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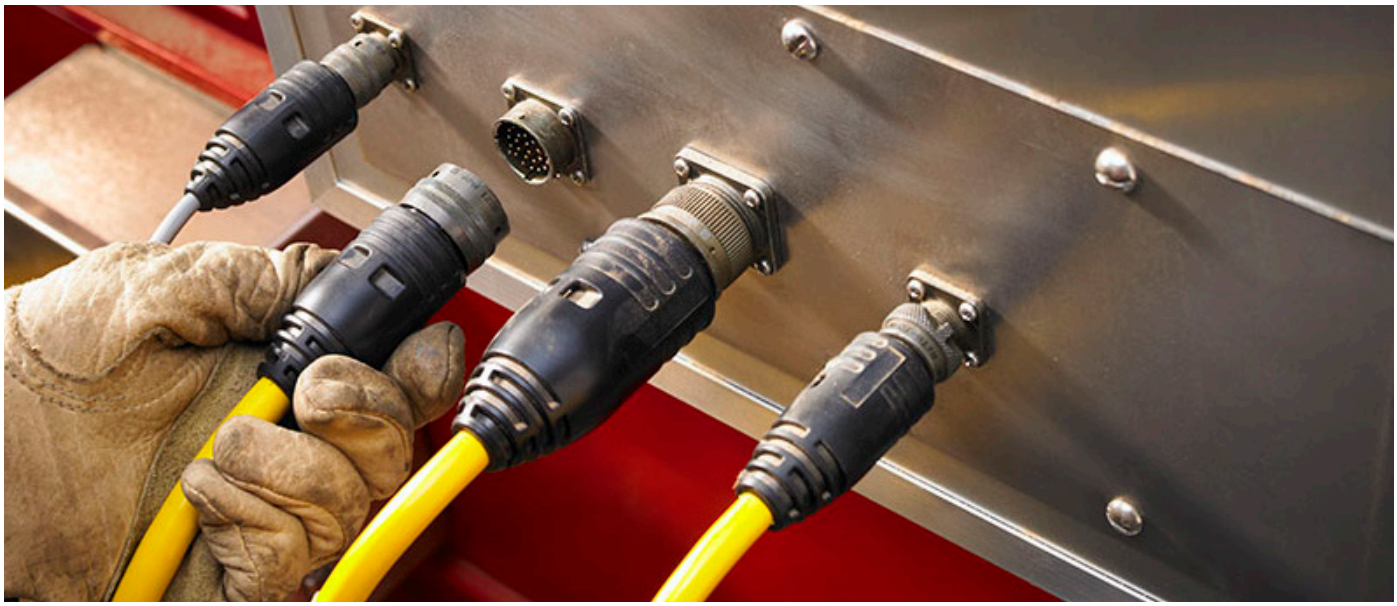
Connectivity
Design Considerations For Harsh Environments

White Paper | W1019



Design considerations for reliable connectivity in harsh environments

Moving industrial processing trailers to field locations places this specialized equipment in extreme environments, with exposure to wide temperatures ranges, UV exposure and constant vibration during transit.

In the face of these challenges, one oil and gas trailer manufacturer noticed its connectivity components were consistently breaking as part of routine transportation and installation. The company needed to upgrade to more robust cables and connectors.

After surveying the market, the manufacturer chose overmolded Deutsch connectors and a new cable whose design withstands extreme heat and cold, the chemicals of operation and exposure to the elements. By doing so, the company was able to accelerate installation time of the trailers and provide a more dependable solution for its customers.

This trend of replacing legacy connectivity components continues to rise across industries, as engineers, system designers and OEMs require increasingly rugged solutions to maintain reliable connectivity in harsh environments.

In response, connector and cable designs have evolved as connectivity manufacturers keep pace with these user and application demands. From innovative overmolded solutions to stainless steel potted connector bodies, today's products improve performance and are more convenient than traditional field-assembled connectors.

This white paper discusses the key criteria to consider in choosing harsh-environment connectivity products, specific design considerations for automotive, mobile equipment and oil and gas applications, and best practices in choosing a robust and reliable solution.

Factors that affect connectivity performance

A number of factors influence how a connector or cable solution preforms in an environment. Material selection and chemical compatibility are two leading criteria because they can directly affect the integrity of the solution for a specific application.

