



REPORT

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# Breaking Boundaries: Uniting Ruggedization and Miniaturization in Connector Design

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# INTRODUCTION

The electronics industry has long grappled with the trade-off between ruggedness and miniaturization. Ruggedized components designed to withstand harsh conditions are often bulky and heavy for added protection. Conversely, miniaturized components, valued for their compact form factor, can be perceived as more delicate and less robust.

Why can't we have both?

We are at a turning point. Advanced materials science, innovative design techniques and evolving manufacturing processes are driving the emergence of a new generation of connectors. These connectors defy the traditional trade-off, providing both exceptional durability and compact size.

Born from the automotive industry, more space-efficient interconnects that could withstand harsh conditions satisfied the needs of vehicles overloaded with new electronic features. This convergence is now transforming other industries, enabling the development of smaller, lighter and more reliable products that can excel in the most challenging environments.

How can ruggedized miniature connectors move the landscape of electronic devices forward? Let's look ahead.





# THE CONFLUENCE OF RUGGEDIZATION AND MINIATURIZATION

Design engineers across industries may still believe that a rugged component must also be bulky. Historically, ruggedized electronic components have had larger form factors, while miniaturized alternatives have been perceived as delicate. To understand how small and mighty merged, let's explore their origins in the auto industry.

## THE AUTOMOTIVE REVOLUTION

Necessity remains the mother of invention. In the late twentieth century, features like anti-lock brakes, electronic fuel injection and early infotainment systems were introduced. As demand grew for these electronic features, so did the need for smaller, more reliable connectors. Early attempts to miniaturize connectors often resulted in components that lacked the robustness required for the harsh automotive environment. This spurred manufacturers to innovate, developing robust miniature connectors that could withstand demanding environmental conditions.





## THE DATA CENTER ON WHEELS

The popularization of hybrid electric vehicles (HEVs) and electric vehicles (EVs) has only further intensified the need for small, durable connectors. As more electronic systems have been introduced in modern vehicles, the need for dependable, space-saving components is increasingly evident. The average automobile contains about a mile of wiring, which tips the scales at over 100 pounds.

Modern vehicles are also packed with sensors, cameras and communication systems, requiring high-performance interconnects in confined spaces.

All of these automotive advancements have laid the foundation for the miniaturized rugged connectors we see today, which have since found applications in many industries beyond the automotive and transportation category.



## EXPANDING HORIZONS

Emerging from the automotive industry, the trend of rugged miniaturization is now permeating across various industries, from consumer electronics and IoT devices to industrial machinery and smart agriculture. An extensive selection of mini-ruggedized hardware available as off-the-shelf components is changing the game for design engineers and enabling key functionality in applications such as:



### Consumer Electronics

- **Fitness Trackers and Smartwatches**  
These lightweight, high-functioning devices require protection against sweat, water and impact during daily use.
- **Action Cameras**  
Densely packed action cameras must maintain signal integrity and deliver power while protecting internal components during extreme activities.
- **Smart Home Devices**  
Smart thermostats and video doorbells can maintain a minimal footprint thanks to smaller connectors that also provide high durability for reliable device operations indoors and outdoors.





## Industrial Automation

- **Human-Machine Interfaces (HMIs)**  
Touchscreens and buttons provide reliable operator interaction even in harsh factory conditions.
- **Industrial Robots**  
Robotic arms receive dependable power and data transmission to operate in demanding industrial settings.
- **Sensors**  
Sensors continue to collect data accurately despite exposure to dust, vibration and temperature extremes.



## Medical Devices

- **Endoscopes**  
These devices maintain optimal image quality and device functionality during procedures.
- **Insulin Pumps**  
Accurate and uninterrupted insulin delivery is made possible thanks to strong connections between internal components.
- **Wearable Health Monitors**  
Sensors are comfortably and unobtrusively connected while being protected from sweat and movement.







## Aerial/Aviation Devices

- **Electric Vertical Takeoff and Landing Aircraft (eVTOLs)**  
Critical flight systems receive reliable power and signal transmission despite the elements and conditions of low-altitude flight.
- **Mapping and Surveying Drones**  
High-powered LiDAR and camera equipment function properly in a compact design, providing accurate data collection.
- **Delivery Drones**  
Drones withstand the rigors of delivery operations, ensuring secure payloads and reliable navigation and communication.



