2023

Emerson's Request for the Creation of a New Industrial Automation Monitoring and Control Use Sector and a 12-Year Derogation for Fluoropolymers in that Sector

Section IV, Non-Confidential Attachment
May 9, 2023

Contents

Cross Reference Matrix

As per the REACH Annex XV PFAS Restriction proposal, a cross-reference matrix is provided as a tool to assist in the evaluation. The cross reference matrix maps the information between the various elements of the Annex XV PFAS Restriction proposal and Emerson's response.

Table 1. Cross-Reference Matrix for the Annex XV PFAS Restriction Proposal and Emerson's Response

Requirement Description	*Restriction Report Consultation Info Note*	*Emerson's Response*
Missing Use Request	*Section 6, Page 5*	*Section 2.0, Page 4*
12-Year Derogation Request		*Section 2.0, Page 4*
Socioeconomic Implications		*Section 8.0, Page 18*
Annual Tonnage & Emissions		*Section 7.0, Pages 17 & 18*
Key Functionalities		*Section 5.0, Pages 8-14*
Number of Companies affected by the restriction		*Section 8.0, Page 19*
Alternatives		*Section 6.0, Pages 14-17*
Availability		*Section 6.0, Page 14*
Technical Feasibility		*Section 6.0, Page 15 & 16*
Economic Feasibility		*Section 6.0, Page 16*
Hazards and Risks for the Relevant Use		*Section 6.0, Page 17*

Abbreviations

	Term / Material	CAS RN
IAMC	Industrial Automation Monitoring and Control	
ECTFE	Ethylene chlorotrifluoroethylene	25101-45-5
ETFE	Ethylene tetrafluoroethylene	25038-71-5
EPDM	Ethylene Propylene Diene Monomer	25034-71-3
FEP	Fluorinated Ethylene Propylene	25067-11-2
FFKM	Perfluoroelastomer	26425-79-6
FKM	Fluoroelastomer	25190-89-0
H-NBR	Hydrogenated - Nitrile Butadiene Rubber	9003-18-3
PCTFE	Polychlorotrifluoroethylene	9002-83-9
PEEK	Polyetheretherkeytone	29658-26-2
PFA	Perfluoroalkoxy Polymer	26655-00-5
PPS	Polyphenylene Sulfide	26125-40-6
PTFE	Polytetrafluoroethylene	9002-84-0
PVDF	Polyvinylidene Fluoride	24937-79-9

1.0 Introduction

Emerson, a global technology and engineering company with significant operations in Europe, including 7,000 staff and 17 manufacturing sites spread across 13 member states, is fully committed to making industrial products that are safe for our end-users and the environment, consistent with Europe's Chemicals Strategy for Sustainability and Green Deal initiatives. Emerson is committed to comply with all applicable environmental laws and regulations in the EU.

2.0 Purpose

Emerson has closely reviewed the REACH Annex XV Per-and Polyfluoroalkyl Substances (PFAS) restriction proposal and has identified missing uses that are critical to the EU and the world. This paper provides justification to add Industrial Automation Monitoring and Control (IAMC) as a new use sector to fill a critical gap in the missing uses of the restriction proposal. Subsequently, a request is made for a 12-year derogation of fluoropolymers. These requests are submitted within the framework of the restriction proposal and are summarized in Table 2. In this document fluoropolymers and fluoroelastomers are both referred to as fluoropolymers.

Table 2. New use sector and fluoropolymers derogation requests.

Requests:	Description
New Use Sector Request	Industrial Automation, Monitoring and Control, hereby known as IAMC
Derogation Request	12-Years Allowing the use of fluoropolymers in: Industrial Automation, Monitoring & Control Equipment

The rationale and details justifying these requests are provided below and will conclusively demonstrate the criticality of this use sector and the use of fluoropolymers as an enabling material in critical-to-the-world applications.

Summary of the Rationale for Our Requests:

- IAMC Equipment is foundational to the safe, efficient and sustainable production of any semi-automated or fully automated manufacturing process, including those used to produce most of the products that comprise the 14 use sectors identified in the REACH Annex XV restriction proposal.
- The exclusion of IAMC equipment as a use sector from the derogations established in the restriction proposal will result in severe economic distress in the EU, including impacts on employment within the EU and shortages within the EU and throughout the world of critical products such as semiconductors, process chemical feedstocks, and sterilization equipment, among many others.
- IAMC equipment was a €56B industry in Europe in 2022 and is expected to grow to €111B by 2030.
- IAMC equipment operates in harsh environments where only fluoropolymers can deliver the performance needed for safe and efficient operations.
- No suitable alternatives exist today that can deliver the properties required to ensure the safe and sustainable operation of these challenging IAMC operating environments.
- In the event that suitable replacements become commercially available, implementation timelines are in excess of five years due to complex re-design and re-certification activities.
- Fluoropolymers are typically a cost premium over non-PFAS materials. They are used because the technical requirements of existing IAMC applications eliminate the possibility of utilizing existing alternatives.

