QwikConnect

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Designing for COMPATIBILITY in Electrical Wire Interconnect Systems

With Your Host, ConnectorMan

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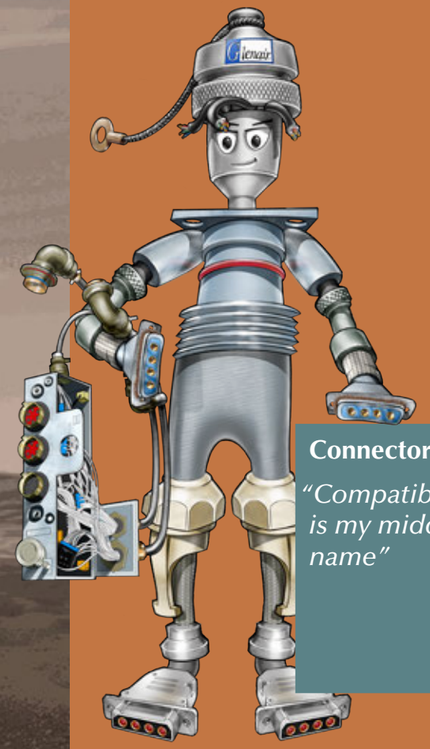
The Mars Perseverance rover operates on Jezero Crater in this NASA/JPL-Caltech illustration. The Glenair Mighty Mouse and Micro-D connectors on cable assemblies aboard the rover are designed for material and performance compatibility to survive the 293 million-mile journey to Mars, and the harsh conditions on the Red Planet's surface.



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"Compatibility is my middle name"

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Materials and Platings for GALVANIC COMPATIBILITY

Selecting base materials and surface finishes for durability and electrical performance

1 Cathodic Delamination While overall EMI shielding isn't a priority for connectors submerged in salt water, subsea overmolded cable assemblies that have been deployed for more than 3 to 5 years routinely suffer delamination between the overmold compound and conductive metal shells, resulting in cable failure. Composite thermoplastic PEEK material, such as used in Glenair's 10K PSI open-face SeaKing™ connector assemblies, entirely eliminates this type of cathodic delamination.

2 Selective Ground Paths Shielded interconnect cable assemblies require a highly conductive, low-resistance ground path from cable shield to backshell to connector, to ensure EMI/RFI electromagnetic compatibility. While damage to surface finishes from corrosion or rough handling is not necessarily fatal, the practice of isolating ground paths to an internal component, such as is accomplished with this unplated composite Swing-Arm™ backshell plus drop-in termination follower design, resolves this maintenance and electrical performance problem.

3 Dissimilar Metals Metal parts with significantly different anodic indices can foster galvanic corrosion, reducing interconnect system durability, environmental sealing, and electrical conductivity—particularly in harsh salt sea applications. While certain dissimilar conductive platings can safely be used, other combinations may lead to catastrophic failure. The best rule of thumb is to always use exact or nearly exact material finishes in multi-component assemblies.

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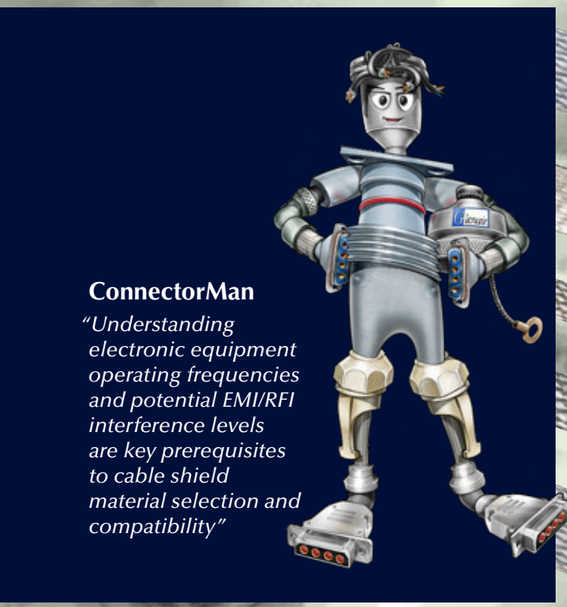
"Ensuring all material types are happy together is Job One for every interconnect engineer"



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"Understanding electronic equipment operating frequencies and potential EMI/RFI interference levels are key prerequisites to cable shield material selection and compatibility"

EMI/RFI Interference Analysis and Cable Shielding Selection

BEST PRACTICES

Electromagnetic compatibility in wire cabling and flex circuits results from appropriate material selection, coverage, and shielding performance

1 **Legacy QQ-B-575 Shield Braid** is suitable for general-purpose aerospace applications and is manufactured from copper wire, conductively plated with tin, silver, or nickel. A high-strength tin-plated copper-clad steel braid is available, well-suited for H-field shielding. Stainless steel versions provide improved corrosion resistance and high temperature tolerance.

