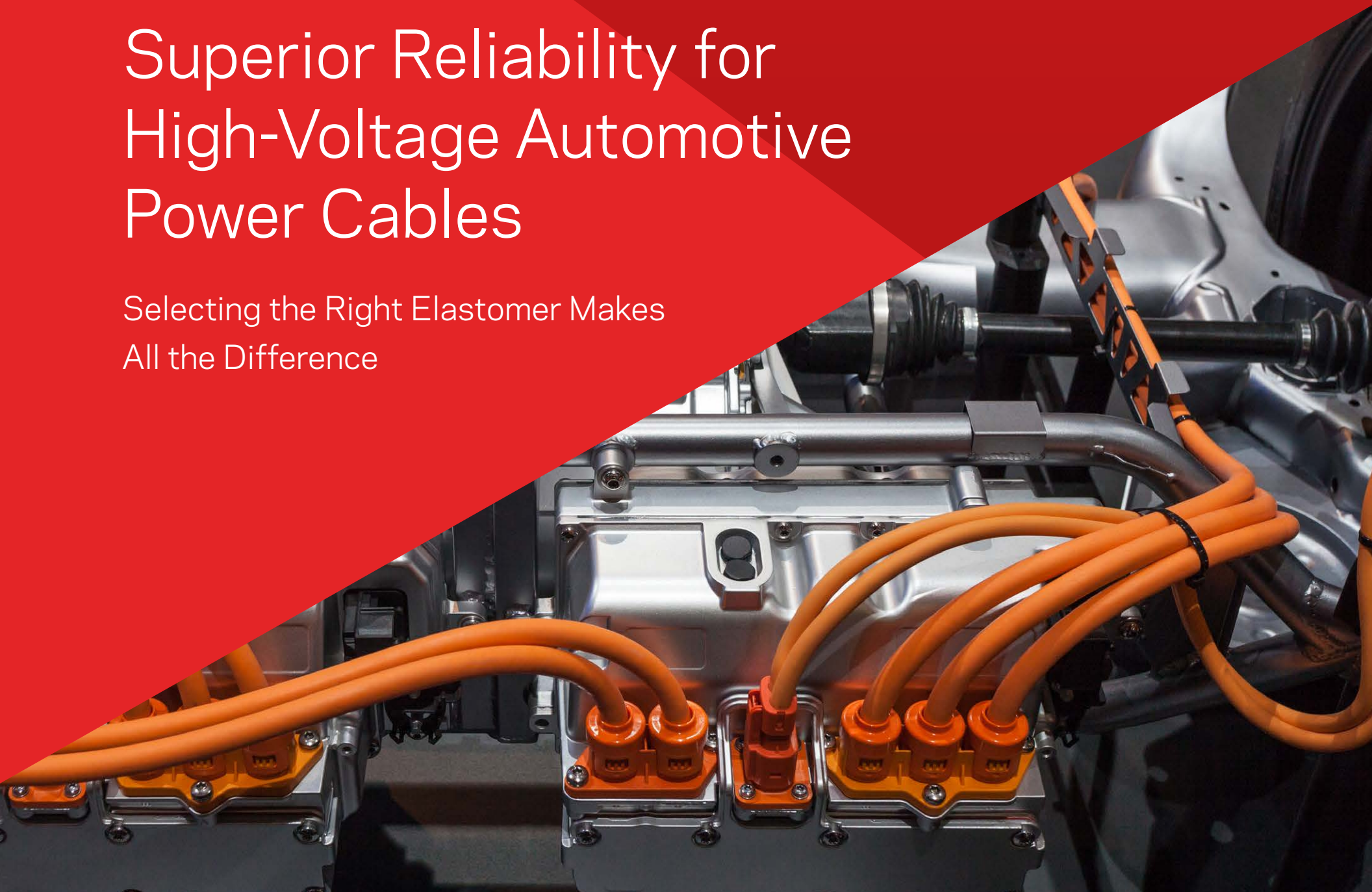
# Superior Reliability for High-Voltage Automotive Power Cables

## Selecting the Right Elastomer Makes All the Difference



## Meeting Growing Demand for Durability in High-Voltage Automotive Power Cables

With a shift toward renewable energy policies in countries around the world, there's a growing emphasis on sustainable transportation options, including electrified vehicles (EVs).

