

WHITE PAPER

OPTIMIZING AUTOMOTIVE ASSEMBLY: SINGLE WIRE SEALS AND CAVITY PLUG INNOVATIONS FOR EFFICIENCY AND LONG-TERM PERFORMANCE



INTRODUCTION

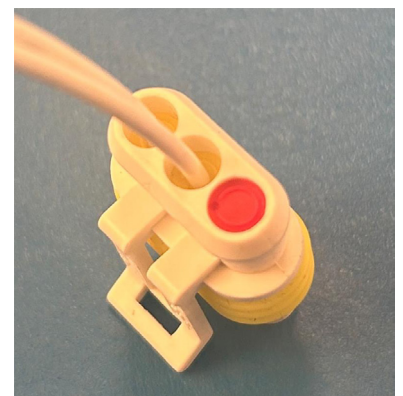
Automotive manufacturers face increasing demands for lightweight, electrified platforms that maintain structural integrity and NVH performance. At the same time, global production networks require components that are easy to install, cost-effective, and standardized across multiple vehicle architectures. TE Connectivity's sealing systems and cavity plugs play a vital role in achieving these objectives by preventing water ingress, reducing noise and vibration, and protecting against corrosion. This paper explores how TE's portfolio combines design for manufacturability with durability optimization, ensuring efficiency without compromising reliability.

TE Connectivity's sealing and cavity management solutions are designed to address critical automotive challenges: reducing assembly complexity, improving production efficiency, and ensuring long-term durability in harsh environments. This whitepaper examines how TE's single-wire seals and smart cavity plugs deliver measurable benefits through advanced material science, precision engineering, and design innovations. These solutions enable OEMs and suppliers to optimize manufacturing processes while meeting stringent performance and sustainability requirements.

DESIGN FOR MANUFACTURABILITY

TE's single-wire seals represent a significant advancement over traditional multi-wire designs. Conventional seals often require multiple layers and precise alignment, increasing assembly time and error risk. TE's single-wire seals feature a streamlined geometry that reduces installation steps by up to 50%, enabling faster assembly and minimizing handling. For example, a typical multi-wall seal may require 45–60 seconds for installation, while TE's single-wire design can be installed in 25–30 seconds. This improvement translates into 20% faster assembly, 15% lower scrap rates, and reduced labor costs.

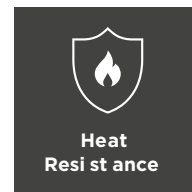
TE's smart cavity plugs further enhance manufacturing efficiency. Adaptive geometries allow a single plug to fit multiple cavity diameters, reducing SKU complexity and simplifying inventory management. Integrated clips and sealing features enable quick, reliable installation, while lightweight polymer materials maintain structural strength and reduce overall vehicle mass. These innovations support automated assembly processes and help OEMs achieve cost savings without compromising quality.



WHY IT MATTERS

Single wire seals (SWS) and cavity plugs are critical subcomponents designed to maintain environmental sealing at the individual thermal and unused cavity level within multiway connector housing. SWS elements typically encircle the conductor insulation, maintaining compression against both the wire and the connector cavity.

MAIN FUNCTIONS



ONE-STOP-SHOP SOLUTION PROVIDING A COMPLETE SEALED AUTOMOTIVE CONNECTION SYSTEM ADDRESSING ALL PERFORMANCE AND SAFETY REQUIREMENTS WHILE HELPING REDUCE SUPPLY CHAIN



Broad, complete portfolio providing a one-stop-shop solution for automotive applications



Protect connectors from dirt, dust, and water ingress



Global manufacturing footprint and supply chain



Harness automation ready



Increased performance, safety, and longevity of your electrical connection



Reliable, safe and validated solutions



40-60 ShA hardness range



Three interlaces: Wire, Contact and Cavity



48V architecture enabled



IP67 waterproof protection



Cavity compatible with some competitor terminal systems

DURABILITY & RELIABILITY

TE's sealing solutions are engineered for long-term performance under extreme conditions. Single wire seals made from **Liquid Silicone Rubber (LSR)** and **High Consistency Rubber (HCR)** maintain integrity through thermal cycles ranging from 40°C to +120°C, resist chemical exposure from coolants, oils, and road salts, and withstand dynamic loads caused by vibration and body flexing. These silicone based materials deliver **excellent compression set resistance**, ensuring stable sealing force over time, while optional surface treatments enhance UV and chemical durability. Together, these features support compliance with OEM specifications and ISO standards, enabling a service life of 10+ years.

