September 2009

Tyco Electronics

Electronic Magazine

www.tycoelectronics.com/adm

TYCO ELECTRONICS – YOUR PARTNER FOR INNOVATION

Tyco Electronics Ltd. is a leading global provider of engineered electronic components, network solutions and undersea telecommunication systems to customers in more than 150 countries.

The Aerospace, Defense & Marine Business Unit (ADM) offers components that are not only aligned to strict military and civil specification standards but also adapted to the respective environmental conditions from space to sub sea platforms. As we have a worldwide sales, engineering, production and logistical network we actively support our customers and its suppliers in global development of new airplanes, ships and defense solutions.

>> Areas of Product Applications

- Passive electronics for inside the box
- Box input/output and outside the box
- Environmental controlled frame installations
- Harsh environmental conditions installations

AEROSPACE, DEFENSE & MARINE BU – MAIN PRODUCT GROUPS

Interconnect

Harness Protection

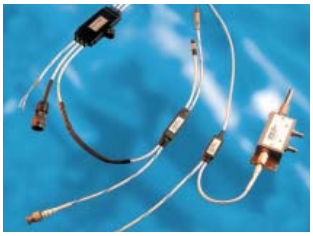
Wire & Cable

Relay

Fiber Optics

RF

Interconnect Devices

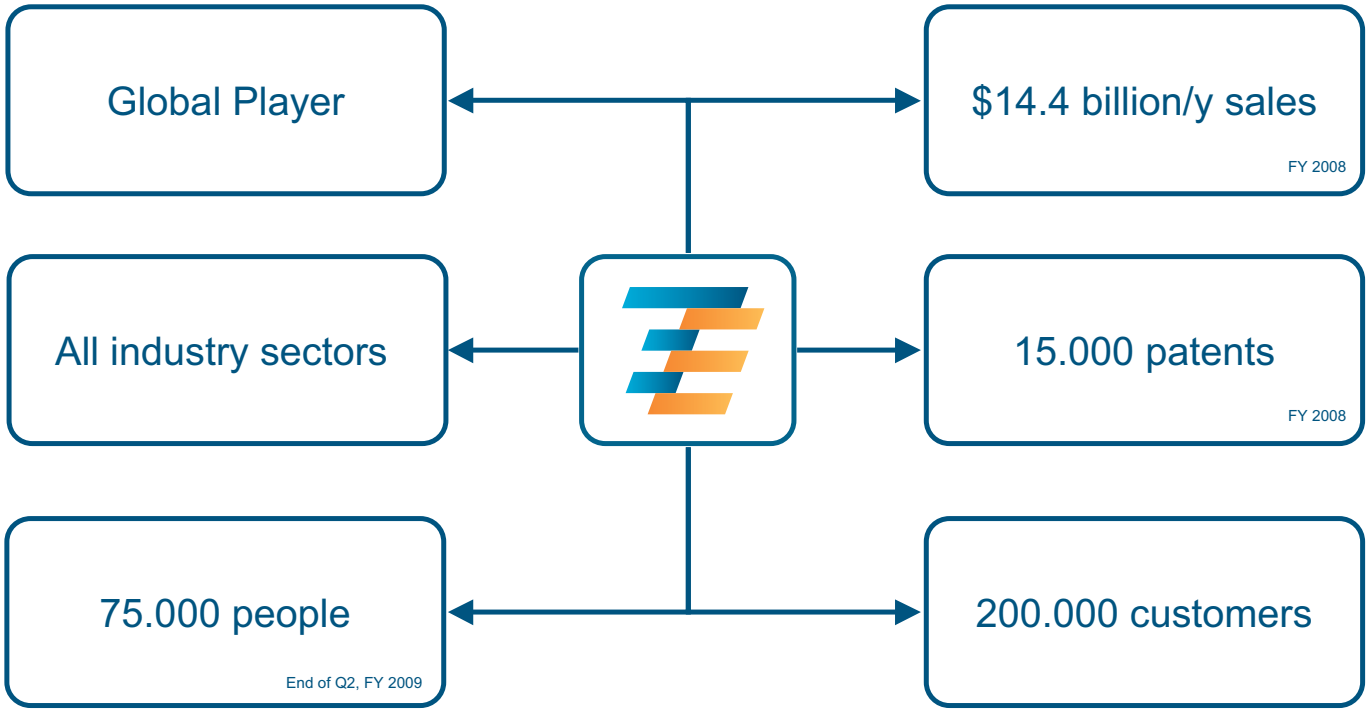


Data Bus

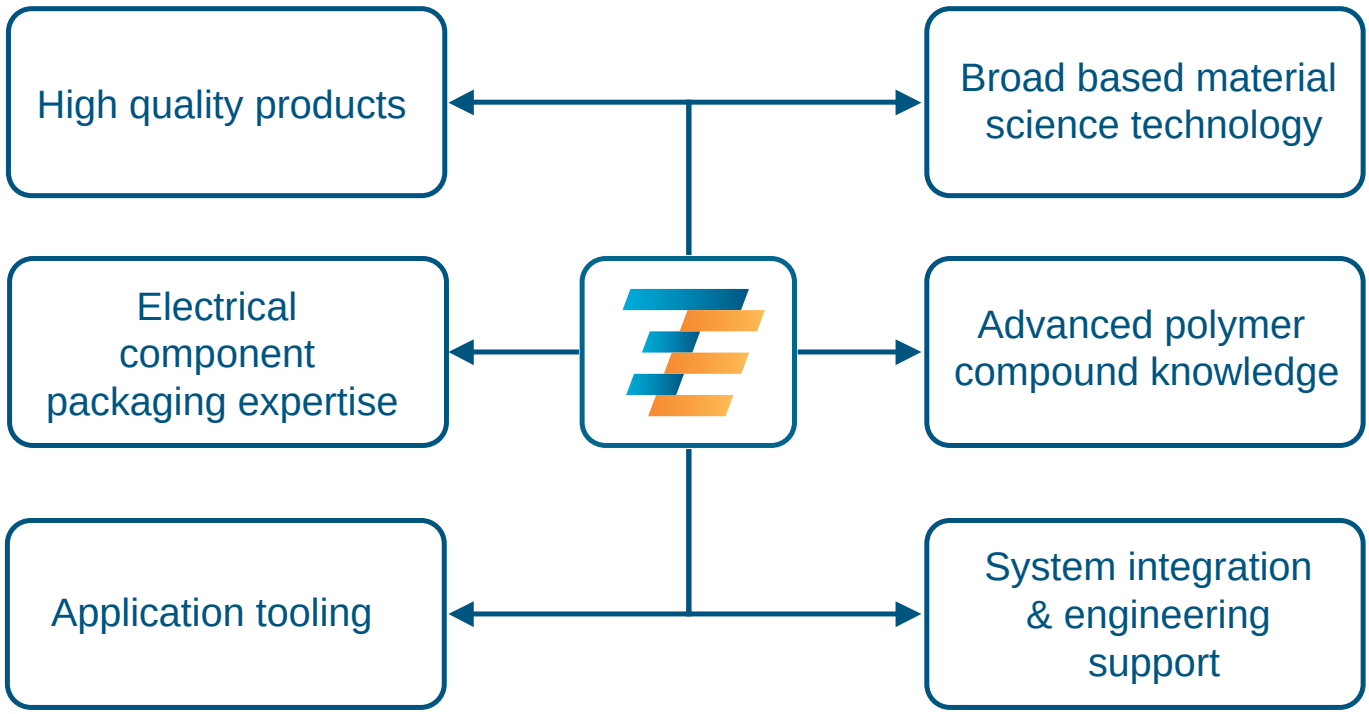
DELIVERING RELIABLE PRODUCTS

>> Global Sourcing with One-Stop-Shop capabilities
>> Technology access to all market developments within Tyco Electronics
>> Ability to achieve specific product customization between military and commercial-off-the-shelf technologies
>> Partnership for new industry standardizations
>> Manufacturing cooperation
>> Inventory management
>> Offset programs
>> Design-to-cost