- The fluoropolymers used in IAMC equipment are discrete solid plastic parts that meet the OECD's definition of a polymer of low concern[1].
- IAMC equipment providers are downstream users of fluoropolymers so emissions are non-existent until end-of-life, which is on the order of 15+ years.
- IAMC equipment using fluoropolymers are key enablers of decarbonization initiatives such as wind, solar, H_2, and mobility, which are foundational to fulfilling European sustainability priorities.

3.0 Industry Description

IAMC, a €194B[2] global industry in 2022 and €56B[2] for Europe, consists of control systems and associated instrumentation, including the devices and controls used to automate industrial processes. This equipment enables delivery of essential resources such as clean water, safe food and reliable energy, and essential goods such as pharmaceuticals, including vaccines, medical devices, electronic components, defense equipment and petroleum. The scope of equipment consists of complex electromechanical products that measure a variety of parameters such as temperature, humidity, pressure, corrosion, and density and process control products such as valves, actuators, flow measurement devices and regulators, per Table 3.

Table 3. The scope of IAMC equipment includes monitoring and control hardware.

Scope of IAMC Equipment
1. Pressure, Flow, Level and Temperature Measurement
2. Corrosion, Erosion & Heat Trace Monitoring
3. Energy Monitoring & Management
4. Density & Viscosity Measurement
5. Liquid, Flame & Gas Detection
6. Machinery Monitoring, Protection & Maint.
7. Marine Measurement & Analysis
8. Distributed Control Systems
9. Hygienic & Sanitary Measurement
10. Vibration Sensors
11. Electrical Power Distribution & Control
12. Valves
13. Regulators
14. Actuators

Figure 1 demonstrates the function of IAMC equipment. In this simple illustrative example, a flow meter is monitoring fluid flow and sending signals to the sliding-stem control valve, which in turn adjusts the valve stem height for optimum flow control. These products operate as a unit and failure could be catastrophic. Any errors could create an unstable and unsafe situation that may result in severe harm to people and/or the environment. IAMC equipment has boundless configuration flexibility to accommodate the broad processing needs of the many industries served.

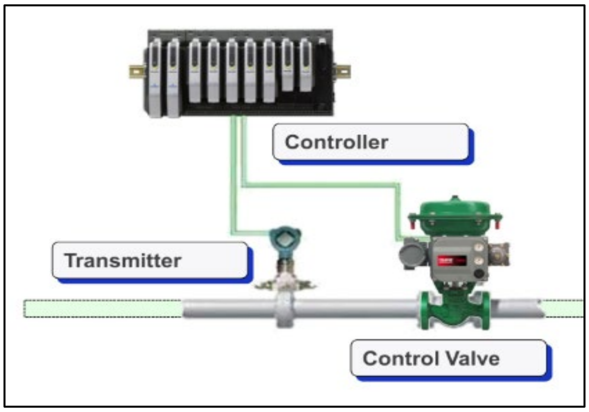

Figure 1. Example of an IAMC Equipment Configuration.

The operating profile, to which IAMC equipment is exposed, is defined by the industries that leverage the technology such as chemical processing plants, nuclear power plants, semiconductor manufacturing, mining, wastewater management, alternative fuels, oil and gas, rail and other mass transportation, and construction operations. These applications often involve exposure to multiple extreme environmental conditions simultaneously. IAMC environmental parameters often include the following:

- **Hazardous environments** are prevalent and include fire, explosion, and toxic chemical threats. These environments often require equipment certifications, namely ATEX Directive 2014/34 in Europe.
- **Broad chemical exposure** is common due to the massive number of chemicals processed every day. These chemicals span the entire pH range and are processed at different temperatures and pressures. Example harsh chemicals include sulfuric acid, hydrofluoric acid and chlorine.
- **Low temperatures near -60°C.** Beyond this for cryogenic processing, IAMC equipment can be exposed to temperatures down to -200°C.
- **High temperatures near 200°C.**
- **High pressures near 150 bar** to accelerate and influence reaction rates and to increase volume-time efficiencies. Pressures up to **1000 bar** exist in some chemical processes.

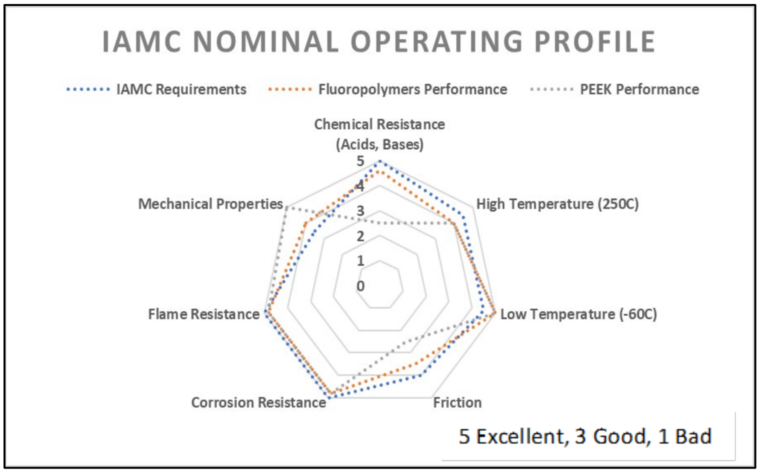

Figure 2. IAMC's operating profile requirements overlap with fluoropolymers performance, which is why their use is so common in industry applications.