2 **ArmorLite™** is a weight-saving, flexible material with virtually no "windowing", that delivers superb optical braid coverage—typically between 85 and 90%, shielding between 80 and 40 decibels in the 100Khz to 1Ghz range. ArmorLite offers complete compatibility with aerospace lightning strike requirements as well as FAA abrasion and burn resistance standards, and is temperature-tolerant from -80˚ to 260˚C.

3 **Aluminum wrapping and braided shielding** are both used to effect a Faraday cage to enclose interconnect wires and cables. Elimination of apertures or gaps in shielding is critical, especially for high-frequency (short wavelength) EMI. Foil wrapping provides high-frequency protection with 100% optical coverage, while braided shielding offers 90-95% optical coverage with greater flexibility and ease-of-installation.

Contact, Cable, and Connector Pairing for High-Speed PROTOCOL COMPATIBILITY

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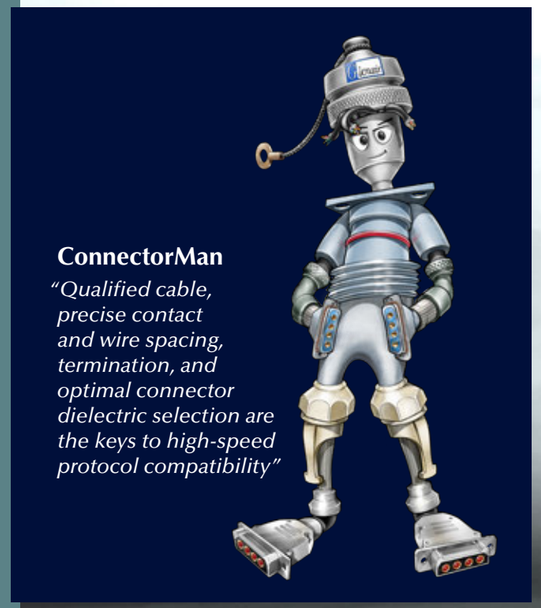
Signal integrity: from cable and flex circuitry, continuing through the connector interface

1 **The High-Speed Micro-D** incorporates low-attenuation contact spacing and separation architecture ensuring protocol compatibility and return loss performance. Contact size matched to wire diameter, as well as ultra-low dielectric insulators ensure matched impedance from wire to contact to connector.

2 **High speed, harsh environment El Ochito®** octaxial contacts are optimized for 10GbE, SuperSpeed USB, and multi-gigabit shielded pairs. As with the high-speed Micro-D and other solutions, the use of different dielectric materials for the connector insulators ensures protocol compatibility for this broad range of high-speed protocols.

3 **Flex circuit assemblies** are uniquely engineered to ensure signal continuity from the I/O interface to the board, including high-speed, matched impedance signal management. This is accomplished through precise circuit-to-circuit spacing and direct, reduced-length terminations to connectors.



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El Ochito® White	El Ochito® Blue	El Ochito® Red
1000BASE-T, 10GBASE-T	**SuperSpeed USB**	**HDMI, DisplayPort, SATA**
El Ochito® White octaxial contacts provide 10GbE in a single size #8 contact cavity (compared to two Quadrax) for 100BASE-T solutions.	***Low-dielectric material. 90 ohms.*** El Ochito® Blue octaxial contacts provide an aerospace-grade solution for SuperSpeed USB 3.0	***Low-dielectric material. Up to 5 Gbps. 100 ohms.*** El Ochito® Red octaxial contacts provide an aerospace-grade solution for multi-gigabit data rates.

Matching Connector Construction and Wire Management to System VIBRATION LEVELS

Not all connector coupling nuts are the same when it comes to vibration and shock

1 Connector couplings designed for vibration and shock resistance include locking and ratcheting technologies such as used on Glenair SuperNine® connectors. This technology is a high-performance benchmark of this series. SuperNine is the only available MIL-DTL-38999 Series III qualified to the Bell 299-100-B29 high-vibration specification.