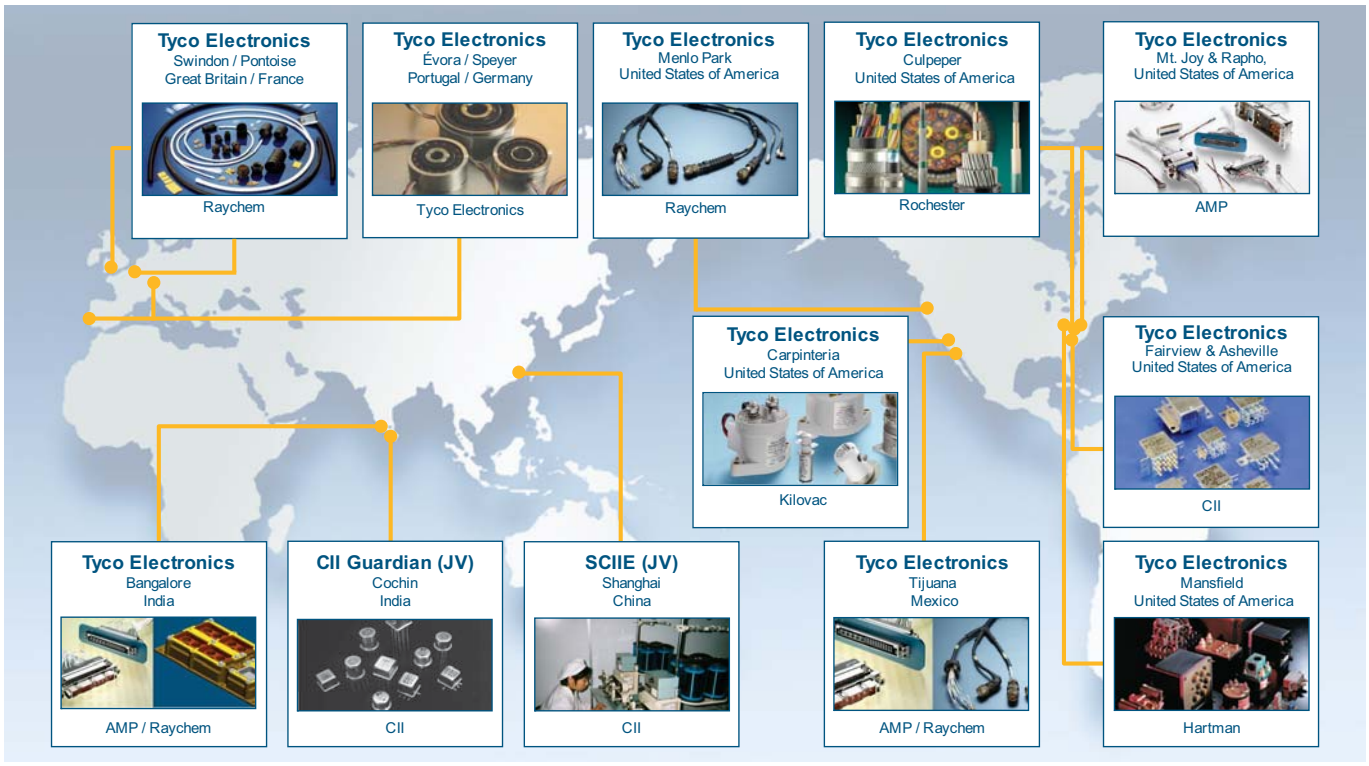
FACTS



ESSENTIALS



ADM OPERATIONAL EXCELLENCE

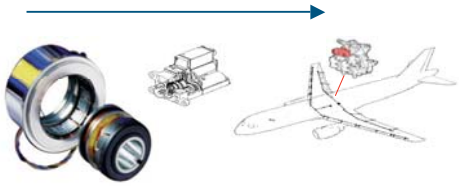


ADM RECOGNIZED COMPETENCIES

Miniaturization
(Nano 025 pitch In/Output)

Lightweight (Composite connectors with GbE data speed capabilities)

Reliability (High lift system aircraft sensors)



Survivability
(Fire resistant wire)

Durable
(1600 amp or
70 KV relays)

Protective
(Cross-Link tubing /
jackets & EMI braids)

Precision (Fiber optical switch at 200G missile impact)

KEEPING IN CONTACT ON THE BATTLEFIELD

photo courtesy of EADS Defense & Security

Aerospace, Defense & Marine developing connectors for military communication systems carried by soldiers into combat.

Is there any place where communications are more necessary than on the battlefield? In today's dismounted regiments, it's not uncommon for soldiers to wear elaborate electronic systems that regularly transmit essential information throughout a mission.

For years, Tyco Electronics' Aerospace, Defense & Marine (ADM) Business Unit has supported military customers by providing sophisticated components. It is continuing that tradition by developing new interconnection technology being used in systems that help military commanders know where their squads are located, where they are going, and hopefully, the location of the enemy.

The connectors link communication and data signals to a soldier's wearable computer system. This allows the members of the squad to relay such information as target locations, their own position using global positioning system (GPS) and digital magnetic compass.

photo courtesy of EADS Defense & Security

During development, Tyco Electronics' engineers carefully considered the requirements of both the system manufacturers and the end users. "New embedded connectors needed to meet strict space and orientation requirements, so they are as compact, reliable and rugged as possible," says Martin Blundell, Ground Systems Market Development Manager.

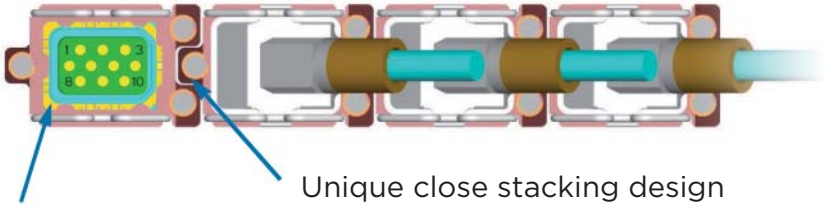
Working with its customers, Tyco Electronics is currently developing new connector assemblies for future soldier projects. A team of Tyco Electronics' designers and project managers in Europe develops these new connector assemblies that are compact, low profile, easy to reconnect and able to withstand harsh battlefield conditions.

"We are proud to support the needs of the modern soldier by developing an integral part of their systems that we hope will ultimately reduce battlefield losses in future, " says Martin.

FUTURE SOLDIER CONNECTOR INTERFACE

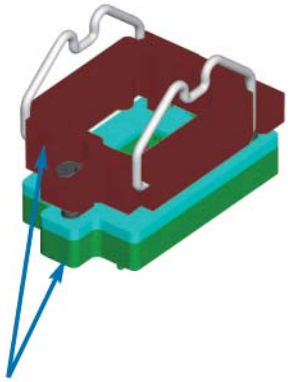
The design is driven by specific requirements and helps to address such issues as cable routing and the space envelope used by the current available connector designs.

These features and benefits are shown below.



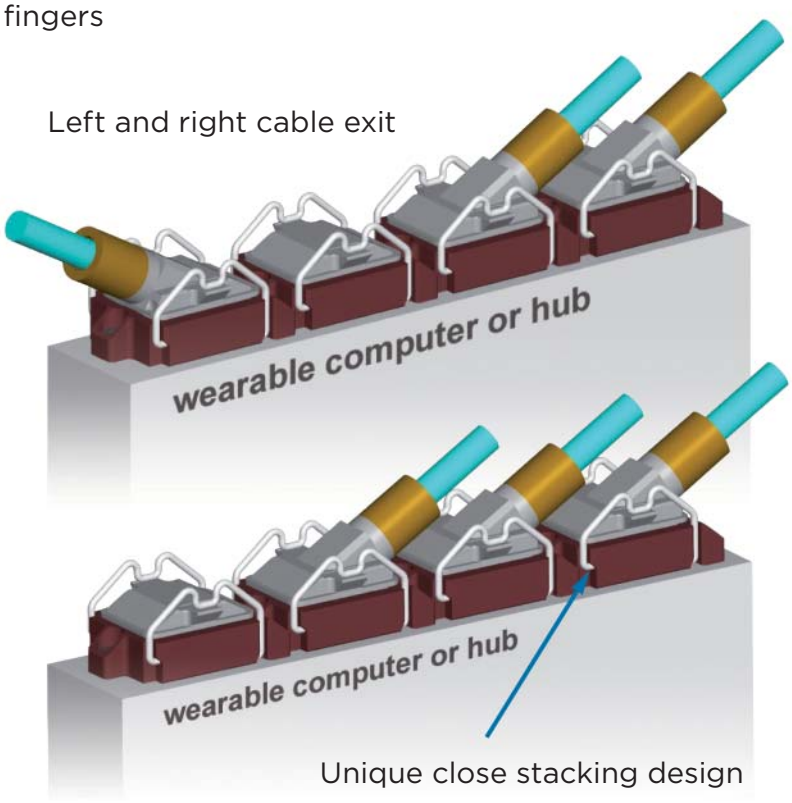
Grounding fingers

Unique close stacking design

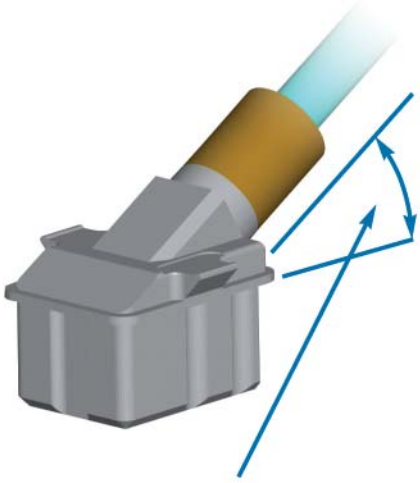


Two piece receptacle suitable for assembly at PCB

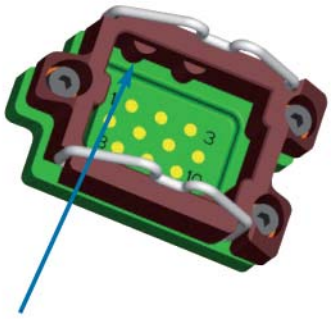
Left and right cable exit



Unique close stacking design



Low cable entry/exit profile



Multiple keying options
Able to be changed at any time

SOLUTIONS FOR MILITARY COMMUNICATION – ELECTRONIC SYSTEMS

We are continuing to introduce the latest in state-of-the-art ruggedized products.

Tyco Electronics offers a broad range of interconnect solutions suitable for addressing the diverse applications found in military communications and electronic systems. From our RF connectors and cabling used in radio and video systems, to our high speed backplane connectors used in embedded computers, and our high voltage relays used in communications satellites, our product portfolio is positioned to solve the most demanding design challenges.

