



Whitepaper

Transportation




Industrial



An engineer's guide to understanding connector for use in harsh industrial environments

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Connectors are often seen as the weakest link between sub-systems, and sometimes this is rightly so. This can be as a result of underspecifying the connector system or not appreciating the difference between the various rating schemes.

As a result engineers tend to over-specify the connectors to ensure they are reliable and don't impact on the performance of the rest of the system, or they use the interconnect parts list off previous designs. Unfortunately, this can lead to connectors that are larger and more expensive than they need to be. This has been particularly apparent when we have had discussions with industrial developers when they have quoted military specifications.

Connectors have to operate reliably in a wide range of environments and increasingly have to carry both power and signals without reducing the overall performance of the system. Humidity and electromagnetic interference (EMI) are among the biggest factors, with moisture and dust ingress being the primary concern in many situations.

Today's systems are also increasingly space-constrained, so equipment makers are looking for interconnect to carry data and power within a single connector/cable combination. As data networking rates and power consumption increases so does the need to pay attention to shielding within the cable and the connector. This is driving the need for effective EMI protection as equipment is packed more closely together and can interfere with each other.

In the industrial space for example, factory floor space is at a premium, so there is a demand to squeeze more and more electronics such as higher voltage motor drives and programmable logic controllers into a single control cabinet. This is driving manufacturers to adopt single connector designs to save space and make the systems easier to maintain and upgrade.

You may consider separate power and data connectors might be your best and cheapest option, however using a single connector solution not only saves space but introduces the right level of protection for the application. Using high end industrial versions can offer a wider range of solutions and be more cost effective against most MILSPEC variants and are typically off-the-shelf solutions.

EMI also needs to be considered carefully when combining signal and power contacts in a single shell. This can require more internal shielding to minimize power-induced noise, but can be much simpler than MILSPEC connectors that include diodes and even capacitor banks to protect against electromagnetic pulse (EMP) effects.

IP ratings

Within the IEC 60529 standard, IP67 and IP68 are the two most common rating over the basic IP54 specification. The ratings are split between two numbers that reflect the ability of connectors to resist solid particles and liquid particles, where the first number represents the solids and second number represents the liquids. See Figure 1.

Ingress Protection (IP) Ratings

Connectors may be susceptible to ingress of foreign materials such as moisture or dust, particularly in the unmated condition. Protection from this ingress is provided for connectors by their housing and the seal between the plug, jack, and cable or between a jack and a panel. The IP standard rating system defines the degree of protection provided. The standard IEC 60529 has specified the degree of protection and divided it into several layers, defined by the IP number, which has the letters IP followed by two digits. The first digit defines the protection against the ingress of dust particles, the second digit defines the protection against the ingress of water. The tables below show IP ratings for electrical connectors:

IP67

1 st Digit	Definition	2 nd Digit	Definition
0	No Protection against contact and ingress of objects	0	No Protection
1	Protected against any large surface of the body, such as the back of a hand. Protected against solid objects greater than 50mm in size.	1	Protected against water drops
2	Protected against access to hazardous parts by a finger or similar object. Protected against solid objects greater than 12.5mm in size.	2	Protected against water drops at a 15 degree angle
3	Protected against access to hazardous parts with a tool or thick wire. Protected against solid objects greater than 2.5mm in size.	3	Protected against water spray at a 60 degree angle
4	Protected against access to hazardous parts with a wire, screw, etc. Protected against solid objects greater than 1mm in size.	4	Protected against water splashing from any angle
5	Protected against access to hazardous parts. Dust protected.	5	Protected against water jets from any angle
6	Protected against access to hazardous parts. Dust-tight.	6	Protected against powerful water jets and heavy seas
		7	Protected against the effects of temporary submersion in water. Test requires 30 minutes at 1 meter depth.
		8	Protected against the effects of temporary submersion. Customer specification applies and specific testing may be required.
		9K	Protects against high pressures associated with steam cleaning.

Figure 1: IP rating standard – source Amphenol

For example, IP54: 5 is dust protected, while IP54:4 is splash proof. For high performance connectors in hostile environments, IP67: 6 is dust sealed while : 7 survives submersion to 1m for 30 minutes. IP68: 6 is also dust sealed, while : 8 supports submersion to customer specification

This means it is essential to find out the actual test used to determine the capabilities of the connector. IP68 could mean that the connector has been tested down to a depth of 1.1m for 31 minutes or it is capable of 100m for 10 years. Alternatively a well-designed IP67 rated connector may meet an IP68 requirement, but because it has not been tested to the particular specification, it has not been granted the IP68 rating.

IP69K addresses protection against high temperature and high-pressure water, able to withstand steam cleaning. The test specifies a spray nozzle that is fed with 80 °C water at 80–100 bar (1160-1450psi) and a flow rate of 14–16 L/min. The nozzle is held between 10 and 15 cm from a 5rpm rotating test bed at angles of 0°, 30°, 60° and 90° for 30 seconds each.

Example connector systems

Amphenol Industrial Operations now offers a new series of rugged connectors for use in harsh environments that has evolved from its military spec designs. The LPT (Lean PT) series is intended for use in factory automation, automotive, hybrid electric vehicles/electric vehicles, energy storage, power distribution, industrial instrumentation and process control applications.