## Smart Agriculture

- **Vertical Farming Systems**  
Dense sensor and lighting installations maintain long-term reliability in humid environments.
- **Crop Monitoring Drones**  
Drones are protected against ingress and vibrations during flight for optimal data collection.
- **Soil Moisture Sensors**  
Buried sensors deliver reliable data transmission despite moisture, pressure and impacts.



## BROADENING THE SCOPE OF RUGGED MINIATURIZATION

The full scope of opportunities for compact, durable components is still largely untapped and yet to be realized. Rugged, miniature parts may lead to further advancements in nascent and expanding fields, such as flying tractors, eVTOL aircraft, vertical farms, space exploration, aerospace and defense applications, wearable technologies or remote weather stations.

## EMERGING TECH RELIES ON RUGGED MINIATURIZATION

Let's briefly consider two examples of burgeoning aerial technology that, if adopted broadly, could dictate the future of smart agriculture and transportation.

### Flying Tractors

In smart agriculture, the advent of "flying tractors" (or agricultural drones) could very well redefine agriculture as we know it. These unmanned aerial vehicles (UAVs) can execute precision farming operations like crop monitoring, spraying and data collection. To do so, flying tractors must utilize small but mighty connectors.

Connectors in agricultural drones require high resistance to vibration and shock, as they experience shaky conditions during takeoff and while maneuvering through turbulent skies. Operating outdoors, connectors in flying tractors are subject to environmental extremes inherent to farming applications, including dust, moisture, extreme temperatures and corrosive chemicals from pesticides and fertilizers. Agricultural drones rely on real-time data transmission for

navigation, control and data collection. These requirements demand miniature connectors with high bandwidth and low signal loss to help farmers make informed decisions in real time.

### Electric Vertical Takeoff and Landing Aircraft (eVTOLs)

While there are regulatory hurdles to overcome, imagine a drone that's capable of transporting humans comfortably. Often cited as the closest we've come to flying cars, eVTOLs could represent a major leap in personal transportation. These boundary-breaking aircraft, powered by electric propulsion systems, could become commonplace as autonomous flying taxis or aerial ride-sharing vehicles.

The underlying technology of eVTOLs hinges on rugged miniature connectors to unlock their full potential for urban air mobility. Electric propulsion systems, while promising quieter and cleaner operation, present significant weight challenges due to the heavy batteries required for flight. This constraint, coupled with stringent safety regulations, underscores the need for lightweight yet durable components. Miniaturized connectors, with their compact size and robust materials, address these needs by reducing overall aircraft weight, maximizing range and efficiency, and ensuring critical systems remain operational despite potential low-altitude incidents. This resilience is crucial for safety and the economic viability of eVTOLs, protecting the significant investment these vehicles represent. eVTOL companies can expand their potential customer base by increasing their payload capacity.

Today, engineers no longer must think of "rugged" and "miniaturized" as mutually exclusive — durable mini connectors will enable new types of devices and systems.



# DEFINING THE NEW LANDSCAPE: WHAT SETS MINIATURIZED AND RUGGEDIZED CONNECTORS APART

The widespread adoption of rugged, miniaturized connectors signals a paradigm shift in design philosophy across industries. No longer seen as opposing forces, miniaturization and ruggedization are now converging to create a new generation of components. But what exactly sets these innovative connectors apart from their predecessors?

## BRINGING TOGETHER THE BEST OF BOTH WORLDS

Merging the strengths of ruggedization and miniaturization can reshape product design and performance. For the context of this report, miniature connectors generally imply a connector with a pitch of 2.54mm or less. A rugged connector is defined as a connector possessing features that allow it to withstand harsh environmental conditions and mechanical stresses. These features include vibration and shock resistance, ingress protection, thermal resistance, corrosion resistance and general durability.





## Enhanced Space Efficiency

By freeing up space within electronic devices, rugged miniaturized connectors enable more compact designs and increased functionality. This is particularly important in applications where size and weight constraints are major factors. By reducing the overall footprint of connectors, engineers can design lighter-weight devices that perform better and deliver longer battery lives.