We are continuing to introduce the latest in state-of-the-art ruggedized products. Relative to connectors, Tyco Electronics is developing and introducing multiple revolutionary products, including the High Speed Ruggedized (HSR) backplane connector, the MULTIGIG extreme backplane connector, the High Reliability Mezzanine Connector, as well as fiber optic and RF modules.

>> The **HSR** is the "Swiss army knife" of backplane connectors, being user configurable and length scalable. The modular connector utilizes a common insert size to enable +10 GHz differential pair, single ended circuits, power, RF and fiber optics. Its metal shell makes it suitable for demanding LRM/LRU applications as found in many of today's mobile/or transportable electronic systems. The HSR is in production and available today.

>> Presently in development, the **MULTIGIG** extreme backplane connector is an evolution of Tyco Electronics' revolutionary VITA 41 (VXS) and VITA 46 (VPX) MULTIGIG RT2 backplane connector. It includes a shell and machined guide hardware set that is integrated with the daughter card connector, acting as a card edge stiffener, protecting the connector mating interface and offering packaging features to supplement ESD and EMI resistance.

>> Also in development, the High Reliability **Mezzanine** Connector is being designed as a rugged alternative for the present XMC interconnect. The 114 position two piece connector, known as VITA 61 connector, will use the exact same footprint as the present VITA 42 connector, but utilizes the four beam socket contact system for increased mating durability and consistent performance in demanding applications.

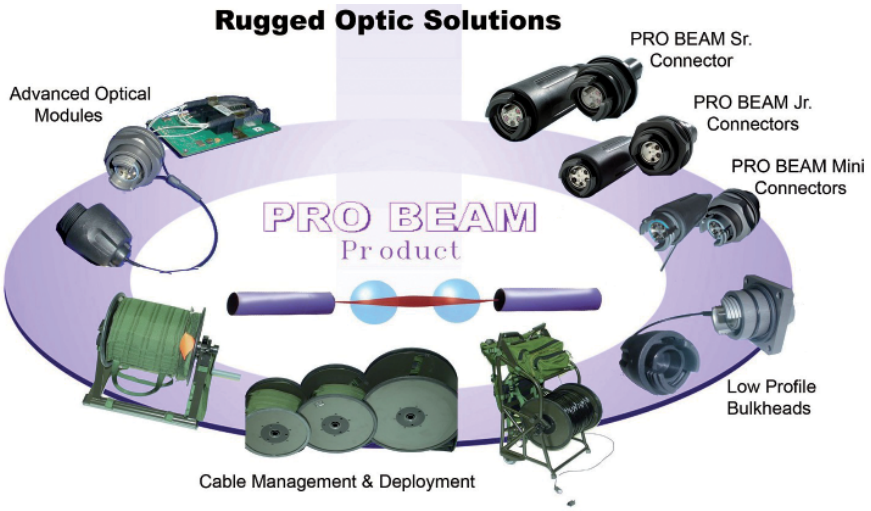
>> Finally, Tyco Electronics is developing **Fiber Optic** and RF modules in support of VPX. These modules will be installed next to the digital connectors and are another example of our dedication to expanding the functionality and capabilities of our industry leading products. These products are being made available to customers today, while we work concurrently with the VITA Standards Organization to finalize the standards for the modules.

Whether it is with an industry standard product, such our VITA 46 (VPX) interconnects, or with a Tyco Electronics unique product, such as the High Speed Ruggedized backplane connector, our goal is to give our valued customers the technological advantage in all of their high reliability communications and electronic system applications.

Application images courtesy of the Department of Defense

TACTICAL BATTLEFIELD RUGGED OPTICS

Tyco Electronics is offering a full range of products for the installation of tactical battlefield communication networks. Our products are in use for communication links, fire control, battlefield identification and in many sensing and radar applications.



>> Interconnects
Based on our proven expanded beam technology our customers are able to choose between 3 sizes of our Pro Beam interfaces for in field installations and 2 sizes of the Mil-C-38999 series shell size 11 & 13 for in shelter installations. Products are delivered as components, Fan-Out or fully proven harnesses.

Further to this we offer also panel mounted connectors for mass termination with up to 128 channels. Particular at the panel mounted connectors all inserts are individually spring loaded with self-alignment maiting features.

>> Expanded Beam Inserts
All interfaces are using the same insert style and are fully interchangeable within their size range between our Pro Beam interfaces, Mil-C-3899 and panel mount inserts. One interface can carry up to 4 fibers and we offer 850/1300 dual wavelength, 1310 or 1550 nm configurations.

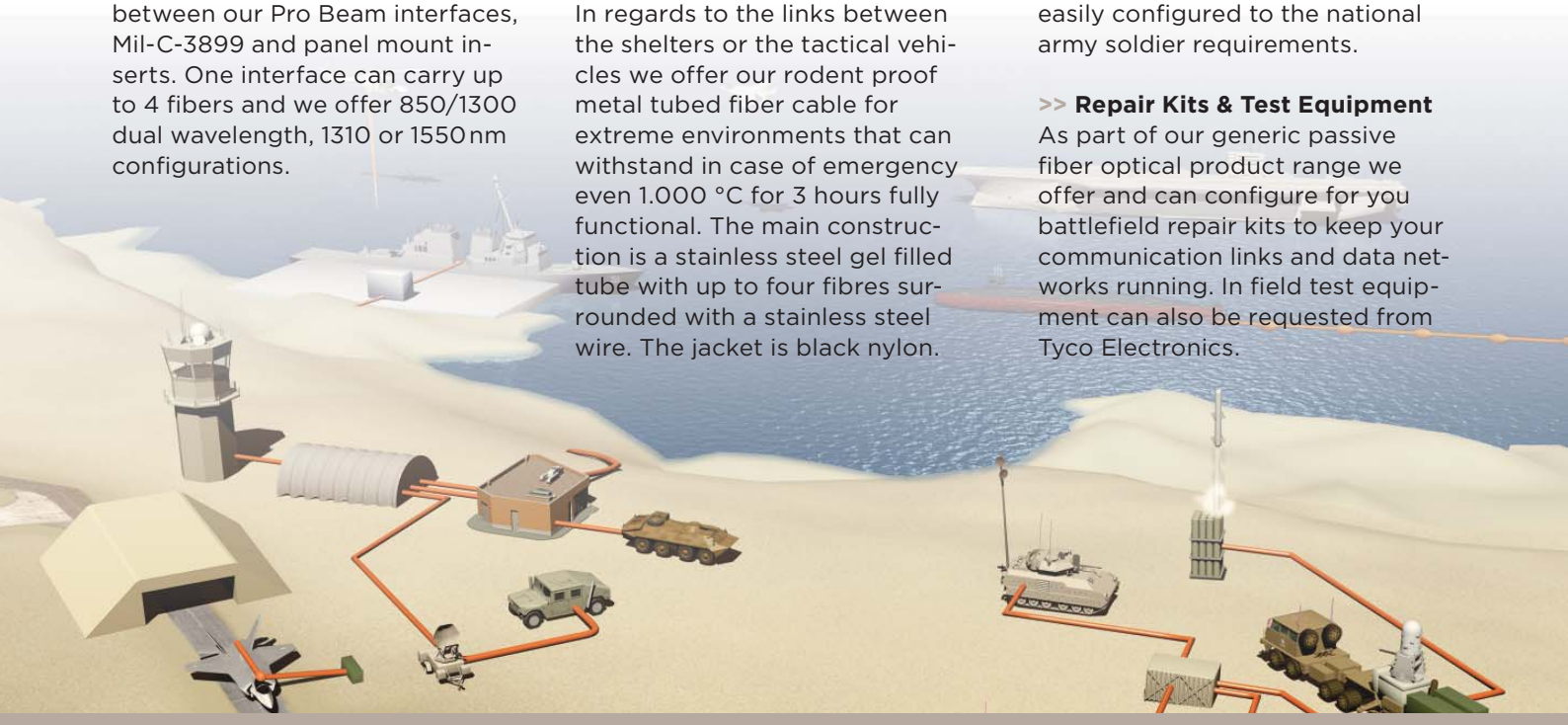
Our expanded beam inserts can be easily repaired with pre-assembled ferrules and do not require special measurement equipment. A spring loaded ferrule cavity construction provides the correct fiber core position in front of the ball lenses. This allows the optimal light transition between the contact free ball lenses interfaces.

>> Armor Cables
In regards to the links between the shelters or the tactical vehicles we offer our rodent proof metal tubed fiber cable for extreme environments that can withstand in case of emergency even 1.000 °C for 3 hours fully functional. The main construction is a stainless steel gel filled tube with up to four fibres surrounded with a stainless steel wire. The jacket is black nylon.

Fiber types can be chosen from 50/125/250 µm, 62.5/125/250 µm and 9/125/250 µm.

>> Cable Reels
Heavy duty light weight cable reels organize and protect connectors and cable for easy pay-out and save storage. Reels are available up to 2.000 meters (6560 ft) for vehicle mount. In regards to backpacks our reels carry about 500 meter (1649ft) and can be easily configured to the national army soldier requirements.

>> Repair Kits & Test Equipment
As part of our generic passive fiber optical product range we offer and can configure for you battlefield repair kits to keep your communication links and data networks running. In field test equipment can also be requested from Tyco Electronics.



