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HARSH MILITARY ENVIRONMENTS DEMAND TOUGH SOLUTIONS



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ABSTRACT

There are few environments that come anywhere close to the harsh conditions of a wartime battlefield. Military equipment must be able to survive extremes of temperature, weather, vibration and shock rarely encountered in commercial applications. Key pieces of that equipment are the cables that interconnect the various devices mounted in military vehicles and on the soldiers themselves, together fulfilling applications such as short- and long-range communications, vehicle guidance and control, weapons control, and threat

detection. Failure of any component in these systems could result in exposure to the enemy and the resulting death of soldiers.

To help ensure that cables and connectors are not potential points of failure, ODU recently introduced its ODU AMC® Series T connectors, specifically designed for military and rugged applications.

THE BATTLEFIELD ENVIRONMENT

It surprises many people to know that there are currently more than twenty wars going on in the world, in each of which more than 1,000 lives have been lost. It seems that wars are an inevitable part of human existence, and that is why countries with technological capabilities must always remain vigilant and be prepared to defend themselves against outside threats. This implies that they must also be

constantly developing or seeking the best military equipment, in order to stay ahead of their enemies. But no matter how advanced the equipment may be, it would be worthless if proven to be unreliable in the harsh environment of the battlefield.



Fig 1.
Mud Covered Cable
Connection

Of particular importance in this regard are the cables and connectors that provide the linkage between various devices, such as a radio and its associated headset and microphone, or a landmine detector and its sensors. Cable failure in either of these cases could result in soldiers being killed.

What then are the harsh battlefield conditions which military equipment must be able to withstand, while continuing to function normally? They include:

- Temperature extremes
- Rain, snow and ice
- Mud, sand and dust (Figure 1)
- Immersion under water
- Vibration and mechanical shock

Each of these conditions has been studied extensively by appropriate standards' bodies, and desirable performance characteristics have been established for numerous classes of connectors and cables. This whitepaper focuses on connectors that meet Military Specification MIL-DTL-38999, which specifies four series of miniature, high density, quick disconnect, bayonet coupling, circular, environment resistant, electrical connectors, referred to as Series I, II, III and IV.

DESIGN SPECIFICATIONS

MIL-DTL-38999 encompasses all the required characteristics that ensure sustainable functioning of the four series of connectors in battlefield conditions. The full specification incorporates dozens of other MIL-STD specifications, totaling

hundreds of pages in length. However, in summary, the major physical requirements for harsh environment applications are as follows:

Temperature Extremes

History tells us that battles may be fought on the coldest days of winter in some of the coldest places on earth; or they may be fought on the hottest days of summer in some of the hottest places on earth. To accommodate both extremes,

connectors and cables must be able to function normally in temperatures ranging from -65°C to $+175^{\circ}\text{C}$.

Protection Class

The International Standards Organization (ISO) has defined a set of Ingression Protection (IP) codes that define the standards for the ability of connectors to prevent rain, snow, water, mud, sand, and dust from penetrating their shells. These codes are defined in Table 1 (pg. 5). Obviously, connectors and cables in the battlefield environment must be capable of withstanding the worst that mother nature can

throw at them, which translates to the connectors being rated at IP6K9K. Note that the ratings are cumulative. For example, IP6K.... means that neither dust nor tools can penetrate the connector shell, while IP....9K means that the mated plug and socket can continue to function when immersed in water to a depth of up to 1 meter, or when being washed in a high-pressure steam cleaning process.

Vibration

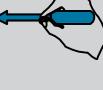
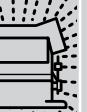
Tanks and other military vehicles do not offer the comfortable ride of a Cadillac – especially not when being driven over dirt roads marred by bomb craters! For MIL DTL 38999 compliance, connectors must withstand two types of vibration – sine wave and random. Sine wave vibration results from some continuously running system such as a portable

generator, while random vibrations are the result of driving on the dirt roads mentioned previously. The specification requires connectors to be capable of tolerating a continuous 30 g sine wave vibration in each of the three orthogonal directions for 4 hours each, and 37.8 g random vibrations in each of the three orthogonal directions for 8 hours each.

