durable and flexible—especially in cold weather—the 16 AWG to 450 MCM TurboFlex cable features high strand count rope lay inner conductors made with tin-, nickel- and silver-plated copper. TurboFlex is jacketed with Glenair's unique Duralectric™ compound that provides outstanding flexibility and resistance to environmental and chemical exposure. Duralectric is also low smoke, zero halogen. Long life and performance are critical in power distribution applications. TurboFlex, with its flexible conductors and durable jacket delivers both.

Ultra flexible rope lay construction

Available in a broad range of gages, 16 AWG to 450 MCM

Many sizes In-stock and available for immediate, same-day shipment. No minimums!

◂ Duralectric™ is the high-performance TurboFlex™ jacketing material perfectly suited for immersion, chemical or caustic fluid exposure, temperature extremes, UV radiation and more—available in a broad range of colors including safety orange

Glenair®

Voltage rating data • Duralectric™ jacketing specifications and colors

961-001 TURBOFLEX, .125 WALL, 4500 VAC

961-001 Wire Weight and Outer Diameter

AWG Code	Weight lbs/1000 ft. (nom.)	Ø A In. (mm)	Jacket wall thickness In. (mm)
G	494.50	.681 (17.30)	.125 (3.18)
H	600.00	.733 (18.62)	
I	749.50	.797 (20.24)	
J	916.00	.863 (21.92)	
K	1055.60	.913 (23.19)	
L	1806.20	1.140 (28.96)	

961-002 TURBOFLEX, .093 WALL , 3500 VAC

961-002 Wire Weight and Outer Diameter

AWG Code	Weight lbs/1000 ft. (nom.)	Ø A In. (mm)	Jacket wall thickness In. (mm)
D	138.40	.386 (9.80)	.093 (2.36)
E	207.40	.457 (11.61)	
F	304.60	.528 (13.41)	
G	455.80	.617 (15.67)	
H	558.20	.649 (16.48)	
I	703.90	.733 (18.62)	
J	866.50	.799 (20.29)	
K	1003.10	.849 (21.56)	
L	1740.10	1.076 (27.33)	

961-003 TURBOFLEX, .062 WALL , 3000 VAC

961-002 Wire Weight and Outer Diameter

AWG Code	Weight lbs/1000 ft. (nom.)	Ø A In. (mm)	Jacket wall thickness In. (mm)
A	40.20	.223 (5.66)	.062 (1.57)
B	56.20	.250 (6.35)	
C	81.00	.283 (7.19)	
D	117.90	.324 (8.23)	
E	182.80	.395 (10.03)	
F	275.90	.466 (11.84)	
G	422.00	.555 (14.10)	
H	521.40	.607 (15.42)	

961-004 TURBOFLEX, .032 WALL , 2000 VAC

961-002 Wire Weight and Outer Diameter

AWG Code	Weight lbs/1000 ft. (nom.)	Ø A In. (mm)	Jacket wall thickness In. (mm)
R	14.40	.127 (3.23)	.032 (.81)
S	20.70	.144 (3.66)	
A	29.40	.163 (4.14)	
B	43.90	.190 (4.83)	
C	66.90	.223 (5.66)	
D	101.40	.264 (6.71)	
E	162.40	.335 (8.51)	
F	251.60	.406 (10.31)	
G	392.70	.495 (12.57)	

Jacketing Options

Weatherproof, halogen free, flame resistant, functional to 260°C

0	Black	Fed-Std-595C #17038
1	Desert Tan	Fed-Std-595C #33446
2	Red	Fed-Std-595C #11120
3	Orange	Fed-Std-595C #12300
4	Yellow	Fed-Std-595C #13591
5	Green	Fed-Std-595C #14193
6	Blue	Fed-Std-595C #15125
7	Violet	Fed-Std-595C #17142
8	Gray	Fed-Std-595C #26270
9	White	Fed-Std-595C #17875

Consult factory for other specific Fed Std colors

Abrasion Resistance	Good
Wear Resistance	Good
Flame Resistance	Excellent
Sunlight Resistance	Excellent
Flex Resistance	Excellent

DURALECTRIC™ ENVIRONMENTAL PERFORMANCE

Temperature rating: -60°c to 260°c

Halogen free per IEC 60614-1

Accelerated weathering and simulated solar radiation at ground level per IEC 60068-2-5; 56 Days exposure, suitable for greater than 50 years of service in direct sunlight

Flame resistant per IEC 60614-1

Flame resistant per UL 1685, section 12 (FT4/ IEEE120), vertical-tray fire-propagation and smoke release test

Flame resistant per FAR 25.853 (A) amendment 25-116, appendix Fpart I (A) (1) (i), 60 second vertical burn test

Limiting oxygen index of 45 per ISO 4589-2:1999

Low smoke per NES 711, smoke density of 11.75

Smoke density class F1 per NF F 16-101 IAW DIN EN 60695-2-11:2011

Low smoke toxicity per NES 713, tested value of 1.9

Fungus rating of 0 per MIL-STD-810g method 508.5, Does not support fungal growth

ASTM D624, die B tear strength, 150 pounds per inch minimum on jacket material

Low outgassing per ASTM e595 after post curing, TML .06%, CVCM .006%, WVR .02%

Resistant to fluids per MIL-STD-810F, method 504
- JP-8 per MIL-DTL-83133 (NATO type 34)
- MIL-H-5606 hydraulic fluid
- MIL-PRF-23699 lubricating oil
- MIL-C-85570 cleaner
- TT-I-735 Isopropyl alcohol
- AMS 1432 potassium acetate deicing/anti-icing fluid
- MIL-C-87252 coolant
- Amerex AFF fire extinguishing foam

THE ULTIMATE IN SEALING

Glass-sealed Hermetic Connectors

When an environmental-class connector, no matter how effectively sealed, will simply not do the job... go hermetic!