As automotive original equipment manufacturers (OEMs) are working hard to remove barriers to the adoption of EVs by the public, greater focus is being placed on improving the battery systems necessary to power these vehicles. In order to increase energy efficiency and increase driving range, some manufacturers are switching to higher voltage systems. As a result, the use of larger diameter power cables in full hybrid and battery EVs is increasing significantly.

This change is creating the need for high-performance materials to be used in the manufacture of power cables that connect the battery, motor and inverter in order to guarantee both performance and safety of vehicle operation. It's critical that these materials have the right combination of electrical insulation properties and temperature and chemical resistance.

The automotive industry expects the wire harness market segment to grow at a compound annual growth rate (CAGR) of 4% through 2024.* The need for large diameter high-voltage power cables is expected to grow much faster than that as the number of EVs being produced will grow at a CAGR above 30% from 2021 to 2026.**

*Global Power Electronic Market for Electric and Hybrid Vehicles Report 2020: Integration of Power Components for Modular and Flexi-Electric-Vehicle Platforms to be Key Focus Until 2025, Research and Markets

**Global Light Vehicle Production Forecast 2020-2032, IHS Markit

# A Demanding Environment Calls for Materials That Go the Distance

Choosing materials that can stand up to high temperatures, high voltage and longer periods between inspections is especially important in the design of EVs.

## High Temperatures

EV manufacturers are increasingly specifying automotive large-diameter, high-voltage cables to withstand operating temperatures exceeding 180°C (356°F)—an increase in service temperature from 150°C (302°F).

## Longer Service Gaps

EVs tend to require less scheduled maintenance than their conventional counterparts, because the battery, motor and related electronics require very little regular maintenance.* Without as many regular inspections, the parts used in EVs need to be ready to go the distance and EV manufacturers will need to depend on the durability and longevity of each material they use.

## Passenger Safety

Lithium ion batteries used in EVs generate a large amount of heat during use. This increased temperature can affect the life and performance of the battery, as well as the safety of those inside the vehicle. Viton™ fluoroelastomers are designed to resist a broad range of chemicals and to withstand temperatures above 200°C (392°F). Viton™ Fluoroelastomers provide a proven solution to address these known EV issues.

## High Voltage

Cables need to be larger in order to effectively accommodate and distribute the power generated in a higher voltage system. This can be a challenge when working in environments where space is already at a premium. To manufacture and install these larger cables, automotive OEMs will need materials that offer greater flexibility and higher elasticity.

*https://afdc.energy.gov/vehicles/electric_maintenance.html

# Material Options for High-Voltage Power Cables in EVs

The most popular materials for high-voltage power cables in automotive applications include:

- **High-performance fluoroelastomers (FKMs)**: Copolymers and terpolymers with various compositions and fluorine content that deliver the highest temperature resistance in addition to excellent resistance to wear, abrasion, heat, ozone, oil, fuel, and permeation
- **Tetrafluoroethylene propylene (FEPM)**: A partially fluorinated polymer that is composed of both propylene and tetrafluoroethylene monomers, offering a combination of temperature and chemical resistance
- **Silicone (VMQ)**: A high-molecular weight organo-siloxane with excellent heat resistance and strong low-temperature properties
- **Acrylic rubber (ACM)**: A polymer of ethyl acrylate or butyl acrylate with a small amount of a monomer that offers good resistance to ozone, oil, mineral oil, and fuel
- **Polyethylene**: Lightweight, durable thermoplastic made from the polymerization of ethylene monomer with excellent chemical resistance and high tensile strength*
- **Polyester**: Tough, transparent material used as shield insulation that offers thermal stability and additional strength**
- **Polyurethane (PUR)**: Versatile polymer composed of organic units joined by carbamate (urethane) links that offers lighter weight and high strength to protect against heat and noise under the hood***

*https://omnexus.specialchem.com/selection-guide/polyethylene-plastic#:~:text=Polyethylene%20is%20a%20lightweight%2C%20durable,plastic%20parts%2C%20laminates%2C%20etc.