These challenging environments demand the use of high performance and high reliability materials like fluoropolymers, which are vital as an engineering material class, not because of one particular characteristic, but **because of the multiple properties any one of them simultaneously possesses**. This is demonstrated in Figure 2 where IAMC requirements and fluoropolymers performance are overlayed. The overlap in performance across this specific array of properties is what sets fluoropolymers apart from other materials and makes them a requirement for many IAMC applications. Fluoropolymers' most commonly leveraged properties include:

- **Broad chemical resistance to virtually all chemicals.**
- **Low temperature performance down to -200°C.**
- **High temperature performance up to 260°C.**
- **Corrosion resistance**
- **Intrinsic flame resistance with a high heat of combustion and limiting O_2 Index**
- **Good electrical properties, excellent dielectric properties**
- **Low friction / Non-adhesive resistance**
- **Purity / inert**

Other polymers can demonstrate superior performance in one single property. For example, Polyetheretherkeytone (PEEK) has slightly higher temperature performance than fluoropolymers. However, fluoropolymers are the best choice when both high temperature and chemical resistance are needed simultaneously. This is also demonstrated in Figure 2 where PEEK is overlayed for comparison purposes.

4.0 Implications

The potential impact of excluding IAMC as a use sector and implementing an all-PFAS ban will have significant consequences to the world, not least the loss of key products, including, but not inclusive to, the ones provided below in Table 4:

Table 4. Exclusion of the IAMC use sector and a PFAS ban will have far reaching consequences to Europe and beyond.

Potential Implications of a PFAS Ban	Rationale (see Table 5 for functional properties)
No Fluoropolymers = No Clean Water **No Fluoropolymers = No Safe Food**	• Measurement equipment and valves utilize **PTFE & PFA** liners in the production of chlorine, the most common type of drinking water disinfectant. • Chlorine is used to clean and sterilize food processing equipment to prevent bacteria growth. • Highly concentrated chlorine is corrosive to metals and highly toxic to people and the environment. • Exotic metals that might withstand the corrosive environment are not viable due to the high weight and increased CO_2 associated with their manufacturing processes.
No Fluoropolymers = No Semiconductors	• Pressure regulators utilize **PTFE** and **PCTFE** in valve seats to control the pressure of media used in etching and chemical vapor deposition processes for semiconductor manufacturing. • **PTFE** and **PCTFE** provide unprecedented purity and compatibility with the processed gases to prevent a reaction with the media. **PCTFE** also delivers an ideal compressive modulus and creep resistance for maintaining sealability.
No Fluoropolymers = No Processing and/or Storage of Chemical Feedstocks, Pharmaceuticals, Petroleum, H_2, etc.	• Control and isolation valves utilize **PTFE** valve packing in the production of pharmaceuticals, chemicals, hydrogen processing, etc. • **PTFE** valve packing is better at sealing gases than graphite, is inert and delivers performance at extreme temperatures, -200°C to +260°C • **PTFE** waveguides are used in non-contact, radar level measurement applications for safe storage of harsh chemicals. • **PTFE and PFA** liners are used in flow meters to control process conditions. Liners protect metal from corrosive media.
No Fluoropolymers = No Pressure Vessels for processing of pharmaceuticals, power, and food.	• Across all pressure vessels – from a home pressure cooker to a three-story pressurizer in a nuclear reactor – **a relief valve is required by law for safety.** • Industrial relief valves use **PTFE, FKM & FFKM** in valve seats at high temperatures (>150°C) and high pressures (>100 bar). • Pressure vessels include boilers, heat exchangers, chemical reactors, etc. • Alternative materials do not provide adequate properties for reliable seals on these devices.

No Fluoropolymers = No Low Temperature Sterilization	• Solenoid valves are used to seal the sterilization chamber. • **PTFE** seals, which are inert, prevent contamination of the sterilization media at temperatures down to -200°C. • Other elastomers are unable to deliver these temperature and mechanical requirements.
No Fluoropolymers = Slower Adoption of Sustainability Initiatives	• Fluoropolymers such as **PTFE** are utilized in most decarbonization activities such as H_2 production and storage, mobility, wind and solar. • Fluoropolymers are used as protective films in solar, coatings, for offshore wind turbines, and membranes for transportation activities involving H_2 and battery manufacturing.

These potential implications show the value of fluoropolymers as an enabling material for IAMC applications. The loss of these resources and goods would have significant global consequences.

5.0 PFAS Functionality

IAMC equipment must be designed with substantial robustness to operate reliably in industrial processes. This equipment is built with high safety margin and high-performance materials often defined by industry standard bodies such as ATEX or IECEx. Failure is not an option for this equipment. For example, a bad flow meter measurement could shut or open a valve incorrectly or make a change in a sulfuric acid production process and cause a catastrophic safety issue. Errors, which could arise from a component material breaking down due to chemical attack, thermal degradation, or a locked system due to unacceptable surface friction, are very rare because of the use of high-performance materials.