Mechanical Shock

Unlike vibrations, mechanical shocks are caused by individual events such as a nearby explosion or earthquake, or the cable/connector being dropped, trodden on or kicked. The

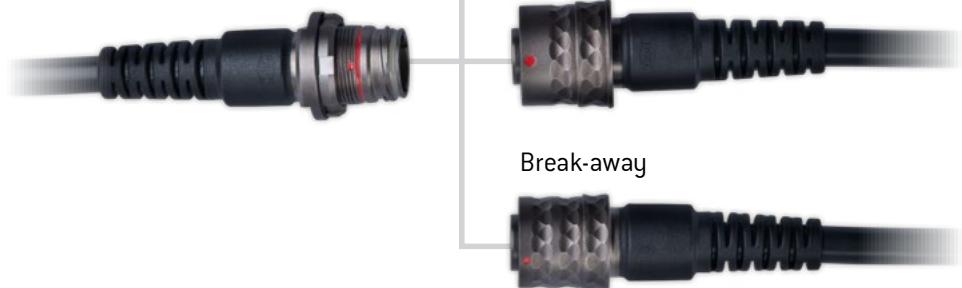
MIL-SPEC requires connectors to be capable of tolerating 18 shocks of 300 g lasting for no more than 3 milliseconds each.

Code letters (International Protection)		First code number (Degrees of protection against access to hazardous parts respectively against solid foreign objects)		Second code number (Degrees of protection against water)			
IP		6		5			
Code no.	Protection against access to hazardous parts / Protection against ingress of solid foreign objects			Code no.	Protection against harmful effects due to the ingress of water		
0	No protection		No protection against contact / No protection against solid foreign objects	0	No protection against water		No protection against water
1	Protection against contact with the back of hand (no protection against intentional contact)		Test probe with diameter 50 mm shall not penetrate completely and maintain sufficient distance from hazardous parts.	1	Protection against dripping water		Vertical drips shall not have any harmful effects or impair performance.
2	Protection against finger contact		Jointed test finger with diameter 12.5 mm may penetrate completely, but shall maintain a sufficient distance from hazardous parts.	2	Protection against dripping water (tilted)		Vertical drips shall not have any harmful effects or impair performance when the enclosure is tilted at any angle up to 15° on either side of the vertical
3	Protection against penetration of tools (e.g. screwdrivers)		Test probe with diameter 2.5 mm, may penetrate completely, but shall maintain a sufficient distance from hazardous parts.	3	Protection against spray water		Water spray at an angle up to 60° on either side of the vertical shall have no harmful effects or impair performance
4	Protection against granular foreign objects		Test probe with diameter 1.0 mm, may penetrate completely, but shall maintain a sufficient distance from hazardous parts	4	Protection against splashing water		Water which splashes against the enclosure from any direction shall not have any harmful effects or impair performance
				4K	Protection against splashing water with increased pressure		Water which splashes against the enclosure from any direction with increased pressure shall not have any harmful effects or impair performance
5K	Protection against dust		Dust shall only penetrate in quantities which do not impair performance and safety.	5	Protection against high-velocity water		Water which is directed against the enclosure from any direction as a jet shall not have any harmful effects or impair performance
6	Dustproof		Protection against contact with a wire / Complete protection against ingress of dust	6	Protection against powerful water jet		Water which is directed against the enclosure from any direction as a strong jet shall not have any harmful effects or impair performance
6K	Protection against ingress of dust		Dust shall not penetrate	6K	Protection against strong high-velocity water with increased pressure		Water which is directed against the enclosure from any direction as a strong jet with increased pressure shall not have any harmful effects or impair performance
				7	Protection against the effects of temporary immersion in water		Water shall not penetrate in a quantity causing harmful effects or impair performance if the enclosure is immersed in water temporarily under specified pressure and time conditions
				8	Protection against the effects of continuous immersion in water		Water shall not penetrate in a quantity causing harmful effects if the enclosure is continuously immersed in water under conditions which shall be specified by the manufacturer
				9K	Protection against water during high-pressure/steam-jet cleaning		Water which is directed against the enclosure from any direction shall not have any harmful effects or impair performance