**https://www.iewc.com/resources/technical-guide/tape-types

***https://www.polyurethanes.org/en/where-is-it/automotive/

# Viton™ Fluoroelastomers Outperform in the Field

| Characteristics | Chemours Viton™ | VMQ (silicone rubber) | ACM / AEM (Acrylic rubber) | Polyethylene | Polyester | Polyurethane |
|---|---|---|---|---|---|---|
| Heat resistance (service temperature) >200°C (392°F) Meet OEM specification at 200°C (392°F) | 4 | 3 | 2 | 2 | 2 | 2 |
| Oil / chemical resistance | 4 | 2 | 3 | 2 | 1 | 2 |
| Mechanical properties (tear strength, elongation, tensile strength) | 4 | 2 | 3 | 3 | 3 | 4 |
| Flexibility at low temperature | 4 | 4 *(could be too soft)* | 4 | 1 | 1 | 1 |
| Dielectric strength [kV/mm] | 3 | 3 | 2 | 4 | 3 | 3 |
| Processability (extrudability for large diameter) | 4 | 1 | 4 | 4 | 4 | 4 |
| Process cost (e.g., curing, formulation) | $$ | $$ | $$ | $ | $ | $ |

1 Poor 2 Moderate 3 Good 4 Excellent

# Selecting the Right Materials for High-Voltage Power Cables in Automotive Applications

When selecting products to use during the manufacturing process, a full evaluation of a material's properties is required, including long-lasting durability and temperature resistance.

## Temperature Resistance

In high-heat automotive cable applications, Viton™ fluoroelastomers perform better than any other polymer on the market. Viton™ fluoroelastomers combine heat resistance with the low-temperature performance needed to qualify for use in temperature classes E and above.*

Viton™ compounds can operate continuously at 200°C (392°F) without showing any significant change in tensile (Tb) or elongation (Eb) properties. Viton™ compounds also show substantial tolerance to spikes in temperatures above 200°C (392°F) without sacrificing the physical properties. Low-temperature Viton™ grades have demonstrated excellent sealing performance at temperatures well below their glass transition temperature (Tg).

## Volume Resistivity

Volume resistivity is the internal resistance of an insulating material to current flow. High volume resistivity guarantees that the material acts as an insulator. If a material's volume resistivity is below $10^5$ Ohm*cm, the material is considered conductive. If it's above $10^9$ Ohm*cm, the material is considered an electrical insulator.

The volume resistivity of Viton™ fluoroelastomers depends on the compound recipe and filler system used, along with cure conditions and post cure time. Mineral-filled Viton™ compounds can reach a volume resistivity of greater than $10^{13}$ Ohm*cm. Volume resistivity of Viton™ compounds can be further enhanced by using fluoropolymers like Teflon™ PTFE as fillers.

## Dielectric Strength

Dielectric strength is the voltage at which dramatic deterioration of insulating properties is observed within the material.

Viton™ compounds can achieve a dielectric strength exceeding 20 kV/mm, depending on the recipe and curing conditions.