EXPANDED BEAM VERSUS PHYSICAL CONTACT

Ruggedness has always been a challenge to fiber optic systems. The thin glass strand transmitting the optical signal is well protected within the cable, but the exposed fiber ends transmitting the signal through a mating interface are susceptible to contamination and mechanical damage. For protection and alignment reasons, the fiber is usually terminated via an epoxy bond to a precision ceramic ferrule followed by an end face polish. Generally, there are two main methods of transmitting an optical signal between two fibers, physical contact (PC) and expanded beam (EB).

The following review focuses on a comparison of these two concepts.

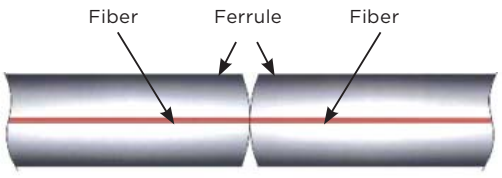
Rugged connector types: PRO BEAM Series connectors, GPRB1 with LuxCis® termini and ODVA-conforming connectors with LC

Typical beam expansion: For a 62.5/125 multimode (MM) fiber with a 3mm lens, the beam expansion factor is 14, and the cross sectional beam area is 200 times larger. For a singlemode (SM) fiber with a 3mm lens, the beam expansion factor is 30, and the cross sectional beam area is 900 times larger.

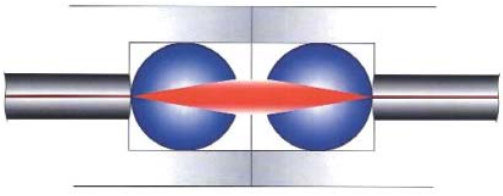
>> Physical Contact

The first method makes use of physical contact between two fibers. In this concept, the ferrules are mated within a precision sleeve to assure radial alignment between the two ferrules in order to minimize optical misalignment losses.

The ferrule assembly and mating sleeves of one channel or multi fiber connectors can be designed into a sealed rugged circular style connector very similar to those known from electrical connectors. Most notably is the MIL-C-38999 series III and M28876 circular shell connector which can contain up to 72 fiber channels. Due to the rugged design, they are suitable for a wide range of applications in indoor as well as outdoor applications and are therefore subjected to a more challenging environment.



Physical Contact of fibers mounted in ferrules



Expanded Beam concept

>> Expanded Beam

The second method introduces a beam expansion/contraction at the respective fiber end faces and allows an air gap in the optical pathway.

The expanded beam concept makes use of optical lenses (typically a 3mm ball lens) to expand and collimate the beam emitted from the launch fiber. The expanded beam remains collimated across the mechanical interface

planes until the receiving lens focuses the beam onto the receiving fiber.

Channel counts for the EB design are 1, 2, 4 and 8. The PRO BEAM Mini connector version is also used with a MIL-C-38999 Series III, size 11 circular shell (see Fig 7) and in the ARINC 600 connector which can hold up to 128 EB channels. Since these connectors are used in rugged environments they are usually terminated on a metal tubed fiber cable as well as an Avionic/Flight grade cable.

The simplicity of the PC design provides a lower SM insertion loss (typ. 0.2dB) than what is achieved by the SM EB concept (typ. 0.7dB). A major advantage of the EB concept, however, is that there is no mechanical contact between the optical elements of the two mated connectors and there is no need for use of fragile alignment sleeves. This makes the concept especially suitable for use in rugged environments, which are subjected to vibrations such as avionics, industrial and military applications.

>> The key advantages of the beam expansion are:

- No contact between optical elements of the mated connectors
- Less sensitivity to soil and contamination particles
- Connector misalignment and vibration have little effect on the signal loss
- Consistent performance during repeated matings

Relative Performance Ratings

The below two examples illustrate the fundamental performance effect depending the concept chosen.

>> Example of the connector misalignment effect on insertion loss:

- Assume a SM connection with a lateral offset of 2 µm at 1310 nm.
- For the EB connectors (with 30x expansion) this will result in a negligible loss increase of 0.001 dB.
- A similar offset of the PC connection will result in an insertion loss (IL) increase of 0.82 dB.

>> Example of angular misalignment between a mated connector pair:

- For a PRO BEAM Jr connector type, SM at 1310nm, a tilt between two mated housings caused by a 10 µm particle will result in 0.27 dB increase in loss.
- The same degree of tilt for a PC connection will only yield a 0.0007 dB increase in loss.

Looking to the bigger picture the following table summarizes where both concepts have their advantages. The system designer must determine which categories best apply to his specific application and make a connector selection based on the individual scores.

Fiber Optic Connector type:	PHYSICAL CONTACT (PC)				EXPANDED BEAM (EB)			
RATING (key below):	Poor	Good	Very Good	Excellent	Poor	Good	Very Good	Excellent
Insertion Loss				✔		✔		
Return Loss (SM)				✔		✔		
Return Loss (SM) – Unmated	✔					✔		
Lateral Connector Misalignment	✔							✔
Connector Angular tilt				✔	✔			
Mating Durability		✔						✔
Water Exposure			✔			✔		
Dust Exposure	✔						✔	
Vibration Suceptability		✔					✔	
Repair		✔				✔		
Cleanability		✔						✔
Wear	✔							✔
Wavelength Range				✔		✔		

It should be noted that the results in the table were achieved using equal weight for all categories.

HARNESSING CAPABILITY

>> An Evolutionary Approach

At the centre of any vehicle hull is a network of electrical harnesses – the vehicle's virtual electrical backbone. Mission and system requirements change to meet new threats, with upgrades to incorporate new technologies, but the basic vehicle hull remains a constant.

This creates a need for an electrical harness strategy that can evolve with each phase of the vehicle's life cycle.

>> Complete range of component systems

Tyco Electronics offers an extensive array of compatible component systems for different working, climatic and threat environments. These systems – which include products tested and perfected for the cost-conscious, performance-driven automotive market – provide optimal cost/performance in all sorts of environments, from general-purpose applications to platforms exposed to extreme temperatures and aggressive fluids.

>> Benefits with Tyco Electronics' Harn*Ware* harness design software

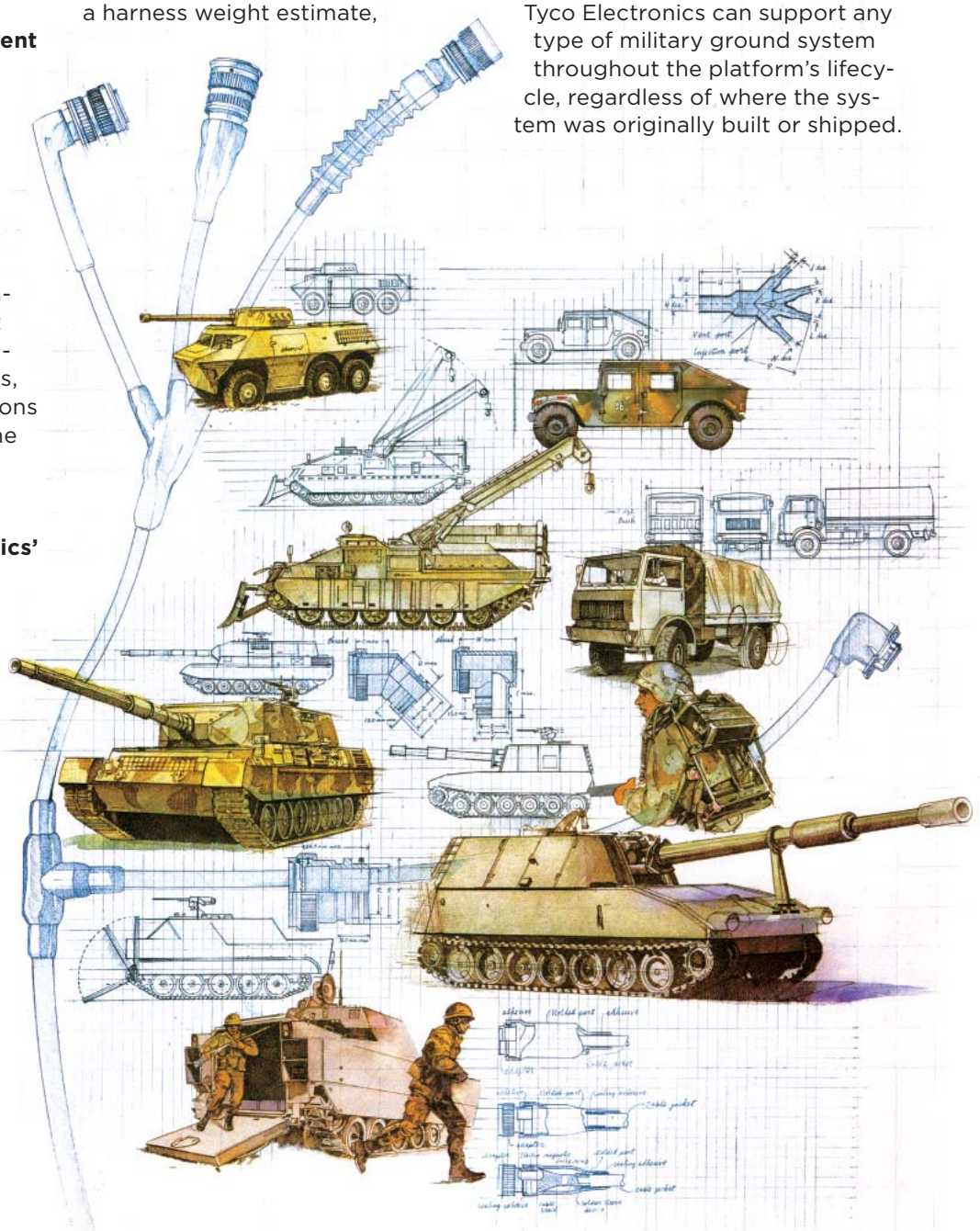
Harn*Ware* design software is Tyco Electronics' computer aided electrical wiring harness software. It was developed for the harness designer who knows exactly what he wants from his harness but needs a tool to help him design it quickly and easily. From a simple input of geometry, dimensions, connector and wiring details, the interactive Harn*Ware* software can help with many aspects of wiring harness design. It utilises a drag and drop drawing interface that enables the designer to rapidly draw and designate the overall parameters of his harness. Once complete, the drawing combines with Harn*Ware* software to guide the designer through series of design operations that enable the harness system to be specified and a range of fully compatible components to be selected.