VITREOUS GLASS TECHNOLOGY ADVANTAGES

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

CIRCULAR GLASS-SEALED HERMETIC CONNECTORS AVAILABLE WITH ACCELERATED LEAD TIMES


MIL-DTL-26482


MIL-DTL-83723


MIL-DTL-38999 (QPL)


MIL-DTL-5015


Series 80 Mighty Mouse

HIGH PRESSURE, HIGH TEMPERATURE

Glass-sealed hermetic connectors

GLASS-SEALED Hermetic CONNECTORS

GEOPHYSICAL AND OFFSHORE CONFIGURATIONS


GeoMarine® double-start hermetic connector


Special flange design


Single-way tool joint hermetic connector

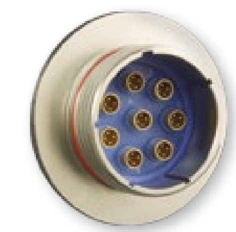

Hermetic probe connector


Hermetic bulkhead penetrator

HIGH-SPEED/SHIELDED DESIGNS


Triax hermetic


Hybrid coax/signal hermetic

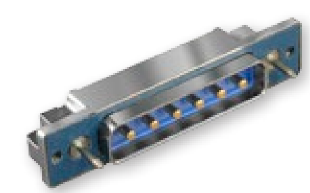

Quadrax hermetic


MT ribbon fiber optic hermetic


Hybrid coax/signal hermetic

RECTANGULAR PACKAGES


MIL-DTL-24308 QPL hermetic


Series 79 Micro-Crimp hermetic


MIL-DTL-83513 type micro-D hermetics


Sealed panel-mount micro-D hermetic

MIL-DTL-38999 QPL PIN AND SOCKET HERMETICS


Series I Scoop-proof 3 Point Bayonet Coupling


Series II Low-profile 3 Point Bayonet Coupling


Series III Scoop-proof Triple Start, Self-Locking


Series IV Scoop-proof Breech Lock

Outlook

Dollars vs. Dimes

There is an old saying, sometimes attributed to Mark Twain, that *history does not repeat itself, but it rhymes*. We see the truth of this wisdom played out almost daily at Glenair. Now the last thing I would ever want to do is lecture our customers on how they ought to run their businesses. Life is complex, and there are countless variables at play in every important decision. But there is a pattern in certain decisions—a rhyme if you will—that deserves some attention. I am talking about the tendency at big OEMs to focus so intently on the price of an item that they wind up booby-trapping their own technology with a built-in weakness.

This issue of *QwikConnect* is all about sealing, about protecting essential electronic equipment from water ingress due to an inadvertent leak in the interconnect system. There is no mystery as to why this is important: Nothing could be more mission-critical than protecting electrical circuits and equipment electronics from moisture damage. And yet it is a common, almost daily, occurrence at Glenair to receive requests for technical assistance on leak-path problems that could have easily been avoided with just a little more attention to sealing requirements—and yes, some additional up-front cost.

Glenair interconnect technologies are designed for use in high-performance applications, from oil rigs to Navy ships to jumbo jets. And we get to see the full range of environmental stress factors that put working systems out of commission: The high heat and caustic chemicals in a railroad locomotive that destroy inferior jacketing materials; the vibration and shock stresses that beat an under-built cable assembly to bits; the relentless, corrosive effects of salt spray on materials that have no business on the weather deck of a navy ship; the unexpected flood that brings an electrical grid to its knees over the cost of a shrink-boot… the list goes on and on.

Currently, we are engaged with a major OEM to design a sealed, over-molded cable assembly as a replacement for a light-duty sensor cable responsible for numerous Aircraft-on-Ground (AOG) incidents. Another customer is recalling and retrofitting a small battlefield device due to leakage that could have been prevented easily with a higher grade of back-potting.

We fully understand the competitive pressures that drive OEMs to prioritize near-term cost savings over long-term durability—even if in our view they are "stepping over dollars to pick up dimes." But as I said at the start, history doesn't repeat itself, but it often rhymes. Sometimes it's poetry, other times it's just a painful lesson everyone involved wishes they could have avoided. I would encourage the Glenair team to study the technologies and processes detailed in this issue of *QwikConnect*, and in turn, to encourage our customers to take *proactive measures* to prevent environmental damage in mission-critical interconnect systems before it has an opportunity to occur. In our experience, this approach not only saves money in the long-term but also results in better customer satisfaction in the user communities we all serve.

Chris Toomey

QwikConnect

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Publisher
Christopher J. Toomey

Managing Editor
Marcus Kaufman

Editor/Art Director
Mike Borgsdorf

Editor
Carl Foote

Graphic Designer
George Ramirez

Technical Consultant
Jim Donaldson

Issue Contributors
Lisa Amling
Chad Heydorff
Guido Hunziker
Sam Farhat
Sheila Melcher
Lutz Mueller
Jose Silva
Troy Sweet
Robert Tillman

Distribution
Terry White

To subscribe or unsubscribe, please contact Terry White: twhite@glenair.com

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GLENAIR, INC.
1211 AIR WAY
GLENDALE, CA 91201-2497
TEL: 818-247-6000
FAX: 818-500-9912
E-MAIL: sales@glenair.com
www.glenair.com

Glenair®