WHAT'S UNDER THE HOOD MATTERS MORE THAN EVER

How to Select an Elastomer That Stands Up to Harsher Underhood Environments

EXECUTIVE SUMMARY

The breadth of change in the automotive industry is the greatest it's ever been. As if digital enhancements and the lurking promise of autonomous vehicles were not enough, rigorous emissions and fuel economy regulations are putting extra pressure on automotive suppliers to meet the pace of change, while keeping costs at a minimum. It has created a "wild, wild west" of sorts, where suppliers are scrambling to figure out the most efficient and profitable route to deliver on consumer and regulatory demands, while also meeting high performance, safety, and reliability standards.

The automotive underhood environment has experienced a dramatic makeover that can't be ignored. Everything under the hood is now hotter, more hostile, and more unforgiving than ever. Choosing an elastomer that can withstand the increasingly harsh conditions under the hood is essential, but not easy to do with an ever-growing list of options. This white paper will demystify the elastomer selection process once and for all.

As the drive for greater fuel efficiency and lower emissions gets hotter, so does the underhood.

Never before has the underhood of a vehicle been a more severe environment for an elastomer. In order to meet rigorous global emissions and fuel efficiency regulations, automotive manufacturers have been downsizing, turbocharging, and lightweighting—which has resulted in smaller and hotter running engines packed into lighter and therefore tighter engine compartments. Fuel compositions are also changing rapidly and creating increasingly unforgiving chemical environments for elastomers.

Traditional anti-knock agents, such as tetramethyl-lead and tetraethyl-lead, have been replaced by oxygenated (alcohol or ether) additives, creating a wide range of potential fuel compositions that have varying swelling effects on underhood parts. In addition, advances, such as Exhaust Gas Recirculation (EGR) and Selective Catalytic Reduction (SCR), are introducing harsher and more acidic chemicals and oils into the engine.

All of this, combined with longer warranty periods, means elastomers designated for high-temperature and harsh chemical operation must be validated for longer service lives. Suppliers need to seek elastomers capable of extended performance at elevated temperatures that also can be in contact with aggressive chemicals and oils.

Feeling the Squeeze

Hotter Conditions

Before, underhood components only needed to perform in conditions as hot as 170 °C to 190 °C (338 °F to 374 °F). Today, some applications need parts capable of performance at temperatures up to 250 °C (482 °F).

Harsher Chemicals

Variations in fuel mixtures and advances in EGR and SCR send harsh chemicals through the powertrain and fuel systems, leading to component deterioration.

Longer Warranties

The need to provide lengthier warranties means parts must be validated for longer service lives.

Elastomers at a Glance

When it comes to elastomers used in underhood environments, one size does not fit all.

Selecting an elastomer is a balancing act, with an array of different types—each available in several different compounds or grades. The following are seven of the most popular elastomer types used in automotive underhood environments:

Silicone (VMQ)
A high molecular weight organo-siloxane known for excellent heat resistance and strong low temperature properties.

Fluorosilicone (FVMQ)
A methyl vinyl silicone rubber with fluorine-containing groups that maintains VMQ's strong heat and low temperature resistance, while improving fuel and oil resistance.

Nitrile (NBR)
A copolymer of butadiene and acrylonitrile that is inexpensive and has great compression set, tear, and abrasion resistance.

Hydrogenated Nitrile (HNBR)
Prepared by partially or fully hydrogenating NBR to improve ozone, heat, and ageing resistance.

Polyacrylate (ACM)
A polymer that consists of ethyl acrylate or butyl acrylate with a small amount of a monomer necessary for cross-linking that has good ozone, oil, mineral oil, fuels, and ATF resistance.

Ethylene-Acrylic (AEM) (Vamac®)
Constructed of ethylene-methyl acrylate with carboxyl groups to deliver a high degree of ozone, UV, and weather resistance as well as good resistance to some synthetic fluids.

Fluorocarbon (FKM) (Viton™)
Copolymers and terpolymers with various compositions and fluorine contents to deliver excellent wear, abrasion, heat, UV, ozone, oil, fuel, and permeation resistance.