## Improved Reliability

Miniaturized rugged connectors are engineered to withstand the rigors of challenging environments due to their robust construction and resilience to shock, vibration, temperature extremes and environmental hazards. This enhanced durability translates to longer product lifespans, reduced maintenance requirements and increased reliability in demanding operating conditions. For example, in the automotive industry, where connectors must endure a 15-year lifespan under harsh conditions, these robust components minimize failures and downtime, ensuring consistent performance throughout the vehicle's lifecycle. Similarly, in industrial settings, where equipment is often subjected to constant vibration and chemicals, durable connectors play a crucial role in maintaining overall system performance.

## Optimized Signal Integrity

Although compact, rugged miniaturized connectors can maintain high signal integrity and electrical performance. This is possible due to innovative contact designs, optimized signal routing and the use of high-quality materials with strong conductivity properties. This ensures reliable data transmission,



## Molex Reliability Lab: Ensuring Performance Under Pressure

Molex's commitment to reliability extends beyond design and material selection. The **Molex Global Reliability Lab** rigorously tests connectors under extreme conditions, simulating real-world stressors like vibration, temperature cycling, and exposure to harsh chemicals. This comprehensive testing ensures that Molex connectors not only meet but exceed industry standards, providing engineers with confidence in their long-term performance and reliability. The lab adheres to the internationally recognized ISO/IEC 17025 standard for laboratory excellence, ensuring the highest quality and capability in testing and validation for customer projects.



power delivery and overall functionality, even in challenging environments with high levels of electromagnetic interference (EMI) or radio frequency interference (RFI).

### **Increased Design Flexibility**

Rugged miniaturized connectors allow engineers to fit more features and functionality into smaller spaces, as well as explore new form factors, creating new products that were impossible in previous generations. This newly unlocked design freedom can lead to innovative product designs. Smartwatch designers now incorporate more diagnostic capabilities into a typical watch-sized package, allowing for continuous remote monitoring of vital signs like heart rate, blood pressure and oxygen saturation.

## **WITH INNOVATION COMES CHALLENGES**

While rugged compact connectors offer valuable benefits, they also introduce design and manufacturing roadblocks:

### **Material Selection and Processing**

Designing lighter, smaller and stronger connectors with the required mechanical strength and electrical properties for reliable signal and power transmission in a miniature form factor is challenging. Processing these materials into complex connector geometries often calls for specialized techniques such as micro-molding, high-precision machining, laser welding or selective plating. These techniques allow engineers to work with the intricate shapes and tight tolerances required for miniaturized rugged connectors.

### **Thermal Management**

As devices become more powerful and compact, heat dissipation becomes a concern. Miniaturized connectors, with reduced surface area, may struggle to dissipate heat effectively, potentially leading to decreased performance or device failure.

### **Signal Integrity and Crosstalk**

Incorporating multiple signal lines into a smaller connector increases the risk of crosstalk and signal interference, potentially causing data errors and system instability. As device interconnectivity grows, ensuring signal integrity is critical for reliability. Engineers mitigate these issues through techniques like differential signaling, shielding and optimized PCB layouts, enabling high-performance data transmission even in compact connectors.

### **Mechanical Reliability**

By including features such as locking mechanisms, strain relief features and contact designs, connectors can be optimized to withstand the stresses of vibration, shock and repeated mating cycles.

### **Manufacturing Complexity**

Producing smaller, robust connectors often involves intricate processes, extremely tight tolerances and specialized equipment. This requires careful planning and optimization for the manufacturer.

While challenges remain, the benefits of rugged miniaturized connectors are already being realized. Advances in materials science provide many solutions to these challenges.





## MATERIALS SCIENCE ADVANCEMENTS

Engineers are increasingly turning to innovative materials that offer the ideal combination of lower weight, durability and electrical conductivity to meet the growing need for smaller, tougher connectors.

### The Shift Away from Copper

Driven by the need for lighter, more efficient designs, engineers are shifting away from copper in favor of alternative materials. While copper is an excellent conductor, its weight and bulk pose challenges, leading to the trend of “lightweighting.”

Lightweight alternatives, such as aluminum alloys and specialized high-strength steel, offer comparable or superior electrical conductivity while substantially reducing the overall weight of the connector. However, engineers must carefully consider factors like thermal expansion coefficients, corrosion resistance and mechanical properties compared to copper. A thorough evaluation must be completed to ensure the selected material can withstand environmental stresses and operating conditions of the intended application.

### The Resilience of High-Performance Polymers

High-performance polymers (HPPs) transcend the traditional limitations of materials, offering a combination of lightweight construction and exceptional durability. These advanced materials not only enable the creation of smaller, lightweight connectors but also enhance durability and resilience in extreme conditions.