2 Backshell-to-connector attachment interfaces vary from series to series. For heavy-duty applications such as large form-factor power cables, a splined interface such as is used on MIL-DTL-28840 shipboard connectors and the Glenair PowerTrip™ series are preferred, particularly if resistance to high levels of vibration and shock is an application requirement.

3 Cable strain-relief utilizing appropriate backshells, boots, banding solutions, connector types, overmolded cable design, and so on is critical to interconnect performance in harsh vibration and shock applications. The reduction of severe bend moment forces on cables through appropriate routing is a powerful tool in ensuring long-term durability.

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"Interconnect system design for vibration and shock should include attention to both the mating interface and cable attachment / routing."

So you wanna be a ROCK 'N' ROLL STAR?

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Gene Simmons


Chrissie Hynde


Chuck Berry


David Bowie


Keith Richards


Paul McCartney


David Lee Roth


Pete Townshend


Kurt Cobain


Michael Jackson


Elvis Presley


Stevie Nicks


Jimi Hendrix


Slash


Tina Turner


Jim Morrison

Answers: www.glenair.com/qwikconnect

Managing Power Loads for High Voltage and High Amperage CONNECTOR COMPATIBILITY

High ampacity and high power loads place unique demands on connector dielectrics and design

1 **High altitude DWV** is a critical requirement in non-pressurized and SWAMP zone aerospace applications. This innovative two-piece contact dielectric architecture, with Top Hat insulator design, lengthens discharge creep path in shorting and flashover testing. This unique capability is available in the Series 806 Mil-Aero—the only high-performance micro miniature circular capable of meeting MIL-DTL-38999 70,000 ft. DWV rating.

2 **Increases in operating temperature** often lead to decreased life and reliability in interconnect systems. Contacts and connectors have current ratings both at sea level and at increased altitudes that dictate how much current a conductor can safely tolerate—and its corresponding temperature rise. PowerLoad™ is a high-temperature resistant connector series designed for high-altitude aircraft power distribution applications with premium quality insulation materials and gap-free component bonding to ensure optimal operating temperature performance.

3 **Contact spacing within the dielectric insulator** also dictates current and power load carrying capacity. Legacy power connectors such as the MIL-DTL-5015 typically relied on low-density contact-to-contact spacing to accommodate the otherwise poor-quality dielectric insulator. Modern power interconnects, such as the Super ITS™ - 921, utilize thermoplastic dielectric materials with significantly improved temperature tolerance—allowing for a higher-density connector design.

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"Power distribution current capacity relies on power management techniques that effectively manage heat, partial discharge, and altitude."

Environmental Protection Levels and SEALING COMPATIBILITY

End user expectations are reasonable: that connector sealing technology actually meet the requirements of the application

1 **SuperSeal**™ is a Glenair series of field RJ45, USB, and HDMI-compatible connectors with IP67 open-face sealing for complete system protection against water, sand and dust. Unlike commercial-grade equivalents, SuperSeal does not rely on commodity unsealed connector inserts, and augments open-face sealing with rear sealing grommets and potting to reliably prevent moisture and fluid ingress into critical electronic equipment.

2 **Wire termination zone sealing** is equally important as interfacial sealing. The Glenair Series 806 Mil-Aero utilizes a "triple ripple" wire grommet seal as well as a cork-and-bottle interfacial seal, and an internal O-ring peripheral seal to ensure robust environmental sealing, even during 75,000 ft. altitude immersion testing.

3 **Managing leak paths in high-pressure applications** requires design disciplines with built-in redundancy. SeaKing is a dry-mate connector series fully tested to 15,000 PSI (open face and mated), and equipped with integrated dual O-ring seals, galling-resistant marine bronze coupling nuts, corrosion-resistant stainless steel shells, and high-pressure glass-to-metal seal contact inserts.

ConnectorMan

"Sealing compatibility means different things for different applications. From high-altitude immersion, to deep-sea pressure, to simple moisture and dust. Trust Glenair to get it right!"