TE's cavity plugs, also produced from **LSR and HCR**, provide critical protection against corrosion by blocking moisture ingress into body cavities. Their robust sealing performance complements body in white corrosion prevention strategies, including e coat and seam sealers. Accelerated aging and salt spray validation demonstrate that TE's silicone cavity plugs significantly reduce corrosion related failures compared to conventional designs, helping maintain structural integrity and minimize warranty exposure throughout the vehicle lifecycle.

Selecting the right materials is essential to achieving reliable sealing performance in demanding automotive environments. TE's portfolio of single wire seals and cavity plugs is engineered using three primary material families—**EPDM, Liquid Silicone Rubber (LSR), and High Consistency Rubber (HCR)**—each offering unique advantages in temperature resistance, sealing behavior, durability, and processability.

The comparison chart below provides a clear, side by side view of how these materials differ in mechanical properties, chemical resistance, manufacturing suitability, and cost considerations. This overview helps engineers quickly identify the optimal material for their application, whether the priority is high temperature stability, precision molding, long term aging performance, or cost efficiency.

	EPDM	LSR (Liquid Silicone Rubber)	HCR (High Consistency Rubber)
Polymer Type	Ethylene Propylene Diene Monomer	Liquid Silicone (platinum-cured)	Solid Silicone (peroxide or platinum cured)
Typical Processing Method	Compression / Injection	Liquid Injection Molding (LIM)	Compression / Transfer / Injection
Temperature Range	-40°C to +125/150°C	• -50°C to +130 (standrd grades) • Up to 200°C (fluoro silicone grades)	• -50°C to +150 (standrd grades) • Up to 200°C (fluoro silicone grades)
Low Temperature Flexibility	Good	Excellent	Excellent
High Temperature Stability	Moderate	Excellent	Excellent
Compression Set (at high temp)	Moderate	Very Low	Ultra Low
Long-Term Aging Resistance	Good	Excellent	Excellent
Tear Strength	Good	Moderate	Good (higher than LSR in many grades)
Elongation at Break	High	High	High
Hardness Range (Shore A)	40-90	20-80	30-80
Dielectric Properties	Good	Excellent	Excellent
Ozone / UV Resistance	Excellent	Excellent	Excellent
Resistance to Water & Glycols	Excellent	Excellent	Excellent
Resistance to Engine Oils	Limited	Limited to Moderate	Limited to Moderate
Fuel Resistance	Poor	Poor	Poor
Dimensional Precision (Small Seals)	Good	Excellent	Good
Flash Formation	Moderate	Very Low	Moderate
Manufacturing	Good	Excellent (highly automated)	Moderate
Material Cost	Low	High	High
Tooling & Equipment Cost	Moderate	High	Moderate
Best Application Areas	Cost-driven, non-extreme environments	High-volume, miniaturized connectors, high-temp zones	Custom compounds, higher mechanical robustness

SYNERGY BETWEEN MANUFACTURABILITY AND RELIABILITY

TE’s design philosophy demonstrates that simplified components can enhance durability. Fewer parts mean fewer potential failure points, and consistent installation improves sealing performance. TE leverages advanced digital simulation tools, including finite element analysis (FEA) and computational fluid dynamics (CFD), to optimize seal and plug geometry for both assembly efficiency and long-term reliability. This integrated approach reduces prototype iterations by up to 30%, accelerating time-to-market and delivering significant cost savings.