The latest version contains a general assembly drawing, a wire list, a fully itemised bill of materials, a wiring schematic, a wiring schedule, a labour estimate, a harness weight estimate, a marker page, a 3D model, a lay-up board and much, much more. The dedicated webpage **www.harnware.com** gives users an interactive platform for any form of support needed.

>> Technical support

Tyco Electronics provides technical support through a worldwide staff of technical service and field application engineers trained to design and develop harnesses.

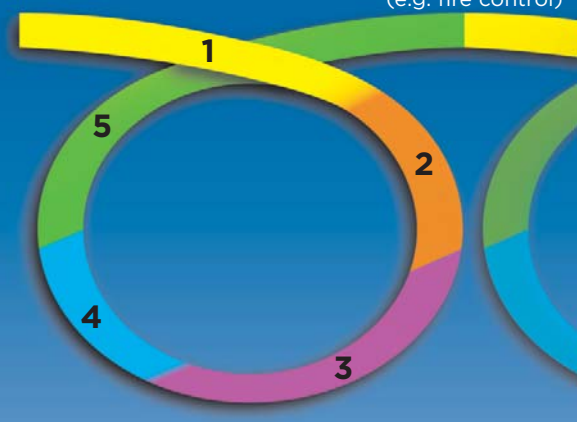
Tyco Electronics can support any type of military ground system throughout the platform's lifecycle, regardless of where the system was originally built or shipped.



PLATFORM LIFE CYCLE

Products for ground systems have to last for decades and allow for maintenance and upgrades. Tyco Electronics' expertise makes it easy to design and develop intelligent, reliable, sustainable solutions for military ground systems.

UPGRADE 1A
(e.g. fire control)



1. DESIGN

Harn*Ware* harness design software:

- Produces complete drawings, diagrams, parts lists and labour estimates in a fraction of the time traditional methods require.
- Allows correct component selection for form, fit and function to produce a systemized harness design.
- Enables different designs to be rapidly evaluated to arrive at the most cost effective solution.

2. PROTOTYPE

Worldwide support for rapid prototyping and mock-up is available through Tyco Electronics.

Harn*Ware* software features

In a fraction of the time needed for traditional methods, Harn*Ware* design software can produce

- Two-dimensional drawings
- Labour and production cost estimates
- A parts list
- A list of selected components compatible with the operating environment

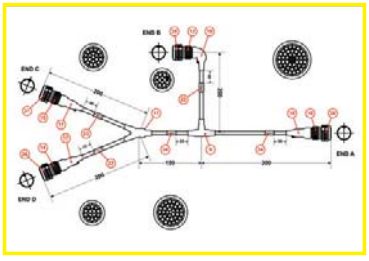
3. TESTING

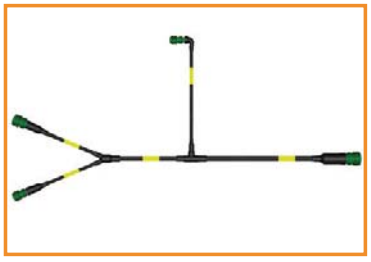
Tyco Electronics is fully equipped to test harness systems for flammability and resistance to:

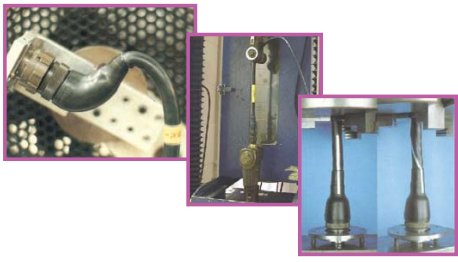
- EMI
- Physical and thermal challenges
- Fluids

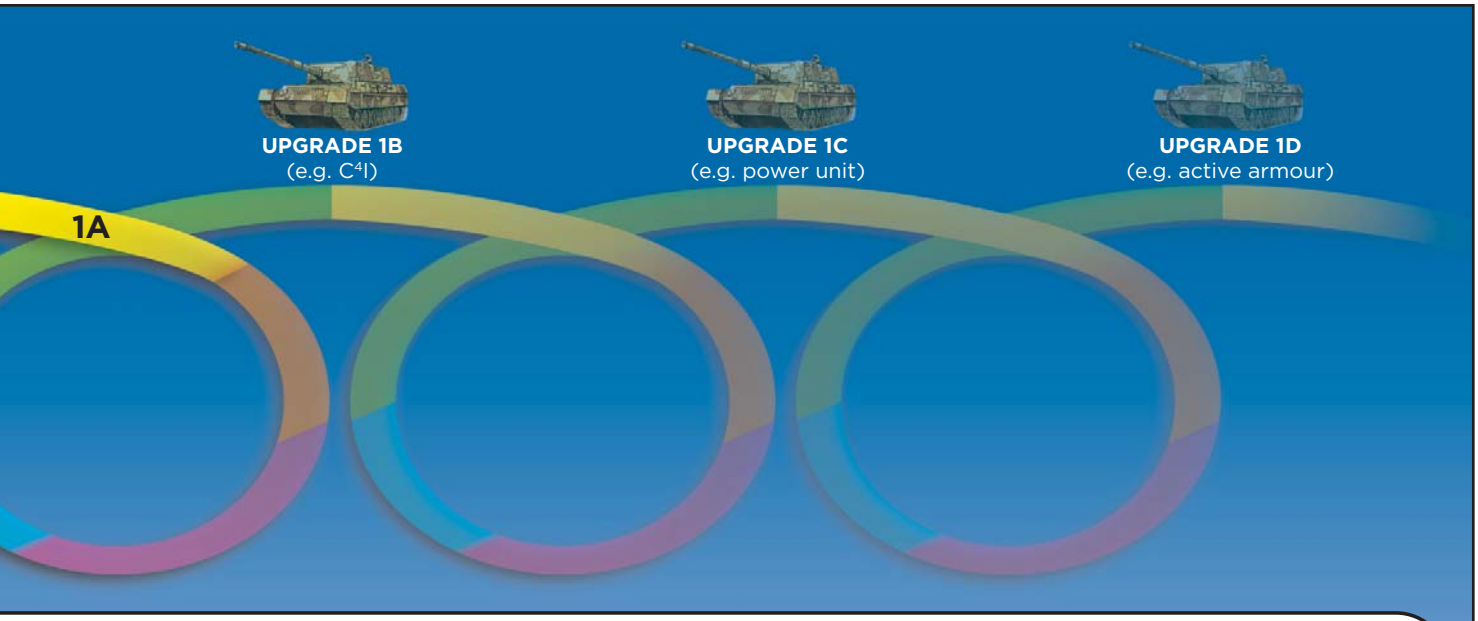
Harn*Ware* software benefits

- Specification of correct components
- Rapid, complete answers
- More control of the design package, which simplifies updates and changes
- Multiple generations of designs (Mark I, Mark II, etc)









4. MANUFACTURING

Tyco Electronics' customer-driven approach to manufacturing has produced:

- Preinstalled components for ease of assembly
- A complete set of compatible harness components (virtually everything that fits between two connectors) designed to meet the user's specific environmental requirements.
- Worldwide support.
- Application products and equipment.
- A complete set of process standards.
- Quality control, training and assurance.

5. MAINTENANCE

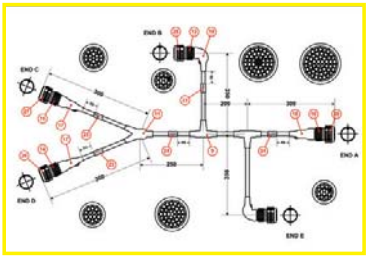
Tyco Electronics offers:

- Harness repair products (including tools and instructions) and techniques.
- Kits qualified to regional specifications.
- Local training and repair techniques.
- A worldwide distributor network for repair products.

1A. UPGRADES

Working with Tyco Electronics simplifies the entire upgrade design cycle, whether it involves incorporating new technology or adding new capabilities as mission requirements change. Tyco Electronics customers can:

- Quickly and easily redesign systems with Harn*Ware* design software.
- Employ Tyco Electronics' full line of repair, retrofitting and upgrade services and products.



IMPROVING YOUR THROUGH-LIFE COSTS

REPAIR KITS

The first General Purpose Electrical Cable Repair Kit (GPECRK) was introduced to the British Army in 1988. It was a result of working closely with the Royal Electrical and Mechanical Engineers REME of the British Army at Woolwich to fulfil their requirement to be able to repair damaged electrical cables and harness assemblies in vehicles.