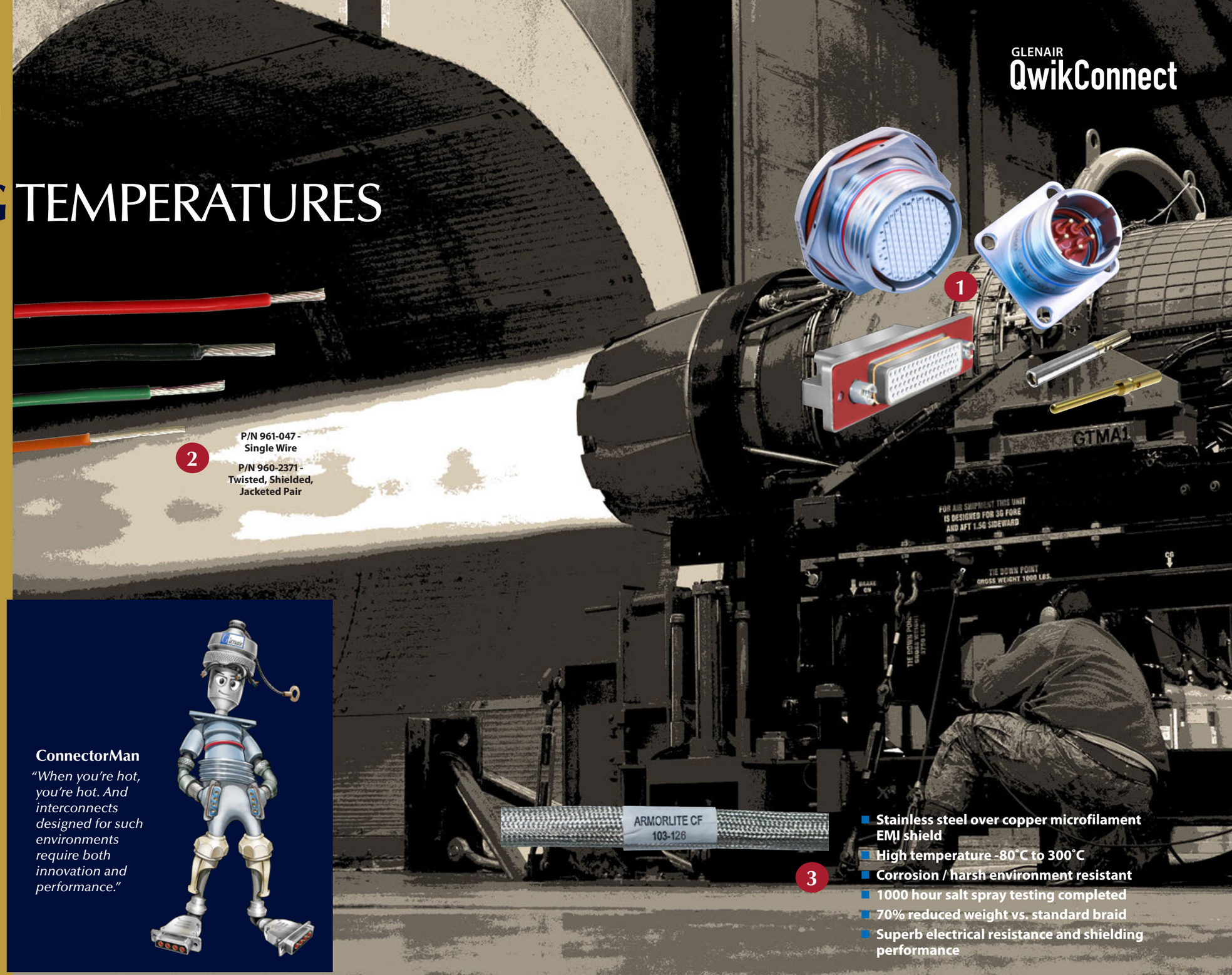
Optimizing Material Selection for OPERATING TEMPERATURES

When you absolutely need high temperature technologies with proven electrical performance

1 **Many applications demand** interconnects that function beyond the usual mil-spec limits of -65°C to 200°C. ThermaRex™ High-Temperature (HT) connectors are designed to function up to 300°C continuous. Cryogenic connector variants are suitable for applications as cold as -200°C or 73 Kelvin. Two key technologies are utilized: the first being an ultra high- and low-temperature tolerant dielectric material, and the second a unique crown ring contact series, resistant to stress relaxation at high temperatures compared to standard split-tine sockets.

