

The PFAS Dilemma: Advancing Material Science Amid Regulatory Uncertainty

Per- and polyfluoroalkyl substances (PFAS) have played an important role in modern society for more than 70 years. These synthetic chemicals are chemically inert and offer low friction and resistance to water, oil and heat, which has made them useful in a wide array of applications. Today, PFAS are used in everything from nonstick cookware and waterproof fabrics to life-saving medical devices and aircraft components.

PFAS are generally defined as a large, complex group of synthetic chemicals that contain chains of linked carbon and fluorine atoms. These molecular bonds are some of the strongest bonds possible in organic chemistry, which is what makes them useful to so many industries.

But the wide-ranging benefits come at a cost. The durability and resistance properties that propelled these chemicals to widespread use also make them highly persistent and mobile in the environment, earning them the pejorative nickname "forever chemicals." PFAS do not easily break down and over time can accumulate in water, soil and even living organisms. According to the Centers for Disease Control and Prevention (CDC), studies show that nearly all people in the United States have PFAS in their blood, and some studies link these chemicals to negative health effects such as [altered immunity](#), hormonal disruption and even [cancer](#).



Their usefulness in modern society and their potential risks place PFAS at the center of a complex global debate. How should these chemicals be managed and regulated responsibly? Public awareness of the risks of PFAS has increased in recent years, fueled by new research and greater news coverage. This has spurred governments worldwide to develop new regulations aimed at limiting PFAS use and potential environmental impact.

As governments around the world look at the issue, regulations in different regions are evolving in different directions, resulting in a complex and uncertain regulatory landscape. In the U.S., the Environmental Protection Agency (EPA) is taking steps like establishing national drinking water standards and incentivizing PFAS-free alternatives. The European Union is pursuing a more aggressive stance and is currently considering a broad ban of PFAS with limited use-specific, time-bound exemptions. These differences present great uncertainty for manufacturers around the world.

As a global leader in high-purity silicones, NuSil[®], an Avantor[®] brand, is closely following these developments to see what role silicone technologies can play in limiting the use of PFAS. In this paper, we'll examine the complexities of today's regulatory environment, its potential impact on the silicone industry and potential solutions for navigating the road ahead.



DIFFERING APPROACHES FROM REGULATORS. INCREASING UNCERTAINTY FOR MANUFACTURERS.

Part of the regulatory challenge is that the term PFAS encompasses such a wide chemical class. Regulators and scientific communities sometimes don't agree on where to draw the line when defining PFAS. There is also a lack of consensus on which PFAS pose risks to human health, as their environmental pathways and potential risks can vary widely. In the past, regulators focused on limiting long-chain chemicals like perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), which studies showed presented relatively greater risks to human health. In response to regulations, many manufacturers replaced long-chained PFAS with alternative fluorinated chemistries that are shorter-chained and unregulated.

In the U.S., the EPA recently expanded its definition of PFAS for flagging contaminants for drinking water regulations. Previously, the EPA was using [a limited, working definition of PFAS](#) as "chemicals with at least two adjacent carbon atoms, where one carbon is fully fluorinated and the other is at least partially fluorinated." Now, the EPA has [broadened that definition](#) to include chemicals that contain at least one of three specified fluorocarbon structures:

1. R-(CF₂)-CF(R')R'', where both the CF₂ and CF moieties are saturated carbons and none of the R groups can be hydrogen
2. R-CF₂OCF₂-R', where both CF₂ moieties are saturated carbons and none of the R groups can be hydrogen
3. CF₃C(CF₃)RR', where all carbons are saturated and none of the R groups can be hydrogen



R, R', R'' = nonhydrogen atoms

Although this expands the regulatory scope for the EPA, this definition is far more limited than that recommended by the Organization for Economic Cooperation and Development (OECD) and used by the EU's European Chemicals Agency (ECHA). The [ECHA classifies PFAS](#) as any chemicals that contain

at least one fully fluorinated methyl (CF₃-) or methylene (-CF₂-) carbon atom (without any H/Cl/Br/I attached to it). To make matters more complicated, some U.S. states are adopting the OECD definition in their state-level PFAS regulations.

In Europe, the ECHA is currently considering a proposal to restrict all PFAS as defined by the OECD across all EU member countries. The proposal — put forward by EU member states Germany, Netherlands, Denmark, Norway and Sweden — would have wide-reaching impacts on industry in the region, affecting manufacturing sectors ranging from textiles and packaging to agriculture and pharmaceuticals.

In August 2025, the ECHA published a revised restriction proposal after reviewing more than 5,600 scientific and technical comments. The revised proposal outlines several restriction options and recommends the middle-of-the-road option of banning PFAS with use-specific, time-bound derogations. Sectors benefiting from these derogations include medicinal products, medical devices, electronics, semiconductor manufacturing and defense applications. The ECHA's Risk Assessment Committee (RAC) and Socio-Economic Analysis Committee (SEAC) are indicating that they will deliver final opinions to the European Commission in 2026.