HPPs feature exceptional mechanical properties, including high tensile strength, stiffness and impact resistance, allowing connectors to withstand physical stresses. Additionally, HPPs offer excellent thermal stability, maintaining their structural integrity and electrical performance over a wide temperature range. Polybutylene terephthalate (PBT) offers a balance of strength, stiffness and chemical resistance, making it a versatile choice for connector housings and other components.

Liquid crystal polymers (LCPs), for example, show exceptional resistance to extremely high temperatures, making them ideal for applications including automotive engine compartments and aerospace electronics. Another popular



HPP, polyphthalamide (PPA), is known for its high melting point and low moisture absorption. This provides dimensional stability and mechanical strength in demanding environments.

## INNOVATIVE MINIATURIZATION TECHNIQUES

To achieve rugged miniaturization, engineers face a unique conundrum — achieving robustness without sacrificing compactness. This dilemma demands creative approaches, with some of the following breakthroughs leading the way:

### Dense Pitch Layouts

Achieving higher contact density through reduced pitch spacing presents engineers with the problem of overcrowding. While the benefits of increased functionality within a smaller footprint are undeniable, the close proximity of contacts increases the risk of crosstalk and poses challenges for effective heat dissipation due to reduced airflow and higher heat density. To mitigate these issues, engineers use advanced signal routing techniques, shielding and isolation methods, along with thermal management strategies like heat sinks or thermal vias.

Dense pitch layouts also demand high precision in manufacturing and assembly. But once these challenges are overcome, they can deliver improved signal integrity, reduced signal loss and, in some cases, lower power consumption.

### Multi-Functional Terminals (MFTs)

Expanding versatility even further, multi-functional terminals (MFTs) represent a significant leap forward in miniaturized connector technology. By integrating

multiple functionalities — such as power, signal and even mechanical features like locking mechanisms — into a single compact unit, MFTs eliminate the need for multiple connectors. This streamlines device design and reduces component count. As MFT designs evolve, we can expect these components to integrate even more functionalities, pushing the boundaries of connector design.

### Miniaturized Printed Circuit Board (PCB) Connectors

Characterized by exceptionally small footprints and fine-pitch contacts, miniaturized PCB connectors contribute to decreased device footprints and increased functionality. They allow for smaller PCBs, creating an intricate nerve center in modern electronic devices.

To achieve their micro status, miniaturized PCB connectors rely on advanced contact designs and materials. Some designs use spring-loaded contacts to maintain steady contact force despite thermal expansion and contraction. Others use high-conductivity materials like Gold or Palladium to minimize resistance and signal loss. Their contribution to lower overall system weight and power consumption makes miniaturized PCB connectors ideal for portable and battery-powered devices.