Due to the potential severity of a failure, significant caution is expressed regarding the removal of fluoropolymers, a material that has performed so reliably for over six decades. One prevailing concern is that ATEX may need to lower their bar for hazardous location equipment to accommodate replacement materials that currently cannot deliver the required performance. As previously stated, fluoropolymers provide an unmatched multitude of high-performance properties simultaneously to deliver the required functionality to the components used in IAMC equipment, per Table 5 below.

Table 5. List of common fluoropolymers and their functional properties leveraged for each application.

Applications	Fluoro-polymers	IAMC Equipment	Functional Properties
Liners	PTFE PFA FEP ETFE	Pressure, Flow, Level and Temperature Measurement	Chemical Resistance Intrinsic Flame Resistance Low Friction / Adhesive Resistance High & Low Temperature Resistance Purity / Inert Corrosion Resistance Mechanical Strength
Seals (O-Rings, Gaskets, Waveguides, etc)	FKM FFKM PTFE PCTFE	All IAMC Equipment	Chemical Resistance High & Low Temperature Resistance Low Friction / Adhesive Resistance Intrinsic Flame Resistance

			Rapid Gas Decompression Resistance Excellent Dielectric Properties, low dielectric constant for microwave transparency
Valve Packing	PTFE	Control & Isolation Valves	Chemical Resistance High Temperature Resistance Mechanical Properties Fugitive Emissions Standards
Valve Seats	PCTFE PTFE ETFE	Valves, Regulators & Actuators	Chemical Resistance Mechanical Properties (compressive modulus) Purity Low Temperature Resistance
Cable & Wiring Insulation	PTFE PFA FEP	All IAMC Equipment	High Insulation Resistance Excellent Dielectric Properties Temperature Resistance Flexibility Chemical Resistance
Electronics (Waveguides, Capacitors, PCB, LCD, etc.)	PTFE	All IAMC Equipment	Excellent Dielectric Properties, low dielectric constant for microwave transparency Low Dissipation Factors Low Flammability

These applications leverage fluoropolymers' performance in many ways with chemical resistance being a common thread. PTFE is the highest performing fluoropolymer. This is due to strong polar carbon-fluorine bonds providing a layer of unreactive and highly hydrophobic fluorine atoms around the carbon-carbon backbone. This construction results in a high molecular weight, high crystallinity, and high-density material with higher performance attributes than other materials.

Liners

Liners are commonly used in IAMC equipment to protect surfaces from corrosion and wear and to provide a low friction surface. They are almost exclusively made out of fluoropolymers, which are applied as a thin coating or as a pre-fabricated sheet, per Figure 3. Fluoropolymers' ability to resist virtually all chemicals coupled with the other high-performance properties makes them appropriate for liner applications. To illustrate, Table 6 includes data from Emerson's liner selection guide to show performance against five common industrial chemicals. For temperature resistance, the value represents confirmed performance, not the limitation of the material. Although several material properties were considered in the down-selection of these candidate liner materials, chemical and temperature resistance are dominant.

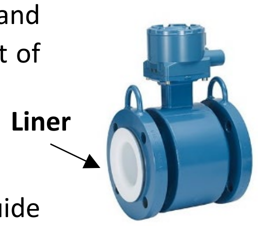

Figure 3. Liner Example.

Table 6. Five common industrial chemicals that rely on the use of fluoropolymers for production.

Chemical Resistance A = Resistant, N = Not Resistant, Blank = No information **For reference, A=resistant to the chemical and 1 = performance to 120°C.**				**Temperatures** 1 = 120°C (248°F) 2 = 100°C (212°F) **A1 = Resistant to 120°C**			3=80°C (176°F) 4=60°C (140°F) 5=20°C (68°F)
Common Industrial Chemicals	**Annual Tonnage (Millions)**	**Liner Materials**					
		PTFE	ETFE	PFA	Polyurethane	Neoprene	Natural Rubber
Sulfuric Acid	20	A1	A1	A1	N	N	N
Ammonia	19	A1	A1	A1	A5	A3	N
Sodium Hydroxide	11	A1	A1	A1	A5	A3	A4
Benzene	8	A1	A3	A1	N	N	N
Sodium Carbonate	3	A1	A1	A1	N	A3	A3

A fluoropolymer is the right choice for many of these chemicals and this performance is consistent across almost the entire list of chemicals in Emerson's liner selection guide (link). Having a material that can be used in almost all liner applications simplifies the selection process, reduces costs, and avoids an incompatible liner being placed with any process media.