The goal was to be able to effect a permanent repair to a range of cables using a single kit of parts, in order to provide performance and size as near as possible to the original manufactured specifications.

The kits employ both hot and cold repair techniques.

A range of Tyco Electronics Raychem branded products was assembled to facilitate the carrying out of repairs to all sections of cables from the core wires, and screening braids through to the outer jackets. This also included all tools that would be needed to effect the repair.

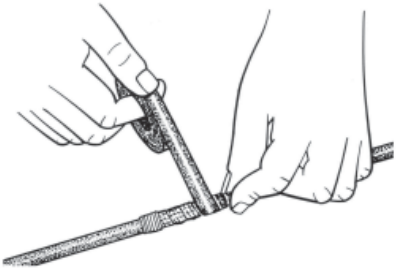
This field repair ability, access to the rear of connectors, and systems that are originally designed for repair ability are key contributing factors in controlling through-life costs of rugged cable assemblies as compared to potted or over-moulded cable termination techniques.

The kits employ both hot and cold repair techniques.

All items within the repair kit are NATO codified to allow easy replenishment of individual items, an important requirement in controlling repair costs.

As important as the repair kit is its correct use and therefore the correct training of the user is essential. To help facilitate the correct use of the kit a comprehensive set of repair techniques (codes of practice) is included within the kit. These codes of practice are proven techniques based on Tyco Electronics experience in the defence industry over 30 years.

Today a range of Tyco Electronics repair kits are in service supporting both the British Army and Royal Navy in their ongoing operations.



>> Features of Tyco Electronics Repair Kits

- Wide application range
- Can be used with almost every type of conductor and material
- Immersion capability
- Easy installation with standard socket spanner
- Torque controlled shear-head bolts provide a good electrical contact (no torque wrench necessary)
- No special tools required (no more heavy crimp tools or lost dies)
- Tools included
- Minimum skill level required
- Installation instructions included in each box
- Full customer support/training available
- Screen repair capability
- Compact design
- Spares readily available
- NATO codification
- Tested in according to IEC 61238-1
- Box to Def Stan 81-41 level J
- Humanitarian aid capability

Tyco Electronics range of repair kits

>> General Purpose Electrical Cable Repair Kit – Military
VG, Def Stan approved Military grade materials

>> General Purpose Electrical Cable Repair Kit – Marine
VG, Def Stan approved LFH materials

>> Damaged Cable Emergency Repair Kit
All repairs are carried out cold

>> General Purpose Electrical Cable Repair Kit – Deployable
Compact design for in-vehicle use

A HERITAGE OF SWITCHING PERFORMANCE

As pioneers in the development of lightweight, sealed relays and contactors, we have extensive capabilities in the design, manufacture and testing.

The aerospace applications include prestigious platforms such as the F-22 Raptor and the F-35 Lightning II for which we have supplied high voltage dc contactors, controllers and assemblies.

These high voltage switching requirements are being ever increasingly seen in ground vehicles not least the electric drive vehicle demonstrators.

Tyco Electronics' EV range of relays was initially developed for space applications; the emerging electric vehicle market soon took notice of this relay range as the same characteristics that qualify it for space applications made them attractive in electric vehicles: small size, light weight, low power consumption, high overload capability, bi directional switching and sealed chambers. These relays are now seeing additional market exposure in the modern armoured vehicle development programs, including the US Army FCS, General Dynamics AHED, BAE designed SEP and Patria's AMV.

TRIGGERING ELECTRICAL DRIVES

In the aerospace and defense world, high-voltage relays are used in antennas, radar, rangefinders and satellites and now also are being introduced in electric vehicles under development in the commercial automotive market!

Some applications switch only several hundred volts, while others switch up to 70 kV. They perform their switching function in either a vacuum or a gas-filled chamber. Some make and break loads, while others only carry current. RF-rated models exist, too.

Overcoming the specifics of high voltage engineers sometimes employ snubbers to protect relay contacts at low voltages, but at high voltages it takes much more to protect the relay contacts.

Interrupting low-voltage circuits handled by general-purpose relays is fairly straightforward. However, as circuit voltage increases, so too does the difficulty. Interrupting a kilovolt circuit with conventional switches and relays can prove nearly impossible because of arching. Since the voltage is so high, the air filling the gap between the opening contacts rapidly ionizes into a conductive path. Thus, even though the contacts are moving apart, the ionized gas maintains the circuit; an issue not nearly as prevalent in general-purpose relays.

>> Vacuum relay technology

A solution to arcing is removing gases that ionize from the contact area. This implies that high-voltage switching works well in a vacuum. In a vacuum of 10-6 millimeters of mercury, for example, dielectric strengths up to 2,000 volts per mil of contact gap can be achieved.

A vacuum dielectric also provides an inert atmosphere for the high-voltage contacts. The vacuum virtually eliminates oxidation and corrosion. When an arc appears in a vacuum, no dissociation of air or dielectric gas can occur to produce corrosive by-products. Moreover, a "gettering" effect occurs during contact interruption. Since the vacuum is not perfect, it contains some impurities. During the short period of each arc, some of these impurities are pulled out of the vacuum and attach to nearby surfaces, thereby improving the quality of the vacuum.

Breakdown between electrodes can occur in an absolute vacuum. The sources of electrons to support the resulting arc are the contact materials themselves. The point at which the arc occurs depends upon the work function of the contact materials. Because of the work function, tungsten and molybdenum, are often used.

The work function dictates the maximum electrostatic field that can be isolated with a fixed contact gap. Note that in hot switching, an arc will be drawn and an electrostatic field increases as the contact gap closes. So, at some point while the contacts close, the electrostatic field will be high enough to result in breakdown of the remaining gap.

An arc in a vacuum, unless extremely intense, will tend to blow out. The blow out occurs because the arc, a high-pressure area of vaporized metals, is surrounded by an extremely low-pressure area — the vacuum. Since there are no physical boundaries between the two areas, pressure equalizes and reduces the arc intensity and quickly extinguishes it. Despite its short life, the arc will cause contact erosion. However, this usually does not affect contact resistance because the metal transferred is pure.

>> The **KILOVAC K49P** series relays from Tyco Electronics are compact, diaphragm-type relays rated for 25 amp continuous current carry and up to 15kV isolation. Offering 1 Form P (SPST-latching) contacts, K49P series relays have a vacuum dielectric suitable for power switching low current loads.

KILOVAC K49P series relays

>> Electro-negative gas dielectrics

Not all high-voltage relays are vacuum type. Inert gas dielectrics are used in high-voltage components and systems. They are flexible since voltage breakdown in a pressurized enclosure can be controlled by variations in the gas mixture and/or pressure. The arc-quenching feature of gas pressurization is another advantage since complete recovery normally occurs within a few microseconds

Gas-filled relays are used for high-voltage power switching when the function is to close normally open contacts. One reason for this is that the gas mixture and pressure can be set so that an arc is struck just before the closing contacts touch. Moreover, if the circuit voltage is above 3500 volts, the arc is stable enough to maintain current flow even though the circuit path is interrupted by contact bounce. This phenomenon contributes to the long life gas-filled relays demonstrated in capacitive discharge circuits.

Gas-filled relays are used for high-voltage power switching when the function is to close normally open contacts.

Ionization doesn't help when interrupting current. In fact, it prolongs the arc and intensifies contact erosion. Tests show that vacuum relays are more suitable for power interruption because they limit arc sustenance ("arc blowout"). Arc blowout reduces erosion and prolongs contact life.

In conventional relays, contact resistance varies from cycle to cycle but in vacuum relays, resistance is low and stable over the life of a relay with 0.015 ohms being a typical value. This is because of uniformly cleaned parts, lack of oxidation or contamination, and the use of pure metals in the contact areas. Because the contacts are sealed within the vacuum envelope, switching may be safely carried out in explosive or corrosive environments.

In a gas-filled relay, contact resistance is generally low, but it is not as low or as stable as in a vacuum relay. Contact resistance also varies considerably with the applied test method. Higher-volume and higher-current measuring circuits usually result in lower contact resistance. Gold plating improves stability and lowers the contact resistance of gas-filled relays.

>> Power switching applications

The terms "power switching" and "hot switching" deal with power being interrupted or initiated by activating a relay. When a relay is power-switched, an arc is formed during the initial closure and subsequent contact bounce. Arcing causes contact erosion and unless precautions are taken, contact welding may result. At the very least, it can result in considerable contact damage. Therefore, the duration of the arc, the level of current and voltage are critical in determining relay life and reliability.

High-voltage power switching relays normally have tungsten or molybdenum contacts because these metals are hard and have

high melting temperatures which help withstand the effects of arcing. Some high-voltage relays with milliamp currents use copper contacts, but are usually for "carry only" applications.

>> Potted in robust, molded enclosures, **KILOVAC K89P** series relays from Tyco Electronics have integral brackets and flying leads for coil and high-voltage connections, offering designers mounting flexibility. The 1 Form P (SPST-Latching) contacts are rated for 25 amp continuous current carry and up to 15kV isolation.

>> Circuit Loads

The type of circuit load is an important factor in selecting the proper relay. Circuit loads can generally be considered capacitive, inductive or resistive:

Resistive load — the interruption of a DC resistive load causes an arc to occur during the separation of contacts and continues until the contacts are further separated. At certain voltage and current conditions, arc duration is determined by the speed of contact separation, the rate of cooling and deionization with the unavoidable inductance and distributed capacitance. An AC load is easier to interrupt than a DC load at the same voltage because the AC interrupts itself each half cycle. Polarity changes prevent continued metal transfer in the same direction, a condition that often leads to early contact failure with DC loads.