FUTURE OUTLOOK

As EV platforms become mainstream, TE is advancing sealing and cavity management solutions with lightweight, thermally stable materials and recyclable polymers to support sustainability goals. Digital manufacturing tools, such as predictive analytics and digital twins, will further optimize design validation and lifecycle performance. TE remains committed to driving innovation that meets evolving OEM requirements for efficiency, durability, and environmental responsibility.

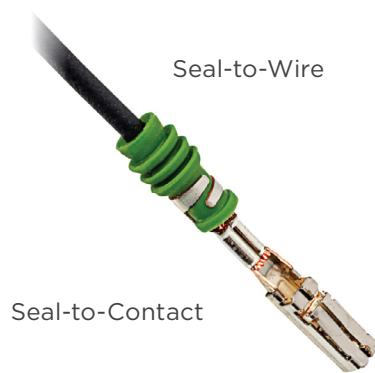
TE CONNECTIVITY SEALS PORTFOLIO

Single Wire Seals (SWS)

- Multi-lip configurations creating three layers of redundant sealing
- Silicon rubber offers a high mechanical resistance in numerous operating temperatures
- Material hardness specified at 50-60 Shore A (ShA) durometer providing optimal compression, tear resistance and durability required
- Lubrication for wire passage through the seal to reduce damage when inserted into the cavity



Single Wire Seals (SWS) consist of three sealing interfaces:

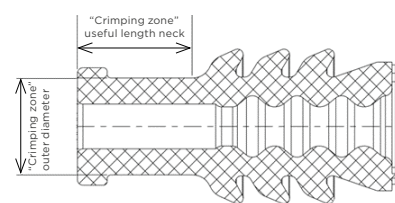


SEAL-TO-WIRE

The SWS is automatically placed on the wire where the outer diameter is within a well-defined range. This wire size is linked to the hole dimension of the SWS and is smaller in diameter to have geometrical interference needed to create the sealing. Seal geometry with two to three lips is generally adopted to provide a point-distributed sealing pressure against the cable.

This geometry allows three main advantages:

- Multiple sealing surfaces are better than a continuous sealing surface due to possible cable shape defects.
- The inner lip profile assures good sealing even when the wires are bent.
- Fluid pressure drops occurs from the first lip to the second lip. For this reason, fluid infiltration is avoided.



Seal-to-Contact Details

SEAL-TO-CONTACT

The seal is crimped onto the contact. The outer diameter of the “crimping zone”, the useful length of the neck where the terminal crimp hugs the silicone, and the presence or not of a collar (defined by design) are important parameters to ensure the contact barrels close and retain the SWS without generating cuts on the surfaces. The crimp quality is fundamental to ensure a proper seal-to-contact interface..



Seal-to-Cavity

SEAL-TO-CAVITY

The sealed contact is inserted into the cavity. The difference between the outer diameter of the seal and the cavity diameter generates a radial compression of the rubber element and the consequent sealing pressure at the interface. This interference causes additional closure pressure on the wire interface increasing the tightness level towards the cable.

Cavity Plugs

TE's cavity plugs are used to seal a single connector cavity where no contact is used and can be used in either female or male housings with some that are cavity compatible with competitor terminals. The geometrical profile is fully sealed from the single wire seal element with the exception that it does not have an inner hole for wire.

Rubber material selection is very often limited to the silicone rubber with a ShA hardness range that is generally between 50 and 60; lubricant in the rubber raw material is generally not requested to increase the seal retention into cavity, as there is not any mechanical constraint for this rubber element.



- Silicon rubber material selection with a ShA hardness ranging between 50-60
- High level seal retention into cavity

CONCLUSION

TE Connectivity's single-wire seals and smart cavity plugs offer OEMs and Tier suppliers a compelling solution to two critical challenges: simplifying assembly and ensuring long-term reliability. By adopting these technologies, manufacturers can achieve measurable gains in cost efficiency, corrosion protection, and sustainability. TE's portfolio is designed to deliver performance today while anticipating the needs of tomorrow's automotive architectures.

For more information, visit www.te.com/seals

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