The chart on the following page rates their performance capabilities across various parameters:

Rating the Elastomers

ELASTOMER	HIGH TEMPERATURE RESISTANCE*	FUEL RESISTANCE** (ASTM FUEL C)	POWERTRAIN FLUID RESISTANCE	FUEL PERMEATION RESISTANCE ***
Silicone (VMQ)	🛡🛡🛡🛡	🛡	🛡	🛡
Fluorosilicone (FVMQ)	🛡🛡🛡	🛡🛡🛡	🛡🛡🛡	🛡🛡
Nitrile (NBR)	🛡🛡	🛡🛡🛡½	🛡🛡	🛡🛡
Hydrogenated Nitrile (HNBR)	🛡🛡🛡	🛡🛡🛡	🛡🛡🛡	🛡🛡
Polyacrylate (ACM)	🛡🛡🛡	🛡	🛡🛡🛡	🛡
Ethylene-Acrylic (AEM) (Vamac®)	🛡🛡🛡	🛡	🛡🛡🛡	🛡
Fluorocarbon (FKM) (Viton™)	🛡🛡🛡🛡	🛡🛡🛡🛡	🛡🛡🛡½	🛡🛡🛡🛡

🛡 Poor 🛡🛡 Fair 🛡🛡🛡 Good 🛡🛡🛡🛡 Excellent

*High temperature limits taken from SAE J2236 document.
**Chemical resistance data provided in Chemical Resistant Guide for Elastomers II published by Compass.
***Permeation data listed in SAE paper 920163 entitled "Fuel-Alcohol Permeation Rates of Fluoroelastomers, Fluoroplastics, and Other Fuel Resistant Materials" by W. M. Stahl and R.D. Stevens.

Things to Look for in a Modern Underhood Elastomer

With underhood conditions more challenging than ever, suppliers need to balance the fluid and chemical resistance, temperature resistance, and extended performance properties of the elastomer to ensure lasting performance. Here’s an overview of key considerations:

#1 Fluid and Chemical Resistance

When an elastomer comes into contact with an incompatible fluid, the result can range from very high swell to rapid deterioration or even complete breakdown. Different fluids obviously have varying effects, which can be impacted by other factors, such as chemical concentration, system pressure, and operating temperature.

Powertrain Fluids

While several elastomers may be chemically resistant to powertrain oils, lubricants, and automatic transmission fluids, engineers must consider volume swell properties in the presence of these fluids in high rotation applications. Similarly, engineers must compare the elastomers’ resistance to the chemicals over time at higher temperatures.

Fuels

Fuels present an even greater fluid resistance challenge for suppliers because they vary so dramatically, with some mixtures causing considerable elastomer swelling and physical property degradation. It’s not good enough to simply have an elastomer that is resistant to chemical attack and volume swell. Fuel applications require an elastomer with low permeation in order to meet strict carbon regulations.