Figure 2: Amphenol LPT series – source Amphenol



The LPT connectors are based on Amphenol's MIL-C-26482 series I and the original PT series but have an aluminum shell design that helps with the EMI protection. This metal connector, with improved structure, also features a standard PT shell with coupling nut, making it inter-mateable with the PT series. There are five shell styles, including box mounting receptacle, jam nut receptacle, straight plug, wall mounting receptacle and cable connecting receptacle, and a variety of finishes, including black zinc, nickel and gray zinc nickel

The LPT includes three retention tines with stamped and formed crimp contacts that can easily be inserted and ensure retention force. Contacts are available in gold, nickel or tin-plated and the connectors accept wire gauges from 22 AWG/0.34mm² to 12 AWG/3.5mm², have quick positive coupling and 5 key/keyway mating to ensure that users don't mis-mate when plugging into a receptacle. The series is waterproof to IP67 standard and self-extinguishing to UL94 V-0. The connectors can withstand 500 mating cycles and have an operating temperature range of -40° C to +125°C.

Similarly Souriau's TRIM TRIO family of connectors provides a common interconnect platform for harsh industrial environments such as automation and control, stage/ architectural lighting, energy, off road, mining and railways.

The family includes plastic circular, metal circular, high mating cycle, mixed power/ signal, and plastic rectangular shells and all use the same, uniquely designed, contact technology. A trio of contact types can be used: machined, stamped & formed, and high-speed. This simplifies the supply chain, reduces the complexity of production and allows designers to switch easily from one series to another.

Using this contact technology and based on the same connector design, the UTS, UTG and UTO series are interchangeable and inter-mateable. See Figure 3. These series also offer the quick-mating 1/3-turn-bayonet coupling system. The UTO is built using zinc and aluminum alloy for full EMI shielding with IP67, IP68 & IP69K in mated condition, while the ruggedized plastic UTS offers a lighter weight option and both offer a waterproof rating to IP68/69K. There are also multiway connection options in the lightweight bayonet UTG version.



Figure 3: Souriau – UTO series – source Souriau

The UTL series is a push-pull connector designed to comply with all modern safety standards as well as offering a quick and audible blind mating latch design. This series is also UV resistant and IP68/69K rated.

The metal shells of the UTO are strong and rugged to resist every environmental and mechanical requirement for indoor and outdoor applications. Amongst several characteristics, UTO offers possibilities on shielding, sealing, and salt spray through 8 shell sizes, 27 insert arrangements, and inter-mateable with the UTG, UTP, and UTS connector series. Mixed power and signal layouts can be included for single connector systems, with EMI attenuation of 98 dB at 1 MHz to meet the UL and IEC standard requirements.



Figure 4: TE Motorman connector – source TE Connectivity

The IP68/69K dynamic mated connectors are aimed at applications that are continuously underwater or need protection from routine pressure washing and dust protection, and can be validated up to 500 mating cycles. They also have protection against salt spray for 48 or 96 hours while still maintaining mechanical and electrical functionality.

One area where the combination of power and signal lines is particularly important is in decentralized servo motors that are typically connected via a deterministic system and power-fed by a separate cable. The Motorman hybrid connector from TE integrates communication, signal and power transmission of locally controlled motors within a single compact rectangular connector and also supports two fast Ethernet sockets to enable motors to be networked, providing the benefit of real-time automation.

The smaller size of the hybrid connector allows for significant space savings in comparison with traditional rectangular industrial connectors and reduces costs by reducing the amount of overall cabling needed as well as shortening cable length. The connector combines signal, power and data in a compact, rectangular housing. The 3-in-1 design reduces housing size by up to 50%, which creates more flexibility and space in machine architecture. The same applies for the cables of which up to 50% can be saved. The cable lengths can be shortened by up to 70% as well.

As the name suggests, the M23 connector from Smiths Interconnect is compatible with conventional M23 connectors but uses crimp contacts for various cross sections and various types of cable clamps to provide 360° EMC shielding connection for rugged environments. Using crimp contacts allows for a consistent high quality connection and reduces the total installation time of a connector by minimizing the number of operations.

The M23 connectors can be supplied with either machined or stamped contacts. The stamped contacts are supplied on a reel and feature an open crimp barrel design, making them suitable for higher volume applications requiring a fully automated process. Machined contacts feature a closed barrel design for manual hand tools.

The open barrel crimp contacts can accommodate a wider range of wire gauges and so can be used to limit the number of contact types required on applications containing mixed cable sizes. These are aimed at motor-drive applications such as machine tools, robots, conveyor systems, handling machines and elevators.



Figure 5: Smiths Interconnect M23 series – source Smiths Interconnect

Conclusion

Choosing the right supplier & specification for environmental protection for a connector system can avoid the costs of over-engineering a system and you should consider these solutions early in your design cycle. As demand increases for single connectors combining power and signal lines to save space in industrial equipment, the temptation is to choose the interconnect platform with the highest performance to ensure the reliability and performance of the system. However this can lead to higher costs.

By identifying the environmental needs, from dust and water ingress to EMI interference, engineers can optimize the interconnect, selecting from the wide range of shell and contact options. This would also allow for a more cost effective and complex network with a reduced footprint.



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