AN INNOVATIVE SOLUTION

In recent years, military customers have been allowed greater flexibility in selecting suppliers. They are no longer required to buy only equipment that has been certified for inclusion on the Qualified Parts List, managed by the Defense Logistics Agency. As long as a vendor can provide independent test reports showing that its products meet relevant requirements of MIL-DTL-38999, those products are acceptable. Better yet, if a vendor enhances its products with innovations that go beyond the MIL standard, they may still be eligible for military use.

Fig 2. ODU's 3-in-1 Innovation



ODU has used this greater flexibility to develop a unique family of innovative products – its ODU AMC® Series T connectors. What makes the family unique is that a single female connector (socket) can accept any of three types of male connector (plug) – thread-lock, push-pull or break-away (Figure 2). This benefits manufacturers of equipment designed for use in diverse conditions because they only need a single model to service all environments.

These robust connectors are available in two sizes, shell size 9 or 12. They can be configured to support either electrical or fiber-optic interfaces. In the case of electrical interfaces, various pin configurations are available – 8 or 10 pins for shell size 9 connectors, and 5 or 18 pins for size 12 connectors. They are also available with either metal or plastic shells and optional overmolding to prevent any liquid, dust or gas ingressions where the cable enters the connector shell. All members of the family are rated at a minimum of 500 mating cycles.

Fig 3. Custom USB® cable



The various pin configurations noted above enable support for several standard high-speed interfaces. For example, Figure 3 illustrates a custom cable terminated at one end by an ODU AMC® Series T connector, and by a USB® connector (either USB® 2.0 or USB® 3.2) at the other end. Similar custom cables have been developed for Ethernet CAT 5 and HDMI® interfaces. ODU also offers high-volume manufacturing of custom cables such as these, if required by its customers.