EGR Fluids

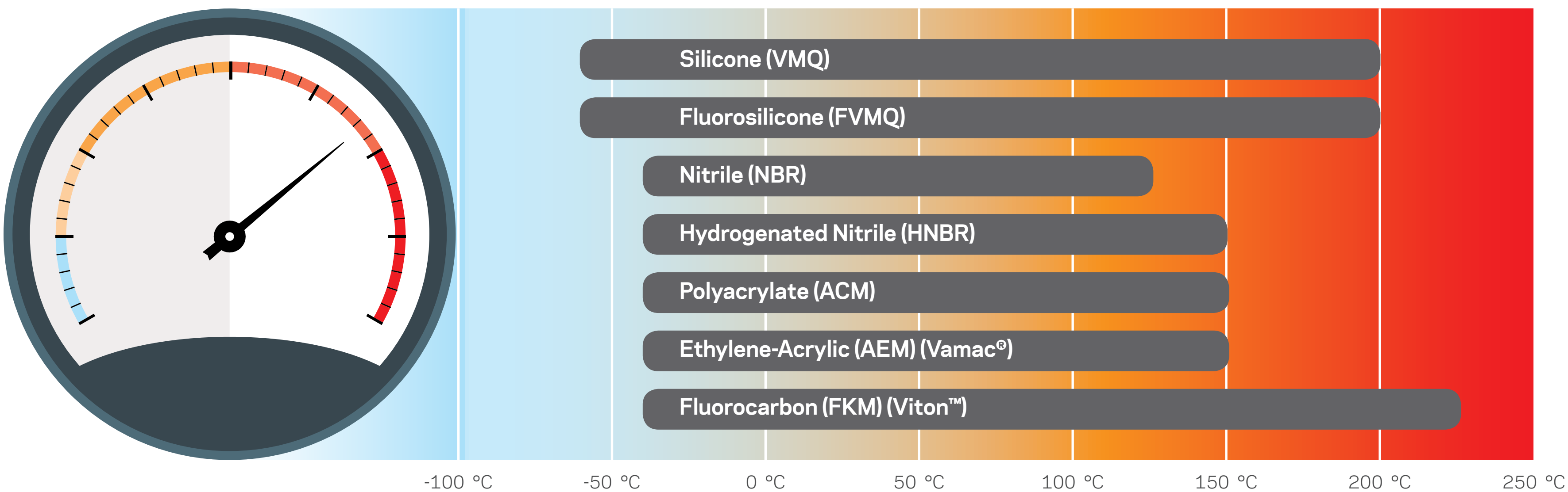
One of the challenges with elastomers in EGR systems is that they need to be resistant to not only high temperatures, oils, and fuels, but also to the acidic chemicals and by-products present in EGR mixtures. Different automakers have different EGR mixtures, which means suppliers must choose an extremely high-performing and versatile elastomer.

#2 Temperature Resistance

Temperature plays a key role in the durability of an elastomer. As temperatures approach the upper service limit, elastomers often undergo irreversible chemical changes. The polymer backbone may break or adjacent polymer molecules may cross-link, causing parts to become more rigid and reducing their resistance to compression set. This can shorten the life of elastomer parts or even destroy them.

Conversely, at low temperatures, elastomers become harder, less flexible, and may crack—losing their rubber-like qualities.

Service Temperatures of Popular Elastomers



#3 Extended Performance

More aggressive underhood environments, combined with the drive for longer part lives, are increasing the demands on specialty elastomers. Seal life requirements are increasing to 15 years – 150,000 miles. Short-term screening tests are no longer enough for qualifying new automotive polymers. Automotive specifications are requiring 1,000-hour aging at a minimum. In some cases, OEMs are requiring as high as 5,000-hour testing to qualify new elastomers. FKM, with their excellent heat and fluid resistance, performs well in these long-term tests.

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FKM—Ideally Suited for the Harshest Underhood Conditions

Across parameters, FKMs, such as Viton™, provide the strongest performance capabilities. FKM elastomers are highly resistant to swelling and permeability when exposed to fuels and fuel mixtures, making them ideal to meet rigorous emissions regulations. Additionally, they boast excellent compression set resistance and long-term performance.

About Viton™ Fluoroelastomers

Viton™ high-performance fluoroelastomers were developed in 1957 for the aerospace industry, but have become the go-to solution for extreme automotive environments.

Why Viton™?

Automotive engineers, suppliers, and distributors trust Viton™ because it offers:

- **Better temperature resistance,** while simultaneously retaining good mechanical properties.
- **Broad chemical and fluid resistance** compared to non-fluorinated elastomers, including **oils, fuels, lubricants, and most mineral acids.**
- **Extremely low permeability** to a broad range of substances, including good performance in oxygenated automotive fuels.
- **Exceptional high pressure performance** and durability, despite extreme temperatures.
- **Superior durability** to atmospheric oxidation, sun, weather, fungus, and mold.

Peace of mind with a partner you can trust.

Our team of Viton™ experts collaborate with customers to identify the right 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.

For more information, visit **Viton.com/Selection** or call a Viton™ technical expert: **1-866-205-1664.**

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