The differing approaches to regulations make for a complex and unclear road ahead for manufacturers. A blanket ban of PFAS could cause major shifts in some industries, as manufacturers are tasked with identifying and adopting viable alternatives. Without shared international guidelines, manufacturers might also face the costly task of tailoring products to meet different regional standards. The challenge for companies today is to anticipate evolving requirements and identify PFAS alternatives while maintaining competitiveness.

CAN MANUFACTURERS GO PFAS-FREE WITH SILICONES?

Manufacturers looking for alternatives to PFAS may find promise with silicone chemistries. These versatile, synthetic materials are known for their durability, flexibility and resistance to extreme heat, UV radiation and chemical degradation. Chemically, they are a family of polymers with a structure built around silicon and oxygen atoms, typically paired with other organic groups. Silicones, which can take the form of liquids, gels or elastomers, already play an important role across a wide range of industrial

and consumer markets, from medical devices and electronics to aerospace and personal care products.

Silicones fall into a different chemical class than PFAS, which means most silicones will not fall under the purview of proposed PFAS restrictions. And as a PFAS alternative, silicones are generally considered to be safer, as many siloxanes are less persistent in the environment and are less likely to bioaccumulate in living organisms. They also offer many performance benefits similar to PFAS. Silicones can be applied as coatings to replace PFAS-laden, water-repellent materials in textiles or packaging. They're also chemically inert and considered biocompatible by the pharmaceutical and medical device industries, making them useful in a wide range of medical applications.

However, when it comes to replacing PFAS, the regulatory outlook gets a little more complicated with fluorosilicones. Fluorosilicones are a specialty class of silicones modified with fluorine groups to enhance functional properties and chemical resistance. These materials are engineered to offer superior performance in particularly harsh environments, such as applications where the silicone is exposed to fuels, oils or solvents. These specialty silicones are used in a wide range of industries that require advanced material resilience, including:



Aerospace — Fluorosilicones are used in gaskets for high-pressure systems and in coatings to protect aircrafts' outer mold lines and seals from damaging fuels and solvents.



Healthcare — Fluorosilicones are used in biomaterials, housing components and medical-grade lubricants for medical devices.



Shipping — Fluorosilicones are used in coatings on ship hulls to increase durability and resist biofouling in corrosive seawater environments.

Fluorosilicones are highly stable polymers that provide many advantages in demanding applications. However, by virtue of their fluorine-containing molecular structure, they may fall under the PFAS umbrella depending on the regulatory definition. Under the EPA's definition, which focuses on substances with fully fluorinated carbon chains, fluorosilicones are exempt from PFAS classification in the U.S. By contrast, under the EU's proposed definition, which casts a wide net over fluorinated substances, fluorosilicones would indeed be considered PFAS.

This discrepancy highlights a key challenge for manufacturers and regulators. While silicones offer viable alternatives to traditional PFAS in many applications, their fluorine content in fluorosilicones leaves them vulnerable to varying definitions of PFAS and regulatory scrutiny. Manufacturers will need to assess how these potential regulations impact their business and weigh the risks and benefits of alternative solutions.



HOW THE RIGHT MATERIAL SCIENCE PARTNER CAN HELP NAVIGATE REGULATORY CHALLENGES

As regulations continue to evolve, companies can keep ahead of requirements by considering alternatives to PFAS and fluorine chemistries with an experienced material science partner. Whether or not the EU chooses a broad ban of all PFAS chemicals in the coming months or years, companies can most likely expect more PFAS regulations to emerge that restrict the use, handling or disposal of PFAS. Collaborating with a material science partner who has expertise in R&D, engineering and compliance can help reduce regulatory risk and ensure business continuity.

As a leading producer of high-purity silicones and a pioneer in medical-grade and space-grade silicone technologies, NuSil works closely with customers to keep ahead of changing regulations. As we continue to monitor legislation around PFAS, we are working with customers to explore silicone-based alternatives to PFAS applications as well as alternatives to advanced fluorosilicone solutions, should they be subject to restrictions in the EU.

Although we do not anticipate any disruptions to our fluorosilicone product line, we are investigating potential replacements for fluorosilicones for different applications. For example, fluorine-free alternatives may be considered as potential replacements in most applications using fluorosilicone fluids as lubricants for silicone elastomers or as barriers to prevent the bleeding of silicone oil.

With extensive expertise in material science and a strong focus on innovation through research and development, NuSil continues to innovate and design new silicone formulations to meet regulatory and application requirements for customers. And as a committed and collaborative partner, NuSil can help companies in a range of industries navigate changing PFAS regulations and keep ahead in their business.

Contact NuSil® to get started

When your advanced applications require customized silicones, we're ready to supply you with the right solution you need.

www.avantorsciences.com/nusil

To learn more about potential silicone-based alternatives, visit avantorsciences.com/nusil or contact NuSil experts today at silicone@avantorsciencesgcc.com or **1-805-684-8780**.

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