MILITARY APPLICATIONS

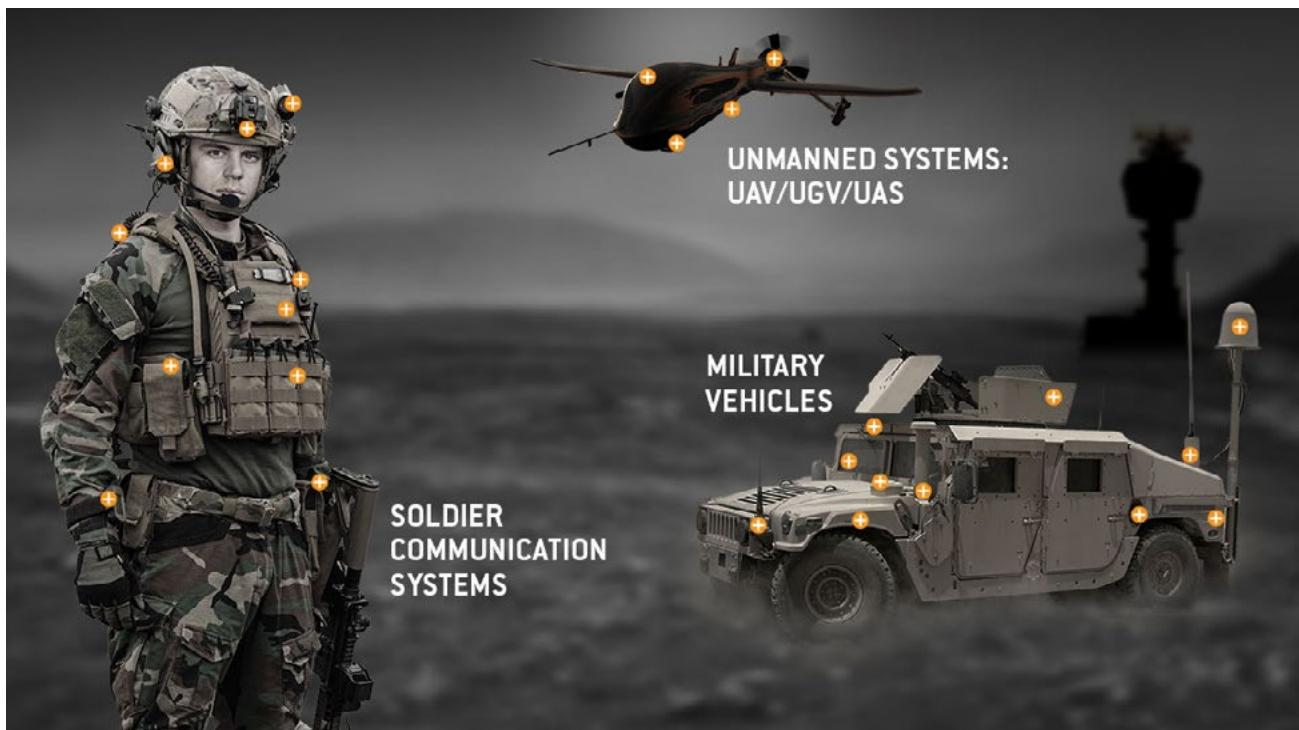
The orange dots shown in Figure 4, illustrate the numerous locations at which cables may be required to interconnect equipment worn by today's soldiers, as well as equipment installed on their vehicles and weapons systems. A complete list of potential military applications includes:

- Active protection systems (APS), such as cameras
- Robotics and autonomous systems (RAS), including smart munitions
- Counter drone systems (CUAV – Counter Unmanned Aerial Vehicle)
- Electronic warfare
- Jammer and counter IED (Improvised Explosive Device) systems

- Power distribution devices
- Radar systems
- Remote controlled weapon stations
- Tactical radios
- Training and simulation systems

An example that encompasses several of these applications is a major military vehicle manufacturer. The value-added cable design & manufacturing services offered by ODU, plus the renowned quality of its products, resulted in the selection of ODU AMC® Series T connectors and custom cables as the most effective solution for their needs. Of particular importance to this customer was the ODU AMC® Series T's tolerance to sine wave and random vibrations, as well as to mechanical shock.

Fig 4.



COMMERCIAL APPLICATIONS

Although the harsh conditions of an active battlefield may be unmatched, there are some commercial applications that come close. For example:

- Deep foundation machinery and equipment
- Forestry
- Heavy construction
- Mining
- Waste industry

A common factor with regard to the types of equipment used in these industries is vibration. Saws, milling machines, jack hammers, cement mixers and other heavy equipment all generate sine wave or random vibrations, making the ODU AMC® Series T connectors and custom cables a good choice for interconnected equipment co-located nearby.



CONCLUSION

The battlefield environment challenges military equipment designers to develop systems that can survive in some of the harshest conditions on earth. Cables and connectors are critical components of those systems, and they must be capable of meeting the rigorous tolerance standards for temperature, weather, ingressation, vibration and shock extremes defined by MIL DTL-38999. The ODU AMC® Series T connectors and custom cables meet all the requirements. The connectors also offer a unique feature that allows one type of socket to mate with any of the three plug types – thread-lock, push-pull or break-away.

If you are involved in the design or acquisition of military equipment that requires external connections for data, signals or power, ODU should be at the top of your supplier list!

*The contact arrangement of an ODU data transmission connector differs from a standard data transmission connector due to the robust ODU specific design. However, the ODU design meets the electrical specifications of the respective standard data transmission protocol

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