2 **Designing interconnects for temperature extremes** also depends on suitable wire and cable that can perform with continuous service at 300° C. Most legacy high-temperature wire designs utilize thick insulation made of fiberglass—not suitable for use with high-density aerospace interconnects. Glenair ThermaRex wire is small enough to work with standard wire sealing grommets and back-end accessories, and has been fully tested for continuous service at 300°C.

3 **High-temperature wire shielding solutions** are also a critical requirement. Traditionally, high temp applications would use Nickel 200 or pure stainless steel braid for shielding—heavy options with only moderate EMI shielding. Glenair ArmorLite™ CF is a stainless-steel-clad copper microfilament braid with -80°C to 300°C temperature tolerance and outstanding EMI shielding performance.



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"When you're hot, you're hot. And interconnects designed for such environments require both innovation and performance."

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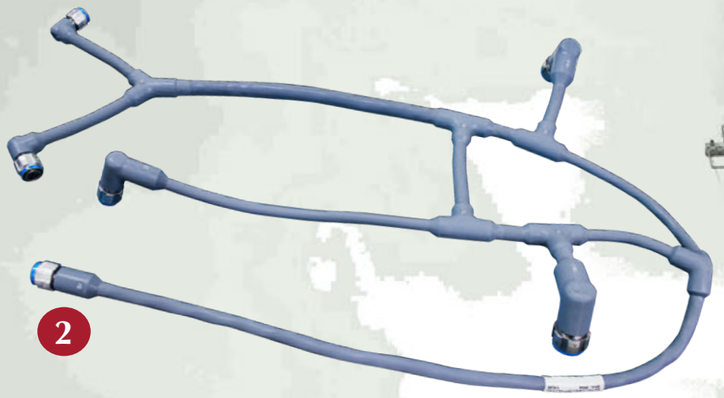

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ENVIRONMENTAL

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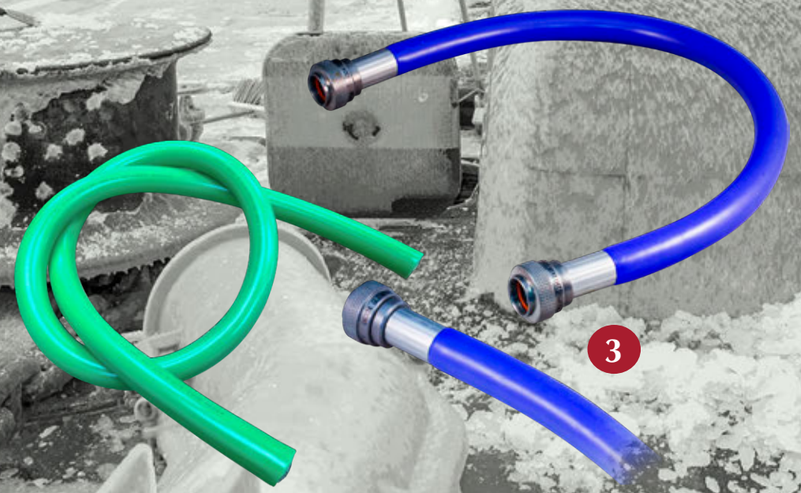

3

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"Correct selection of jacketing material is a great opportunity to improve environmental performance and durability of mission-critical cabling."

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Matching Cable Jacketing Selection to ENVIRONMENTAL CONDITIONS

Neoprene and other conventional jacketing materials do not always meet today's most mission-critical application requirements

1 **Duralectric™ jacketing material** is Glenair's signature solution for a broad range of environmental cable applications, including those equipped with environmental backshells and boots as well as for overmolded designs. Duralectric material has been approved by NAVSEA for use in MIL-PRF-24758 US Navy topside conduit assemblies, and a range of specialty formulas have been fully qualified for the even broader range of environmental requirements encountered in air, land, space, and sea applications.

2 **Specialized variants of Duralectric** include a formula for applications requiring aggressive weight reduction. Duralectric L exhibits all the same attributes as the base material including flame-resistance, functionality in temperatures as low as -65°C and as high as 200°C, flexibility, resistance to a broad range of caustic chemicals and fluids, CBRN and NBC decontamination processes, ozone, long-term direct sunlight, fungus growth, and dielectric breakdown—at 25% lighter weight than standard Duralectric D.

3 **Other formulas beyond the standard Duralectric D material** include versions for increased abrasion resistance, cut resistance, direct long-term immersion in fuel, diesel, or solvents, and a formula for broader temperature tolerance from -110° to 260° Celsius.