Inductive load — interrupting DC inductive loads is more difficult than resistive loads. The stored energy (1/2 LI2) in the inductance induces a voltage (-L [di/dt]) that tends to maintain the current. This continues until the energy of the inductance dissipates. Unless special quick-opening contacts or other means are used to interrupt it, the arc's persistence depends on the load's time constant (L/R), a direct relationship. AC inductive loads do not create the same problem as DC loads because polarity reversal at the end of each half-cycle forces the current to zero. Also, the current is out of phase with the voltage, and during the last part of the current half-cycle, the supply voltage is opposing the voltage of self-induction.

Capacitive load — closing contacts in a DC circuit to charge or discharge a capacitor will cause high inrush currents. Effects on the contacts depend on the magnitude of the initial peak current and the time constant of the circuit. Similar situations in AC circuits are not common. For optimum results, the relay should be placed on the ground side of the load. If this is not done, high current arcs can occur between the contacts and case, bypassing the load. The power source is the only limitation to the current surge.

In real world applications, all three elements are usually present, but circuits with significant capacitive or inductive elements are more difficult to switch because of their stored energy. To further complicate the situation, some circuits have high inrush current. Under high inrush conditions, contacts attempt to interrupt very high currents during the period of contact bounce resulting in a heavy arc being drawn that causes melting of the contact metal. Eventually this may cause contact welding. The situation is worse in the case of sinusoidal AC because the peak voltage and current of the AC are each 41% greater than the equivalent DC current for the same load voltage.

>> Power Distribution Systems

High-voltage relays are used in other applications like power distribution systems. Studies have shown that 270-volt DC systems offer improvements in reliability, maintenance, weight and life cycle compared to conventional 115/200-volt 400-hertz AC systems.

Conventional switching devices currently used with 28-volt DC or 115/200 volt, 400 Hz AC systems require major modifications to reliably switch 270-volt DC circuits. The modifications result in large, heavy units, making them impractical for the intended application. The use of vacuum as an insulating medium to switch 270-volt DC loads provides a significant performance and reliability improvement without increased size and weight.

Selecting high-voltage relays is not as straightforward as selecting a low-voltage relay. For proper selection, a designer should consider the circuit conditions and the relay's electrical, mechanical and environmental specifications. The designer should be aware of the trade-offs in relay operating characteristics and be aware that relay terminology is a special language with special meanings.

KILOVAC K89P series relay

C-LITE CABLE

The next generation wire and cable product for the Military Marine Export Market

Tyco Electronics' Raychem brand is known for its high performance, thin wall wire and cable products for military marine applications for many years.

These Raychem branded products provide military ship builders with many benefits including enhanced performance and lighter weight products when compared to standard technology competitors.

The differentiator is the use of radiation chemistry to cross link products coupled with proven experience in thin wall extrusion and material technologists providing custom designed materials to meet the exacting standards of the market place.

Until recently, the only choice available to ship designers designing vessels for overseas military programmes was to use a product which complies with National Military Standards. These products are not generally volume products and therefore high cost and also have strict export compliance requirements. Or a product which meets the less onerous performance requirements of the commercial marine market and provide a low cost, non export restricted product as well as associated issues with increased weight.

Tyco Electronics recently made a decision to modify its proven material and cross linking technology to develop an enhanced wire and cable product for the commercial marine market which now has a requirement for products with reduced size and weight to offset the increase in electronic installations onboard vessels. The reduced size and weight product could not utilise standard thick wall commercial marine cable technology as the reduced size product still needs to be physically robust to resist the physical rigours of installation proven by a pedigree of shipboard installation.

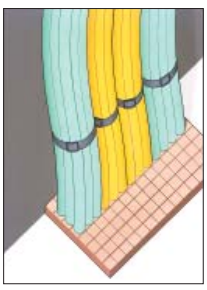
Tyco Electronics' material technologists developed materials to meet the exacting DNV specification for thin wall light weight wires and cables and released the C-Lite product line which has seen much success in the commercial marine and export military markets whereby excellent electrical, physical, flame performance and chemical resistance is provided, at a reduced cost and with no export compliance restrictions.

The C-Lite product line is a range of cables suitable for communications, instrumentation and low voltage power applications up to 600/1000V either EMC screened or unscreened and available as multicore, multi-pair and multi-triple configurations from 0.5 to 10 sqmm.

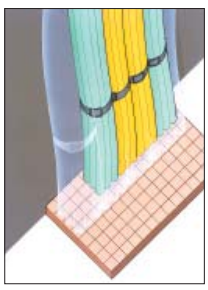
C-Lite cable is approved for use by DNV, LR, GL, ABS, BV, CCS, KRS, NK and RMR.

>> C-Lite cable typically provides the Marine Industry with the following benefits:

1. a weight saving of about 30%
2. a volume saving of about 50%



Transits



50% saving in volume

C-Lite FR cable ignites

>> These savings result in potential benefits for the ship builder:

1. Installation time is reduced (more cables can be pulled at one time)
2. Reduced size of cable routes and trays (especially important with recent legislation changes requiring dual redundant bridges)
3. Reduced size of cable glands and cable accessories

All of these benefits provide potential cost savings (less labour and smaller cable accessories) and further weight saving opportunities.

The C-Lite cable range was initially released as CL105 with a fluid and drilling mud resistant jacket providing an ideal product for the offshore and engine markets, more recently CL90 was released as a lower cost product for applications with less chemical and temperature resistance requirements.

The product range has also been extended to include fire resistant variants denoted by the F in the part number. CL90F and CL105F are fire resistant to IEC60331 which requires the circuit integrity of an electrical connection to be maintained at 850°C for 2 hours whilst being subjected to physical shock.

Initial prototype samples of CL90F and CL105F provided an enhanced performance to 1,000°C and for 8 hours.

NBCCS TUBING AND MOLDED PARTS

Tyco Electronics offers the Raychem 700 Series of nuclear, biological and chemical contamination survivable (NBCCS) harnessing systems. This harnessing system consists of Raychem brand heat-shrinkable tubing, molded parts, wire, cable, adhesives, adapters and other components necessary for system interconnection.

Raychem 700 Series NBCCS harnessing materials withstand chemical agent exposure to HD, VX and TGD at interior and exterior exposure levels. The components are designed to survive not only the NBC operating environment and contaminants, but also have been tested to survive the decontamination process.

Harnesses manufactured with Raychem 700 Series NBCCS components are typically used in battlefield vehicles, military hardware and other combat electronics/electrical systems. Additionally, NBCCS harnesses are used in law-enforcement and in first-responder emergency vehicles.

COMPOSITE HEXASHIELD ADAPTERS

The new Composite Hexashield high-performance EMC/EMI adapters are designed to provide EMC protection solutions for both commercial and military applications up to 200°C environments. Composite Hexashield adapters represent a significant improvement over pigtail termination methods. By providing 360 degree EMC shielding on the termination area of each individual cable, Composite Hexashield adapters provide outstanding shielding effectiveness.

Composite Hexashield adapters are simple to install, easy to maintain, and dependably resistant to mechanical and enviromental stresses.

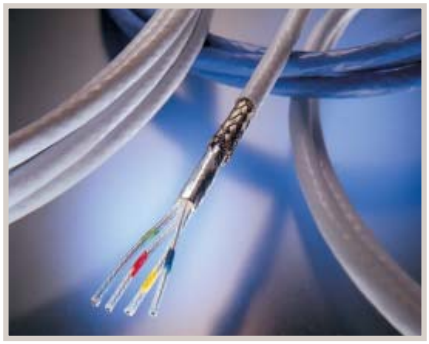
- Easy reentry: To insert or remove ferrules from the Composite Hexashield adapter, simply loosen the backnut
- Superior protection: No degradation of shielding performance
- Mechanical and enviromental protection equal to backshells complying with MIL-C-85049 cat 3B
- Strain relief on each individual cable
- Significant weight reduction by using composite material

- Compact size: not exceeding outer diameter of connector
- Available in straight, 45° and 90° angles
- Max temp up to 200°C

CONTROLLED ELECTRICAL CABLES

Tyco Electronics has developed a reputation for the design, engineering, manufacture and supply of Aerospace and Defense high performance Controlled Electrical Cables to meet the needs of customer's specific applications, as well as applications requiring standard RF cables.

These cables use high performance proprietary materials in their construction and are available to meet a wide range of specifications and standards. Cables are available for most of the common aircraft systems such as ARINC 664 for Quadrax cables, ARINC 810 for CAN BUS or Galley systems, Ethernet or Gigabit Ethernet LAN systems are a few.



Each cable can be custom designed to provide different temperature rating, level of shielding and gauge size in order to meet with the environmental and electrical requirements of the specific system. To compliment this range of high performance data transmission cables, Tyco Electronics can offer a comprehensive range of compatible contacts or connectors that are suitable for the majority of the specific applications.

RAYATEN SCREEN TERMINATION SYSTEM

>> Tyco Electronics Rayaten screen termination range has been available for a number of years now, but it is worth reminding our customers of what it offers.