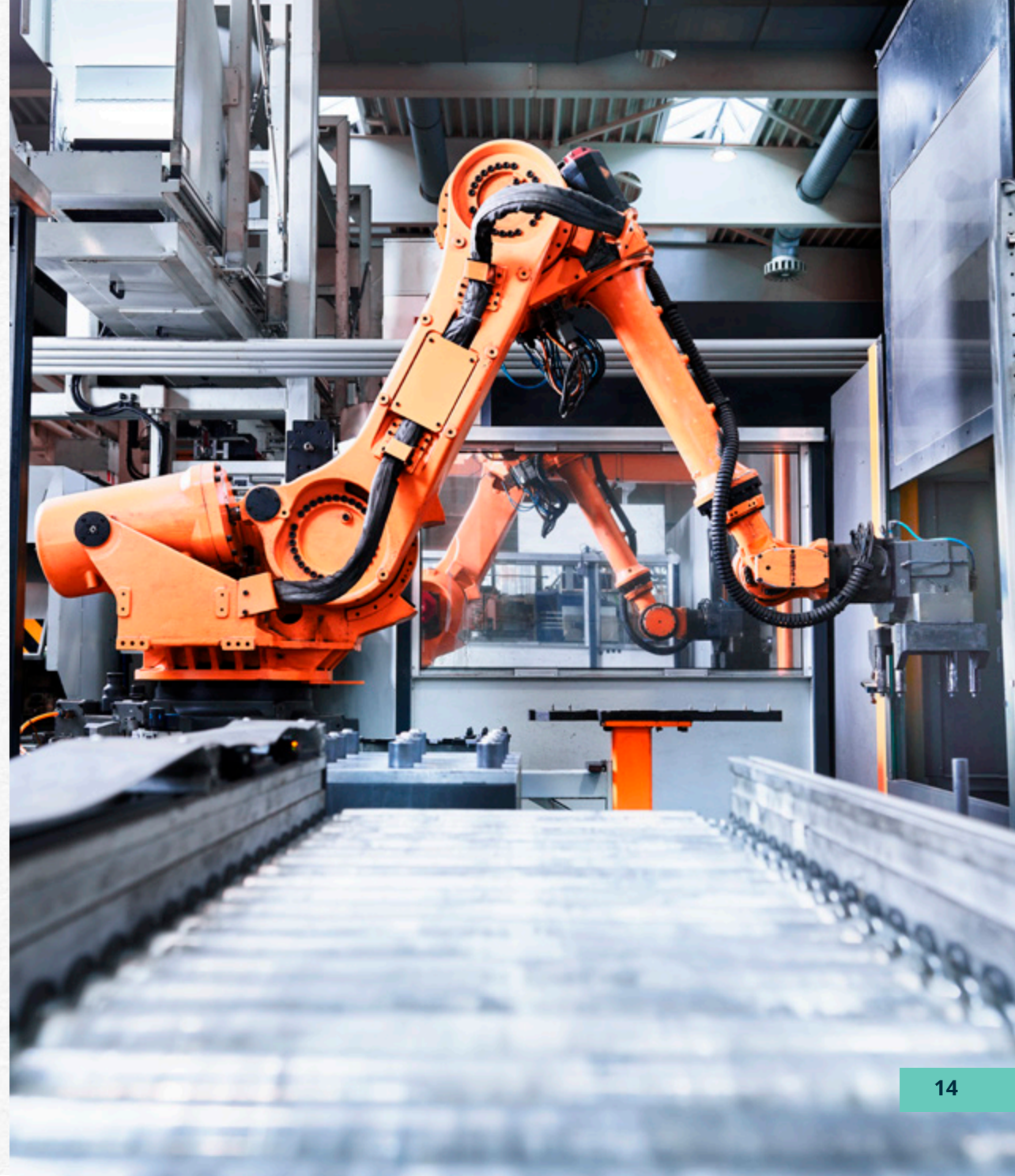
The advancement in ruggedized miniature connector technology is a testament to engineering ingenuity, overcoming the inherent tradeoffs between size and durability to create components that are both compact and resilient. This ongoing evolution promises to unlock new possibilities for electronic device innovation across industries.



# THE MINIATURE RUGGEDIZATION IMPERATIVE: ENVIRONMENTAL CHALLENGES AND SOLUTIONS

Miniaturized rugged connectors are enabling innovation across a wide range of industries. However, to ensure reliable performance in these diverse applications, these connectors must be designed to withstand a variety of environmental hazards. Due to their reduced size and mass, miniaturized components can be more susceptible to damage from environmental factors. This vulnerability underscores the importance of ruggedization to maintain reliability and functionality.

Ruggedization is not just about adding protective layers or increasing the bulk of a connector; it's also a holistic approach that considers the entire lifecycle of a component, from design and material selection to manufacturing and testing. This section explores how environmental factors can compromise component reliability and the strategies engineers are using to create connectors that deliver optimal performance in harsh conditions.







Molex **Micro-Lock Plus Connectors** address vibration challenges with a robust positive locking mechanism that ensures secure mating and prevents accidental uncoupling in high-vibration environments. Additionally, the connector's metal solder tabs provide added strain relief to the solder joints, further enhancing its resistance to mechanical stress and vibration.

## VIBRATION

Electronic devices often experience jostling and shaking. Whether on the factory floor or in the high-altitude conditions of aerospace applications, vibration can wreak havoc on delicate electrical connections.

Mitigating the impact of vibration is crucial for design engineers. This requires a deep understanding of vibration frequencies, amplitudes and durations, and the specific vulnerabilities of the connector in its intended application environment. To combat the threat of vibration, engineers are implementing solutions to enhance the vibration resistance of miniaturized connectors, including:

- **Positive Locking Mechanisms**

Technologies like Terminal Position Assurance (TPA) and Connector Position Assurance (CPA) provide secure mating and prevent unintentional de-mating due to vibration.