Designing Qualification Test Plans IAW INDUSTRY STANDARDS

Industry standards and conventions absolutely dictate all aspects of interconnect design

1 Defense Logistics Agency (DLA) performance standards such as those required for qualification of the popular military / aerospace connector MIL-DTL-38999 Series III, are exacting and authoritative. Everything from mating cycles, DWV at sea level and at altitude, shell-to-shell electrical resistance, performance under severe vibration and shock, material temperature tolerance and more must be adhered to for qualification to the standard. These standards are often used by Glenair as benchmarks in the design of our Signature Series connectors such as the Series 806 Mil-Aero micro miniature circular.

2 The Oil & Gas industry has its own set of compliance standards, such as those published by the American Petroleum Institute, or API. The Glenair SeaKing™ Power connector, for example, is designed for full compatibility to API 16D and 17E-compliant test port applications including open-face pressure ratings to 10K PSI, high-voltage and high-amperage power loads, and support for both overmold and PBOF cable assemblies.

3 The FAA is the qualifying legal authority for equipment intended for use on commercial aircraft. In addition, individual OEMs may impose additional performance requirements. The Glenair Swing-Arm™ articulating 3-in-1 backshell series is an example of a Glenair interconnect technology that satisfies both FAA as well as major aircraft OEM performance requirements.

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"In this business, it's critical to keep every stakeholder happy—including and especially the compliance agencies that ensure product quality, safety, and performance."

Outlook

Multiplying by Zero

Here is some business wisdom that I freely borrow from the world of mathematics. I think it is particularly applicable to this special issue of *QwikConnect* with its focus on compatibility in interconnect system design. It has to do with what is described as the "two different types of arithmetic" that are operative in our business life – additive and multiplicative.

An "additive series" is like a high school student who is captain of the hockey team, has a 4.5 GPA, and is also the student body president. Now when it comes to applying to college, does it matter that he or she doesn't also play a musical instrument? The obvious answer is no. A "zero" in Marching Band would not result in a zero overall when it comes to counting up this student's achievements in high school. This, in other words is an additive series:

Star Athlete + Dean's list + Class President = Welcome to Boston College.

Now let's look at a "multiplicative series", which by the way, is the type of arithmetic we always encounter in business—and let me tell you, in a multiplicative series, do zeros ever matter!

A good example is a night out at a restaurant. Let's say a family stops at a new restaurant and everybody enjoys the easy parking, the ambiance, the service and the food. Until what? Until the meal is concluding and mom goes to use the ladies' room and finds it is a total mess. In a world of Yelp and other forms of media, what do you suppose this family's review would read like? I'm guessing it would be something along the lines of "good food and service but the restrooms were filthy." That then is a multiplicative series:

Tasty Food × Good Service × Dirty Bathrooms = We ain't coming back

In a multiplicative series, any factor that is a zero—no matter how long or robust the rest of the chain is—turns the overall result to zero. The problem in business is that folks mistakenly believe that the system they operate in is additive, not multiplicative and as a result believe that "well, I'm doing great in these six things, it's not going to kill us if we drop the ball on number seven."

As is the case in an interconnect system design, even one flaw, one failing, such as a mis-matched plating or an inadequate strain-relief, can turn the overall performance of the cabling to a zero. Warren Buffett makes this same point in terms of money management. He observes that it doesn't matter if you've had 13 years of great returns. If you overreach and have a single year where everything goes to zero, you've turned 13 years of success into failure.

While it may be comforting to believe that the "critical path" systems in our lives are "additive," the stark reality is they are in fact mostly "multiplicative." The big takeaway on this is to stay engaged, to follow up and follow through on all the work that contributes to a successful outcome—no matter how tempting it is to believe that "one mistake won't matter." In business, like most things in life, nothing could be further from the truth.

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Publisher
Christopher J. Toomey

Managing Editor
Marcus Kaufman

Editor/Art Director
Mike Borgsdorf

Graphic Designer
George Ramirez

Technical Consultant
Jim Donaldson

Issue Contributors
Eran Agami
Josh Castrey
Ken Cerniak
Sam Farhat
Raul Galvan
Ty Geverink
Tony Gulrajani
Guido Hunziker
Lutz Mueller
Sam Peeling
Tom Pfingston
Jim Plessas
Ben Porcaro
Mike Wofford
Ali Yassine
Michael Yost

Distribution
Terry White

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

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