Seals

Figure 4. Seals Example

All IAMC equipment utilize seals for containment of gases or fluids. Types of seals are dynamic or static and include O-rings, bellows, grommets, bushings, and gaskets for important functions such as safety shutoff applications and penetration of transducers into the process fluid or gas. These seals and bushings are also used for isolation between housings, housing, compartments, and from process fluids as required for electrical safety. This allows fluoropolymers such as PTFE to be a unique press fit material which flows to fill gaps and imperfections creating a seal against explosive gases. PTFE also has an unmatched temperature range and can flow into imperfections which enables our product temperature rating and flame protection performance. Fluoropolymers are used when operating conditions exceed the performance requirements of other sealing materials like rubber and soft plastics. Below are three examples of sealing operating conditions that require the use of fluoropolymers, namely PTFE, PCTFE, FKM and FFKM.

1. *Temperature Resistance*
   Fluoropolymers' ability to retain its most important performance properties over a temperature range that is among the broadest of any polymer is an important factor in sealing applications. This is due to the strength of its carbon-fluorine bond, which exceeds carbon-hydrogen bond strength in hydrocarbon-based polymers by over 20%. This gives PTFE a very high and low operating temperature, up to 260°C and down to -200°C, respectively. PCTFE Is used in cryogenic and high temperature sealing

applications. FKM and FFKM are used in high temperature sealing applications. Most rubber materials and soft plastics cannot operate above 150°C or below -40°C.

2. *Chemical Resistance*
   Chemical compatibility of seals is critical in low carbon fuel sources such as biodiesel, bio/digestor gas containing hydrogen sulfide, and hydrogen applications. Chemical compatibility is also critical in oil & gas, chemical production, and plastic production. Often times these materials are specified by the end user as they know their application(s) best.

3. *High concentration oxygen applications*
   Another example is the use of PTFE seals in high concentration oxygen applications. PTFE has high ignition and oxygen index[3] values, per Table 7, which makes it ideal for these applications to prevent combustion. This is due to fluorine's presence in the chemical structure and its inherent flammability resistance. Table 7 shows the dominant Limited Oxygen Index (LOI) performance of PTFE. LOI is the minimum concentration of oxygen, expressed as volume percent, needed for a material to continue to burn on its own once it ignites at atmospheric pressure. Materials with high oxygen index are preferred for oxygen service; the higher the oxygen index, the lower the propensity of a material to ignite and burn. Conversely, the lower the oxygen index, the higher propensity of a material to ignite and burn. PTFE's inherent flame properties are essential in applications such as semiconductor manufacturing, chemical processing, diving, firefighting, and aerospace.

Table 7. PTFE is commonly used in high concentration oxygen applications.

Polymers	LOI (%)
Acetal Homopolymer	15
Polyethylene / Polypropylene	17.4
Polyethylene Terephthalate	20
Polycarbonate	27
Nylon 6/6	29
Liquid Crystal Polymers	36
Polyimide	53
Viton FKM	57
Polyvinyl Chloride	47
PCTFE	95
PTFE	95

Valve Packing

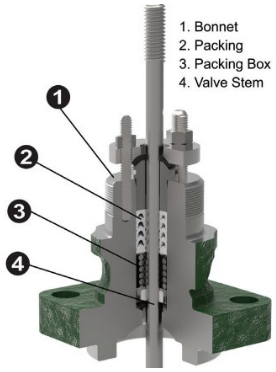

Figure 5. PTFE Valve Packing Example.

Valve packing (Figure 5) is used in rising stem and rotary valves for isolation and process control to prevent leaks between a dynamic stem or shaft and the valve body. Several factors must be considered when choosing a valve packing material, namely fugitive emission standards, chemical resistance, temperatures, and pressures. The potential material options are PTFE and standard graphite. PTFE has significantly better fugitive emissions performance than graphite. Using parameters provided in the International Organization for Standardization (ISO) 15848-1, the amount of time a two-liter bottle would fill with helium due to valve packing leaks:

- PTFE: 1.42 Years
- Graphite: 0.014 Years or 5.1 days

This demonstrates that PTFE provides two orders of magnitude better emissions control over graphite. Removal of PTFE will result in increased emissions of potentially harmful gases that could be detrimental to people and the environment, further contributing to the climate change crisis. For reference regarding scale of use, over 1,000 valves can be used in a single chemical processing facility.

Seats

A seat is a mechanical seal used in relief valves and pressure regulators to create a tight seal between the moving and stationary parts for control of fluid flow and pressure containment. Valve seats are commonly made out of PTFE and PCTFE to accommodate performance requirements such as chemical resistance, inertness, temperature resistance, and mechanical properties such as compressive modulus and creep resistance. Below is an example of a valve seat application that requires the use of fluoropolymers, namely PTFE and PCTFE.

Figure 6. Valve Seat Example

- *High Purity*
  Fluoropolymers are especially important in applications where the high purity of sensitive flowing media has to be maintained throughout the process like in etching solutions in semiconductor manufacturing. Fluoropolymers yield intrinsic inertness and purity due to the layer of unreactive fluorine atoms attached to the carbon-carbon backbone. PFA, FEP and ETFE are also used as valve seats in high purity applications.