Plastics are the primary material used to protect connectors and cables from the elements of harsh applications. The plastic material that is used has a critical impact on chemical compatibility, and variations have been developed for specific uses (*figure 1). For example, certain materials can withstand very cold temperatures without cracking, while others resist high temperatures that would compromise another plastic's integrity.

*FIGURE 1

Plastic	Abbreviation	Best use	Not suitable for
Thermoplastic Polyurethane	TPU	Common oils, cutting fluids	Alcohols, solvents
Polyvinyl Chloride	PVC	Wide range of temperatures (-40°C to 105°C), food and beverage environments	Weld slag resistance, alcohols, solvents
Polybutylene Terephthalate	PBT	High temperatures	Caustic materials
Polypropylene	PPRO	When caustic materials are present, washdown environments	High temperatures, UV exposure
Thermoplastic Elastomer	TPE	Welding applications, alkalines, alcohols	Solvents, greases

Overmolded connectors are recommended for demanding applications because of their reliability and robust construction. These solutions are more than simple plastic housings. Instead, they insulate and protect all the connection points between the cable and the connector against ingress. These fully assembled products are also factory tested and provide ease of installation and improved performance.

With the different plastic material options available, there are overmolded connector solutions to withstand most chemicals in harsh applications. However, some applications can be so demanding that a plastic overmolded body may not offer enough protection.

Complete assembled connectivity packages can provide trusted solutions in demanding environments.

For these applications, there are connector options that utilize a stainless steel housing filled with potting material. This type of solution provides improved mechanical strength and can still hold up well in applications with highly caustic chemicals. There are also versions of this connector that allow for additional hazardous location approvals. With stainless steel connector bodies, grade 316 stainless steel offers the best option for durability in harsh industrial environments. Grades 303 and 304 can be more susceptible to corrosion with highly caustic chemicals.

Once materials and chemical compatibility are taken into account, engineers can review the next layer of specifications: ingress protection, vibration, temperature and pull strength. These specs support a solution's reliability.

Ingress protection

Ingress protection ratings, commonly referred to as IP ratings, demonstrate a product's ability to resist environmental pollutants like dust and water. They are standard ratings set by IEC, NEMA, self-certification and other industry standards.

Engineers should look for a minimum of IP65 protection on cables and connectors used in harsh applications. This ensures no penetration

of dust or jet water. IP69K is the highest level of ingress protection offered, ensuring protection against dust and water at high pressure. It is ideal for food and beverage applications, and washdown environments.

Vibration

Vibration can threaten to disconnect the coupling feature of a connector and disrupt data transfer through the connector. To withstand this hazard, the design and quality of connectors, contacts and cable is critical.

To prevent a connector from coming loose, the connector design must have special features that maintain engagement even at high shock and vibration. The contact design must prevent the mating interface from intermittent connections or damage by vibration.

The contact materials and plating are another critical element for strength, durability and electrical performance. Some criteria to look for in the most robust connector and cable products include:

- Machined contacts, instead of stamped or formed, for better performance
- Gold plating, instead of tin plating, for better electrical properties
- High-stranded wires, instead of solid wires or minimal stranding, for best cable flex

When sourcing a connectivity solution, a supplier will ask a series of questions like the ones below to better understand the application and how it may affect a connector or cable. Assembling details about your application in advance can accelerate this process. Depending on the complexity of the application and environmental factors, a supplier may travel to see the application in person or recommend a custom solution to provide the best performance.

- How would you describe the application?
- What chemicals are present, and at what percent dilution?
- How exposed will the product be to these chemicals, and how often? Will the product be submerged, splashed or wiped down?
- Are explosive or hazardous gases or vapors present?
- What temperature or temperature range is typical?
- Will the cable flex?
- Is vibration and shock a factor? What frequencies or G-forces will be seen on the connectors?
- Is there opportunity for impact on the cable or connectors?
- What's the current and voltage?
- Is this an indoor or outdoor application? Are sunlight, UV and/or water exposure possible?
- What IP ratings are required?