- **Strain Relief Features**

By including features like flexible overmolding, bend-limiting boots and flexible PCB tails, connectors are protected against wire breakage and harming fragile solder joints.

- **Floating Contact Designs**

In a floating contact design, connector contacts lack rigid fixation within the connector housing. Instead, they are designed with a small amount of wiggle room, allowing them to shift ever-so-slightly inside their cavities. A few methods to achieve this floating effect include using spring-loaded contacts, flexible contact beams or floating contact carriers.



- **Potting and Encapsulation**

Filling the connector housing with a resilient material like epoxy can reduce the impact of vibrations and protect internal components. This encapsulating layer acts as a buffer, absorbing and dissipating vibrations. Potting also provides a protective barrier against external environmental contaminants.

## INGRESS PROTECTION (IP)

Moisture, dust and corrosive chemicals are always seeking entry points into connectors, threatening to disrupt electrical connections. Ingress protection (IP) comprises more than compliance with industry standards — it is a foundational design consideration critical to the functionality and reliability of modern devices.

The challenges of IP are magnified in miniaturized connectors. Smaller form factors and tighter tolerances leave less room for error, making them more susceptible to the damaging effects of outside contaminants. Even a single drop of water or a speck of dust can lead to corrosion, shorts and, ultimately, device failure. However, through engineering ingenuity, designers have developed solutions to strengthen miniaturized connectors against these elements.

- **Seals and Gaskets**

O-rings, gaskets and other elastomeric seals provide physical barriers to prevent the ingress of outside elements. Factors like compression set (the permanent deformation of the seal under pressure) and chemical resistance help engineers select the ideal material for the seal to guarantee long-term performance. Seals and gaskets are not a one-size-fits-all decision.

Designed to combat ingress challenges with UL-approved IP68-rated seals, **Molex Squba Connectors** offer enhanced protection against dust and prolonged submersion in water. This robust sealing, combined with protective caps to safeguard the seals during handling and assembly, ensures reliable performance even in harsh environments.







- **Seal Caps and Covers**

Additional protective caps or covers can be added to connectors to provide an extra layer of protection against ingress, especially during storage, handling or transportation.

## **EXTREME TEMPERATURES**

Devices are increasingly subjected to extreme temperatures. From the scorching heat of automotive engine compartments to the subzero conditions of space exploration, temperature extremes can wreak havoc on electronic connections.

Designing for thermal resilience is a critical challenge that demands careful consideration and innovative solutions. Thermal stress can lead to many problems that can render electronic systems inoperable. High temperatures accelerate material degradation, causing plastics to soften, metals to expand and adhesives to fail. At the other extreme, low temperatures can make materials brittle, leading to cracks and fractures. Some key strategies can ensure optimal performance in these conditions.

- **High-Temperature Polymers**

As previously mentioned, materials like PBT, LCP and PPA offer exceptional thermal stability. PBT, for instance, has a continuous operating temperature range up to 150°C, making it a go-to choice for under-hood components, interior parts and electrical connectors in automobiles.





Molex **DuraClick Connectors** exemplify the combination of miniaturization and thermal resilience, featuring high-temperature PBT housings and secure terminal retention to withstand extreme automotive environments. This robust design ensures reliable performance in demanding applications where high temperatures and vibrations are common.

- **Low-Temperature Materials**

In applications exposed to extreme cold, materials with low glass transition temperatures ( $T_g$ ) and high impact resistance — such as certain polyurethanes and silicone elastomers — are less likely to become brittle.

- **Thermal Management**

Heat sinks and thermal vias, among other strategies, can be integrated into the PCB or device design near the connector to support efficient heat dissipation. This is especially important in high-power applications or in environments with limited airflow.

- **Contact Materials and Plating**

Gold and Palladium plating offer excellent resistance to oxidation and corrosion, ensuring reliability even when exposed to high temperatures. Their high melting points and inert nature make them ideal for protecting base metals from the degrading effects of heat.

By addressing these environmental challenges, engineers aren't simply mitigating risks — they're actively shaping the future of electronics. The ruggedization of miniaturized connectors is a fundamental design principle that will continue to empower modern technology to thrive in the most demanding conditions.