Wire and Cable

Figure 7. Wire and Cable Example

Wire and cable are used extensively to power and connect IAMC equipment. Fluoropolymers are commonly used to insulate wires and cables for protection against environmental threats and to prevent electrical leakage. Wires and cables are exposed to the harsh IAMC equipment operating profile and require the same level of reliability. The use of fluoropolymers in IAMC equipment is driven by outstanding electrical properties, such as low dielectric constant, and flame resistance. Other properties such as chemical resistance and crack resistance are also important. Additionally, fluoropolymer insulation is durable and has the highest longevity of materials used in IAMC applications. Below is an example of a wire and cable application that requires the use of fluoropolymers.

- *Low Dielectric Loss Tangent and High Dielectric Strength*
  Fluoropolymers are used to insulate conductors in high reliability applications such as IAMC equipment, aerospace and petroleum and mining. They are chosen for these applications because

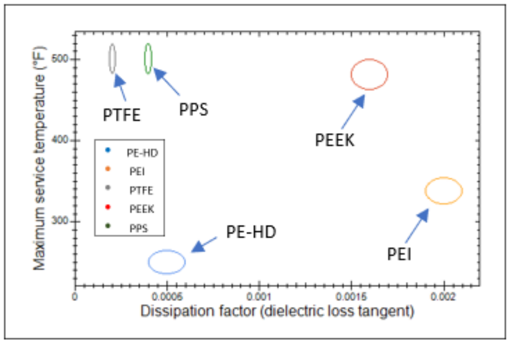

Figure 8. PTFE's dielectric loss tangent is one of the lowest of all polymers, which results in low signal

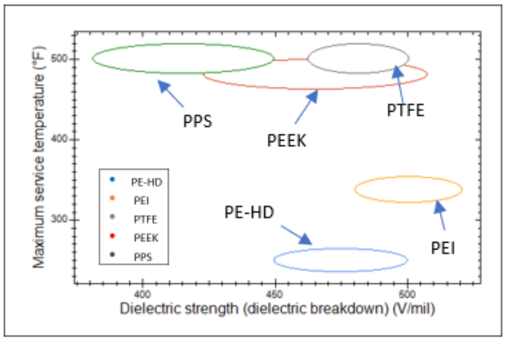

Figure 9. PTFE's dielectric strength makes it a top choice for high temperature applications.

of their low dielectric loss tangent, high dielectric strength, high chemical and temperature resistance, and low surface friction, important for passing wires through tight conduits. Dielectric loss tangent is a measure of signal attenuation as it passes through a material (lower is better). Dielectric strength is a measure of the maximum voltage the material can withstand without breaking down (higher is better). Fluoropolymers' dielectric loss tangent and dielectric strength are demonstrated in Figure 8 and Figure 9 above. As shown, fluoropolymers have the properties that make it a great choice for wire and cable insulation for IAMC applications.

Electronics

All IAMC equipment use electronics to maximize functionality and increase industrial process efficiency. Electronics can be exposed to the harsh IAMC environment, and in some cases, it is not possible to protect them in an enclosure. In these instances, fluoropolymers are necessary given their high performance, namely their electrical, thermal and intrinsic flame resistance properties. Electronic components include Printed Circuit Board (PCB) structures, waveguides, capacitors, piezoelectric devices and liquid crystal displays. Below is an example of an electronics application involving a waveguide that requires the use of fluoropolymers.

Figure 10. Electronics Example – Emerson's Delta V Electronic Marshalling.

- *Low Dielectric Constant*

Figure 11. Waveguide used in a level instrument, the white part that runs up the tube.

Fluoropolymers are necessary in applications where low dielectric constant electrical properties are required, such as a waveguide used in a tank level monitoring transmitter for a toxic chemical, per Figure 11. Waveguides are hollow tubes that transport microwave signals from antennas to electronics. Polymer waveguides are often used when harsh chemicals, such as chlorine or sulfuric acid, are involved and where corrosion-induced surface damage can occur resulting in attenuation of the microwave signal. Polymer selection for waveguides is predicated on dielectric constant properties, which define the material's ability to store energy, and other typical environmental parameters such as chemical and thermal resistance. Low dielectric constant polymers are needed for waveguides to prevent signal attenuation through absorption into the material. Fluoropolymers are a good match for this application because of their low dielectric constant (see Figure 12), which for PTFE is intrinsic due to the non-polar and ordered chemical structure, and high chemical and thermal resistance. This is demonstrated in Figure 9 below, which plots dielectric constant vs maximum service temperature data from Ansys Granta's enterprise materials intelligence database. As shown, fluoropolymers, namely PTFE, FEP and PCTFE, represent the best performance.