Temperature

The temperature of an application can affect performance if the right material isn't in place. Extremely cold temperatures can crack cable jackets or plastic connector bodies, and some materials will break down over time in very hot environments.

For the best-fitting solutions, look for connectors and cables whose rated optimal temperature ranges meet those of the application. Don't forget to take into account potential issues caused by fluctuating temperatures. Rapid temperature fluctuations can result in pressure changes, which can pull in moisture. This ingress can create electrical performance issues. If the application is

susceptible to rapid temperature changes, be sure to choose a suitably rated product.

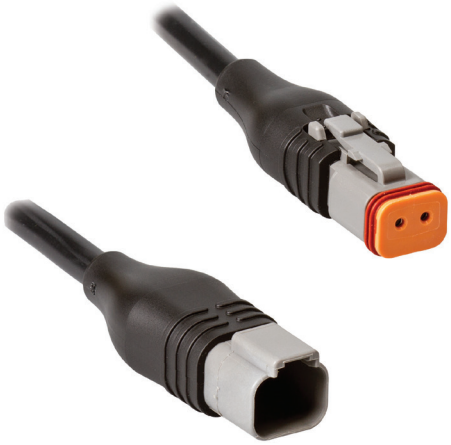
Pull strength

Cables and connectors can experience a lot of force in industrial environments, from getting bumped during operation to serving as improvised step ladders. A product's pull strength indicates how well a connector will hold up to these forces.

A good bond between the plug body and cable is one indicator that a product is likely to exhibit strong pull strength. An additional feature to look for is that the back of the coupling nut is extended over the connector's plug body. This allows any angular forces to be absorbed between the plug body and coupling nut, and not directly on the wire to contact terminations.

Improving connectivity for automotive, mobile equipment and oil and gas applications

With exposure to temperature fluctuations, the outdoors and heavy duty use, mobile equipment and oil and gas industries offer unique harsh-environment challenges. In automotive applications, specific obstacles include welding, metal forming and metal stamping.



Overmolded Deutsch solutions increase longevity and can provide superior performance over standard connectors.

Advances over the past few years have transformed commonplace Deutsch connectors into robust overmolded solutions that stand up to vibration and ingress. These can be used outside the cab to improve connectivity where moisture and the elements have historically caused repeated failures. They're also protected during cleanup and washing.

Vibration issues can also be solved through correct installation. If connectors and cable aren't mounted down properly, they can end up floating as machinery runs, leading to connection failures. Installation is another area where overmolded connectors excel. Companies have run timed studies to determine if overmolded or in-house, hard-wired assembled solutions work better for an application. While overmolded products may cost more from an upfront material standpoint, the companies found their overall cost of operation was reduced because these products required less time and effort to install.

Oil and gas applications face similar outdoor environmental challenges as mobile equipment, but also involve caustic chemicals in drilling muds and the potential need for hazardous location approvals.

Hazardous location approvals ensure a product is safe to use in hazardous locations. Oil and gas companies are increasingly looking for more international approvals to ensure global safety compliance and streamline product inventory. For example, a cordset with both ATEX and IECEx approvals can be specified for use not only in North America, but across Europe and other continents.

Related to ATEX and IECEx connectivity products, field-assembled solutions are still most commonly found in process automation and oil and gas applications; however, some manufacturers now offer fully assembled cable solutions. Because all elements come assembled and factory tested, the products reduce the risk of miswiring while also accelerating installation time and reducing labor.

Automotive manufacturing environments include some of the more challenging, heavy duty

connectivity applications. As parts are welded together and formed or stamped to shape, cables and connectors must be able to withstand the specific demands of these processes.

Material selection is one of the best criteria to use when narrowing the field of options for cables and connectors in automotive operations. TPE plastics are ideal for welding applications because their composition is resistive to pitting commonly caused by weld slag. For metal forming and stamping, TPE and TPU cables are best choices because they hold up to common cutting fluids and oils.

Robust solutions improve connectivity in harsh environments

Harsh environments present some of the most challenging circumstances for connectivity, from water or caustic chemicals to vibration and temperature. It's critical to take into account key factors like materials and chemical compatibility, and understand how an environment interacts with a product. By relying on these best practices, engineers can choose a reliable and robust solution that resists harsh environments and solves their application challenges.