# THE FUTURE OF MINIATURIZED RUGGED CONNECTORS

The convergence of miniaturization and ruggedization isn't a destination, but an ongoing journey. As devices continue to evolve, so, too must the connectors that enable them. Ongoing research and exploration are leading to advancements to address existing challenges and will also unlock new possibilities for electronic devices in demanding environments. As we strive for smaller, lighter and more powerful devices, connectors will play an increasingly pivotal role in ensuring their reliability, performance and longevity.

## EMERGING TRENDS

At what point will connectors be as small (yet still durable) as physics allows? The short answer is: we haven't gotten there yet. Emerging trends continue to push the boundaries of more compact, reliable and functional connectors.

### Flexible Electronics (FPCs and FFCs)

Flexible printed circuits (FPCs) and flexible flat cables (FFCs) are shaping the form factor and functionality of devices. Their inherent flexibility offers engineers more design freedom, conforming to complex shapes without compromising performance. This advancement opens possibilities for wearable devices, flexible displays, implantable medical devices and soft robotics.







Molex **Premo-Flex Flat Flexible Cables** feature an innovative design with staggered pins and fine pitch, enabling a higher circuit count in space-constrained applications. Delivering durable and flexible PCB connections, these solutions are available in an extensive range of off-the-shelf and custom options.

FPCs and FFCs can be integrated directly into a connector's design, eliminating the need for rigid PCBs and reducing overall size and weight.

### Nanotechnology (Materials and Coatings)

Enhancing connector materials at the molecular level, nano-scale coatings can impart exceptional hardness, wear resistance and corrosion protection to connector contacts. Nanomaterials like carbon nanotubes and graphene offer superior electrical and thermal conductivity. Incorporating these materials into connector design can enable smaller, more efficient connectors with improved signal integrity.

Taking this potential even further, nano-engineered materials have the potential of possessing self-healing capabilities, where microscopic cracks can be automatically repaired. Certain nanomaterials, like microcapsules or vascular networks, can release a healing agent or trigger a chemical reaction that repairs damage.







### 3D Printing (Additive Manufacturing)

Already an option for many custom connector projects, 3D printing has the potential to transform both the design and manufacturing of rugged miniaturized connectors. Additive manufacturing allows for the creation of complex geometries and sophisticated internal structures that were previously impossible with traditional manufacturing methods. 3D printing enables on-demand manufacturing, reducing lead times and inventory costs, and facilitates less costly and time-consuming low-volume production runs. Additionally, the ability to rapidly prototype new designs with 3D printing accelerates development cycles, allowing engineers to iterate and optimize connector performance more quickly.

## MARKET OUTLOOK

The global market for rugged miniaturized connectors is poised for significant growth. The relentless demand for these products across a broad spectrum of industries gives no indication of slowing down. A February 2024 market research study by Verified Market Reports related to rugged, miniature and ruggedized miniature connectors **predicts a steady compound annual growth rate** (CAGR), with some estimates exceeding 6% annually.

In addition to this demand, standardization efforts are expected to accelerate the adoption of rugged miniaturized connectors. The development of industry-wide standards for areas like dimensions, electrical characteristics and environmental performance will also lead to compatibility between different connector systems. This standardization will streamline design and manufacturing processes, further increasing connector accessibility.

The future of rugged miniaturized connectors will continue to require innovation. Expect a continuous cycle of applied ingenuity to forge ahead into new possibilities for connector design. Engineers who embrace these emerging trends will be well-positioned to lead this charge.