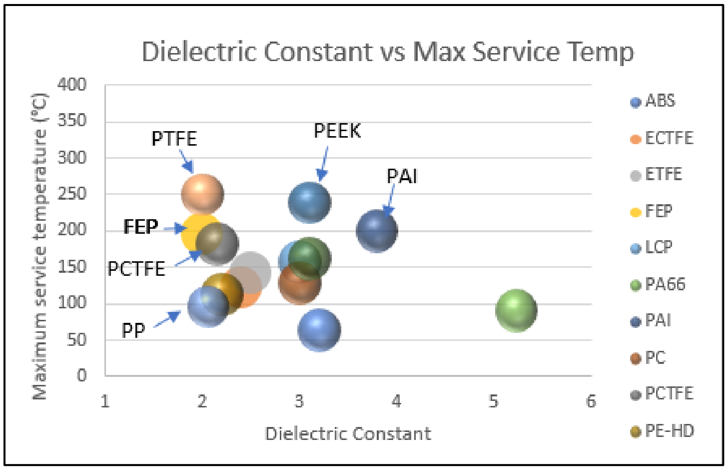

Figure 12. Fluoropolymers have the lowest dielectric constant at high service temperatures.

Alternatives such as PEEK do not fulfill all application requirements. Microwaves are heavily affected by water, that is the higher dielectric constant the more signal is reflected from the surface. Therefore it's also important that the water doesn't "get stuck" on the surface of the antenna and that the water doesn't penetrate into the waveguide material. When PEEK is pressurized with steam, the water will penetrate into the waveguide and affect the reliability of the measurement and even block the signal of the measurement.

6.0 Alternatives

IAMC's requirements are similar to the Petroleum and Mining use sector, defined in the PFAS REACH restriction proposal, in that the materials used require high performance and high reliability to prevent failures in products that could result in harm to people and the environment. The technical properties important for IAMC are durability, high and low temperature resistance (-200°C/+260°C), chemical resistance and high mechanical strength in harsh environments. Petroleum and Mining is being referenced because it is a current use sector in the REACH Annex XV PFAS restriction proposal and is analogous to IAMC in many regards, including the need for a broad derogation of fluoropolymers.

Availability

Non-fluoropolymer alternative materials do not exist today for specific IAMC applications due to the harsh operating conditions in which the materials are required to operate, as defined in Section 3.0. While finding suitable alternatives is extremely challenging, evaluating them is straightforward because the material limits of basic properties are often exceeded. In many cases, one just needs to look up materials property data in standard references to determine suitability. In our search for alternatives, other fluoropolymers often show up as the best secondary and tertiary choices. For example, PCTFE is a good back-up material for PTFE and vice versa.

Technical Feasibility

Multiple classes of materials were considered as potential alternatives for fluoropolymers with none emerging as a direct replacement. These materials were identified and evaluated using a combination of in-house data, publication data and thorough discussions with Emerson material experts and experts consulted from the broader materials industry.

Metals

Corrosion resistant metals such as stainless steel (SS), titanium, Hastelloy, nickel, copper, and brass were explored as alternatives to fluoropolymer liners and considered unacceptable because of significant incompatibility with some chemicals and lack of purity in certain applications. PTFE is commonly used to coat metals such as 316L SS to protect the surface from corrosion in harsh chemicals. A study by Waseem Akram[4] compared corrosion rates for 316L and PTFE-coated 316L SS in two acidic mediums, hydrochloric acid (HCL) and nitric acid (HNO_3). Results are provided in Table 8 and show a significant corrosion performance increase (less Mils Per Year) by adding the protective layer of PTFE.

Table 8. PTFE is commonly used as a protective coating to prevent corrosion of SS in IAMC applications.

Acids	**Corrosion Rate: Mils Per Year (MPY)**	
	Bare 316L SS	**316L w/PTFE Coating**
HCL	29.6	0.7
HNO_3	684.8	4.9

Additionally, other challenges were identified that prevented these materials from emerging as viable alternatives including higher density (increased weight), increased maintenance cycles, and higher life-cycle CO_2 emissions associated with the production process.

Non-PFAS Polymers

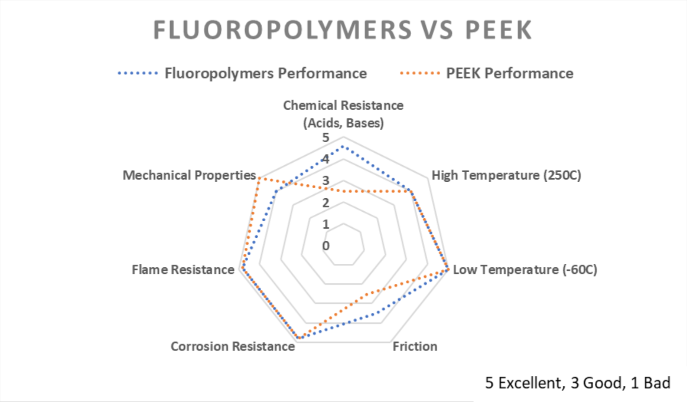

Figure 13. Fluoropolymers' chemical resistance and friction properties are superior to PEEK.

Engineering plastics such as PEEK (see Figure 13) and Polyphenylene Sulfide (PPS) were considered as alternatives for liners, tubing, waveguides and seals but were deemed unsuitable due to their inability to fulfill all the criteria required for IAMC equipment. PEEK and PPS can fulfil the high temperature performance requirements. However, their chemical resistance is inferior to fluoropolymers, especially for chemicals such as hydrogen sulfide (sour) gas and strong acids. Also, PEEK's compressive modulus is too high making it unfit for seats in valves and regulators and its moisture uptake prevents its use in certain waveguide applications. Another polymer considered was acetal, which has excellent lubricity properties. However, its chemical resistance and temperature limitations prevent it from being an appropriate candidate. Another alternative is Polyimides such as Vespel™. They are generally much higher in compressive strength and therefore do not make good lower pressure seal parts. Also they are incompatible with some medias such as water and steam.