## Greater Flexibility

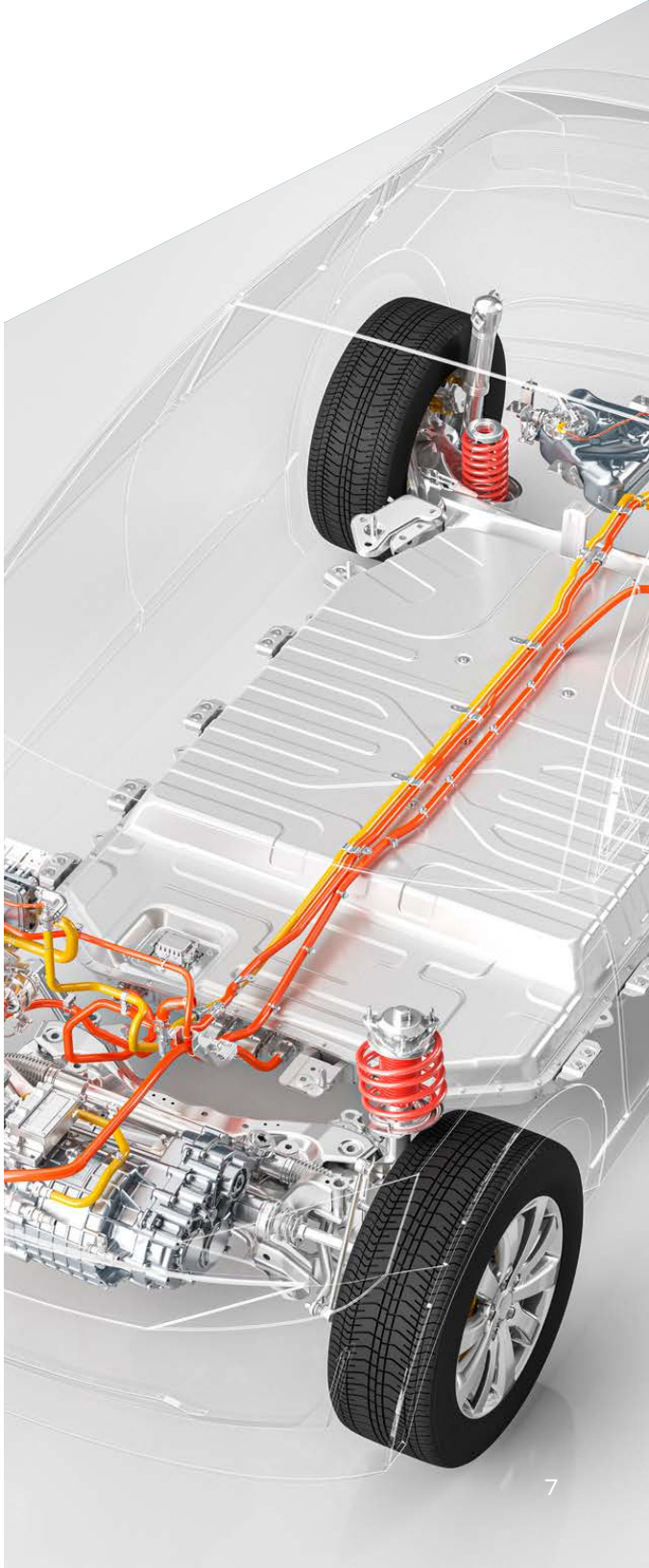
Compared to thermoplastic materials, Viton™ fluoroelastomers are typically compounded and cross-linked to fulfill the application needs. While low-temperature flexibility can be a challenge for thermoplastic materials, vulcanizates of Viton™ FKM show improved low-temperature flexibility while still retaining all their other properties, including resistance to heat, chemicals, ozone, and weathering. This greater flexibility is a real asset in the compact environment under the hood of EVs.

*Temperature class rating as defined in ISO 6722-1

# The Material That Accelerates Innovation in EV Technologies

Viton™ fluoroelastomers deliver the best performance for high-voltage power cables. Manufacturers rely on Viton™ fluoroelastomers for their:

- **Higher reliability** due to good electrical properties that meet the requirements in EV high-voltage power cable applications
- **Longer durability** and improved safety due to excellent heat resistance, oil & chemical resistance, and mechanical properties
- **Unique combination of heat and fluid resistance** that extends far beyond the range of other synthetic elastomers
- **Excellent resistance** to ozone, oxidation, abrasion, and weathering
- **Superior flexibility**, making assembly easier and resulting in ergonomic benefits compared to polyester, polyethylene, and polyurethane
- **Excellent mechanical properties**, including tear strength, elongation, and tensile strength
- **Better processability** for larger diameter cables, allowing for improved yield



# Viton™ Fluoroelastomers: Powering Your Vision for the Road Ahead

We call it the Imagination Component, the fluoroelastomer known as Viton™. It's the original fluoroelastomer that helps innovators and designers conjure up the latest, greatest breakthroughs. Viton™ fluoroelastomers make whatever you make better, including parts that help engines save fuel while packing higher performance into smaller spaces.

Our experts collaborate with customers to identify the right Viton™ fluoroelastomers grade to meet their unique needs and achieve peak component performance.

We pride ourselves on consistent, high-quality products, batch after batch, and our global reach means you can feel secure in our supply and support across the globe. We offer you consistency you can rely on, and in today's unforgiving environments, that matters.

We are constantly innovating and adept at partnering with our customers in new product development, while working with them to create outstanding solutions.

Designers, engineers, and suppliers trust Viton™ fluoroelastomers because they offer excellent mechanical properties, including tear strength, elongation and tensile strength. And with Viton™ fluoroelastomers, OEMs can expect higher reliability, longer durability and greater resistance to environmental conditions, including ozone, oxidation, abrasion and weathering—along with better processibility and improved yield for larger diameter cables.

Contact us for help in building something the world never knew it needed.

For more information, visit **Viton.com** or call one of our experts:

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