Tyco Electronics Rayaten screen termination system is a range of heat shrinkable moulded shapes and conductive adhesive which provide high levels of screening against electro-magnetic radiation across a

very wide frequency range. Screening is provided by continuous metal plating on the inside of the moulded part which conforms with the heat shrinkable shape upon recovery. The outstanding screening levels of the Rayaten screen termination systems, which matches the performance of optimised screened cables and high performance screened connectors, is combined with the exceptional physical and environmental performance of Tyco Electronics' Raychem brand moulding materials, and the benefits of Tyco Electronics heat shrinkable products.

MICRO MOULDED SHAPES

Connector manufacturers are increasingly offering smaller and smaller high performance, rugged, micro circular connectors for use in wiring looms in both civilian and defense markets.

The Tyco Electronics range of small heat-shrink moulded shapes has evolved in order to cater for these requirements and to meet the needs of the ever-increasing demand from the aerospace, defense, marine and automotive market for smaller, lighter-weight products that still offer a great balance of protection properties at the connector-wire interface.

UMBILICAL AND TETHER

Tyco Electronics heavy lift umbilical products combine the unique technologies of the Raychem and Rochester Cables brands. Irradiated, cross-linked
44 wire technology along with the STEEL-LIGHT fiber optic elements and preformed, corrosion resistant steel armor offer optimum size and strength cable packages for the heavy lift requirements of the offshore and marine industry.

Tyco Electronics neutrally buoyant tether cables benefit from high strength aramid packages and mechanically robust, flexible cable jackets and are custom designed to meet customer requirements. Tyco Electronics can also tailor the tether cable's buoyancy in order to maximize the products excursion length or to provide a positively buoyant material.

Tether and umbilical cables feature high voltage, high temperature, highly flexible power conductors, shielded twisted pairs, data bus or coaxial cables for data or video transmission and Rochester STEEL-LIGHT fiber packages.

COLD APPLIED SPLICE

There has been a long standing need for a "Cold Applied Splice" for the repair and protection of splices in the military and commercial aircraft aftermarket. Wire splicing has been seen as a major area of concern especially when heat guns are not allowed in areas such as the aircraft frame where potentially explosive fluids are present.

The cold applied splice concept is an immersion-resistant in-line splice made of a metal crimp splice, insulation sleeve and an innovative sealing material in a silicon gel which does not require any heat source during the installation. This product is lightweight and has a robust construction and a high mechanical strength. It is under qualification to the standard SAE-AS81824.

MILITARY QUALIFIED PRODUCTS LISTING

TERMINALS AND SPLICES

SPECIFICATION	TYCO ELECTRONICS PRODUCT	QPL
CRIMP		
SAE AS7928 Class 1 & Class 2	AMP PIDG Insulated Terminals	QPL-AS7928
SAE AS7928 Class 1 & Class 2	AMP PIDG Uninsulated Terminals	(Class 1 only)
SAE AS20659	AMP SOLISTRAND Uninsulated Terminals	
SAE AS25274	AMP PIDG Spare Wire Cap	
SAE AS17143	AMP PIDG Insulated Terminals	QPL-AS7928-2
SAE AS25036	AMP AMPLI-BOND, AMP PIDG and TERMINYL Insulated Terminals	
MIL-S-81824/1	Raychem MiniSeal Splices	QPL-81824
SOLDER		
SAE AS83519/1 & /2 and NAS 1747	Raychem SolderSleeve Shield Terminators	QPL-AS83519

PRINTED CIRCUIT BOARD CONNECTORS

MIL-C-21097/11, /13 to /17	AMP-BLADE Two-Piece Connectors	QPL-21097
SAE AS39029/1, /11 & /12	ARINC & Terminal Junction System Contacts	
SAE AS39029/57, /58, /63 & /64	AMPLIMITE Contacts	QPL-AS39029
SAE AS39029/73, /74	Raychem SolderTacts Contacts	
MIL-DTL-55302/23-/27, /110 & /113, 117-/119, /129-/130, /156, /173-/182	AMP-HDI, Box & Mini-Box Connectors	QPL-55302
MIL-DTL-55302/127, /128	AMPMODU Connectors	
MIL-DTL-55302/120-/124	MICRODOT MCEM Rectangular Connectors	

DISCRETE SOCKETS

MIL-DTL-83505/6	Augat HOLTITE Series Sockets	QPL-83505

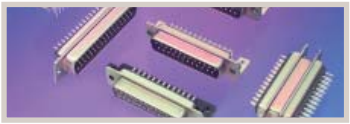
PIN AND SOCKET CONNECTORS

MIL-DTL-24308	AMPLIMITE Subminiature D Connectors	QPL-24308
SAE AS81714	AMP Terminal Junction System	QPL-AS81714
MIL-DTL-83513	MICRODOT Microminiature MCK Connectors	QPL-83513

RACK AND PANEL

MIL-C-81659	ARINC 404 Rectangular Style Connectors	QPL-81659
MIL-DTL-83723	Raychem Circular Connectors	QPL-83723

NASA PRODUCTS FOR SPACE



S-311-P-10 & -4	AMPLIMITE Non-Magnetic Connectors	
S-311-448 Fiber Optics	AMP Fiber Optic Connectors	GSFC-311-QPLD
S-311-P-13 Wire	Raychem Wire	
S-311-P-754 Relays	CII Relays	

MILITARY QUALIFIED PRODUCTS LISTING

RF PRODUCTS

SPECIFICATION	TYCO ELECTRONICS PRODUCT	QPL
MIL-PRF-39012	BNC, N, TNC, SMA Connectors	QPL-39012
MIL-PRF-55339	RF Coax Adapters	QPL-55339
MIL-C-83517	RF Coax Products	QPL-83517
MIL-DTL-22520	Crimp Tooling - RF Products	QPL-22520

RELAYS AND CONTACTORS

Low Power Electromechanical		
MIL-R-39016	CII Relays	QPL-39016
MIL-R-5757, MS27245 & MS27247	CII Relays	QPL-5757
Solid State		
MIL-PRF-28750	CII Relays	QPL-28750
Hybrid		
MIL-PRF-28776	CII Relays	QPL-28776
Contactors		
MIL-PRF-6106, MS24185 & MS27750	Hartman Contactors	QPL-6106
AN3303-2, AN3308-2, AN3320-1 & AN3324-1	CII Contactors (Fairview, NC)	
Mid-Range Electromechanical		
MIL-PRF-6106/19	CII Relays (Fairview, NC)	QPL-6106
MIL-PRF-83536	CII Relays (Fairview, NC)	QPL-83536
High Power		
MIL-R-83725	Kilovac Relays	QPL-83725
Hybrid & Solid State Time Delay		
MIL-R-83726/13	CII Relays	QPL-83726

HEAT-SHRINK MOLDED PARTS (RAYCHEM BRAND)

AMS-DTL-23053	Insulation Sleeving	N/A
SAE AS31091	Straight Boots	
SAE AS31171	Right-Angle Boots	
MIL-PRF-46846	Tubing	
SAE-AS81765	Insulating Components	

WIRE AND CABLE (TYCO ELECTRONICS AND RAYCHEM BRANDS)

SAE-AS22759	SPEC 44 and SPEC 55 Wire Wire - TE UK Ltd.	QPL-AS22759
MIL-DTL-24640	SPEC 44 Cable Cable - TE UK Ltd.	QPL-24640
MIL-W-81044	SPEC 44 Wire	QPL-AS81044
MIL-C-85485	ElectroLoss FilterLine Wire and Cable	QPL-85485

TOOLING

MIL-DTL-22520/36	AMP SMA Crimp Tool	QPL-22520
MIL-DTL-22520/37, /39	Raychem Splice Tool	
MIL-I-81969/1	Insertion/Extraction Tools	QPL-81969

CAN YOU FIND THE 10 MISTAKES?

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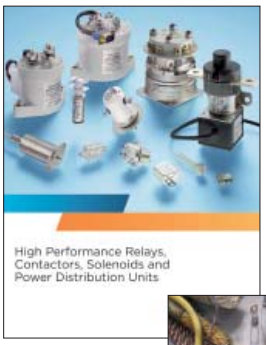

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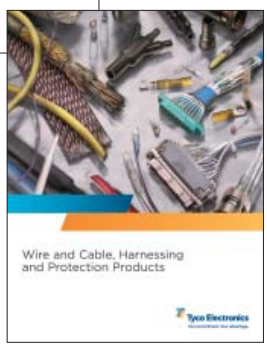

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Thought we only did Wire & Cable....?

Tyco Electronics provides an impressive list of products and capabilities to solve your needs for today and tomorrow:

- **Connectors**
- **Relays, Contactors, Solenoids & Circuit Breakers**
- **Wire and Cable**
- **Harnessing, Protection and Identification**
- **Value-Added Assemblies**
- **Sensors**
- **Switches**
- **Power Resistors**
- **Fibre optics**

Tyco Electronics focuses on the Aerospace, Defence & Marine industries with a dedicated sales and marketing team available across Europe ready to help and advise you on new and existing products.

Our early involvement in programmes, provide a systems approach that ensures compatibility and speeds up your development cycles, helping to reduce costs.

We back our products with expertise in electromagnetic shielding; high-speed circuit design; polymer science and metals and plating materials; quality assurance, testing and approvals; and programme management.

To find out more, please contact Claudia Wiedmann at: cwiedmann@tycoelectronics.com
www.tycoelectronics.com

Tyco Electronics
Our commitment. Your advantage.