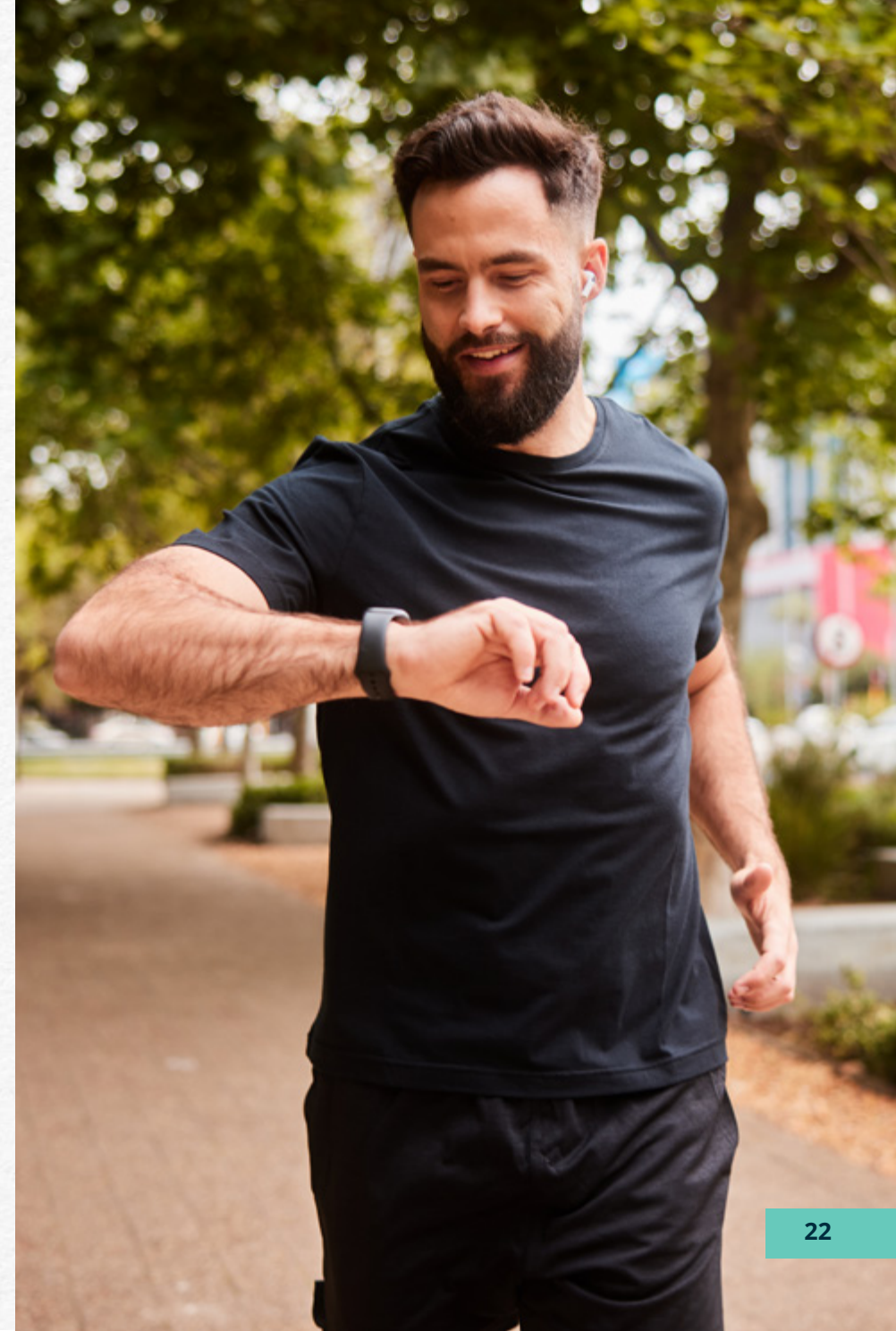


# MOLEX: BUILDING A MORE CONNECTED WORLD

The successful miniaturization and ruggedization of electronic connectors have already yielded far-reaching benefits. Today's compact, durable components not only outperform their predecessors but also enable significant advancements in device design and functionality. From intricate electronic systems in EVs to wearable sensors monitoring our health, rugged miniaturized connectors drive modern technology, transforming industries and improving lives.

Recognizing the vital role of miniaturized rugged connectors in these diverse applications, Molex has developed a comprehensive portfolio of solutions designed to address specific industry challenges. The **DuraClik connector** system, for instance, offers robust performance in high-vibration and high-temperature environments, making it ideal for demanding automotive and industrial applications. Molex **Squba connectors**, on the other hand, provide exceptional ingress protection, ensuring reliable operation even in harsh outdoor conditions. For applications where space constraints are paramount, the **Micro-Lock Plus connector** system delivers compact size and secure mating without sacrificing reliability.

As a global leader in connectivity solutions, Molex is committed to pushing the boundaries of miniaturization and ruggedization. With a deep understanding of the challenges engineers face, Molex is constantly researching and developing cutting-edge technologies to meet the evolving needs of the market. Our extensive portfolio of high-performance connectors encompasses a wide range of applications. By applying the principles and emerging solutions discussed in this report, Molex delivers connectivity solutions that set the standard in performance, reliability and durability. Let's keep innovating together to create a more connected future.







*creating connections for life*