Non-PFAS Elastomers

Traditional elastomers such as Ethylene Propylene Diene Monomer (EPDM), Hydrogenated Nitrile Butadiene (H-NBR), and Silicone were considered as alternatives for seals, but were deemed unsuitable due to their inferior chemical resistance, temperature limitations, and mechanical properties. Most elastomers cannot perform at operating conditions that exceed 150°C. Silicone has higher temperature resistance but is inferior in mechanical performance and is also not recommended in high friction and high wear applications. Using materials that are not adequate for the operating condition is not recommended and would, at a minimum and best case, require an unrealistic number of maintenance cycles. Furthermore, safety of workers and the environment could be compromised due to increased probability of failure and possible releases of hazardous materials.

All potential alternatives, metals, non-PFAS polymers, and non-PFAS elastomers, are high performance materials that will likely be persistent similar to fluoropolymers, resulting in substitution of one persistent material with an inferior performing one, leading to increased maintenance cycles and generation of higher amounts of environmental waste.

Economic Feasibility

Cost is not the deciding factor for use of fluoropolymers in IAMC applications. Fluoropolymers are typically more expensive than non-PFAS materials. They are used because the technical requirements of existing IAMC applications eliminate the possibility of utilizing existing alternatives. The primary consideration for IAMC applications is performance to ensure that safe and efficient operations are maintained.

Even if alternatives were available today, the time needed for careful and comprehensive engineering work that accompanies a material change in a highly regulated segment such as IAMC can be in excess of five years with substitution costs ranging in the hundreds of thousands of Euros for a single IAMC product. Substitution costs, while substantial, will pale in comparison to the on-going costs of increased production facility downtime due to more frequent maintenance cycles and shorter life of components caused by decreased performance of any alternative.

Another significant consideration is the intensive engineering effort that accompanies a material change in IAMC's highly regulated segments. Activities to be conducted include finding and evaluating alternatives, modifying designs, re-qualification testing and re-certification (ATEX, Pressure Equipment Directive 2014/68/EU), supply chain cadence change, and customer relations. Some of the standards that are directly applicable are:

- IEC 60079-0 (Explosive atmospheres: General equipment requirements)
- IEC 60079-11 (Explosive atmospheres – Part 11: Equipment protection by intrinsic safety)
- IEC 60079-1 (Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures)
- UL 1203 (Explosion Proof and Dust ignition proof electrical equipment for use in hazardous locations)
- ANSI/ISA 12.27.01 (Requirements for Process Sealing Between Electrical Systems and Flammable or Combustible Process Fluids

Hazards and Risks

Safety is the deciding factor for use of fluoropolymers in IAMC applications. These materials are selected due to their high performance. A good example is PTFE liners' chemical resistance, specifically its ability to prevent toxic substances from leaking. The use of inferior performing alternatives could lead to a breach of containment and a subsequent release of toxic media, which could harm humans, the environment and critical equipment. Another example is PCTFE's limited oxygen index compared to alternatives. PCTFE is a go to material for oxygen enriched applications such as life support for space travel and NAVY diving and also Aerospace fueling applications like rocket propellant and oxidizers.

Non-Polymeric PFAS Processing Aids in Fluoropolymers

IAMC equipment providers are downstream users of fluoropolymers and do not handle any non-polymeric PFAS. The main concern related to fluoropolymers, in terms of human and environmental exposure, is the use of non-polymeric PFAS as polymerization aids in the manufacturing process, rather than the fluoropolymer itself. The fluoropolymer itself is not toxic, bio-accumulative, and/or water soluble, in contrast to the processing aids. Suppliers are addressing this and making progress on the development of non-fluorinated processing aids to be used in the production of fluoropolymers. Our latest update from one of our polymeric PFAS manufacturers indicated that ~80% of all fluoropolymers can be made with non-PFAS processing aids. It is expected that fluoropolymers will not degrade to other PFAS during normal conditions of use or in the environment. Also, recent indications received from fluoropolymer suppliers suggest that incineration of fluoropolymer waste at industrial incinerators can achieve complete thermal destruction of fluoropolymers under specific conditions; therefore it could be concluded that the environmental impact of their by-products can be controlled.

7.0 Annual Tonnage and Emissions

Although fluoropolymers containing parts are vital for IAMC equipment and applications, they are relatively small in terms of tonnage and emissions.

Annual Tonnage

IAMC fluoropolymer tonnages are shown below in Table 9 and were estimated based on product sales over the past year and then extrapolated based on Emerson's 5% estimated share of the total European IAMC market.

Table 9. Fluoropolymer Tonnage for IAMC Equipment Applications in Europe.

Application	Fluoropolymers	Estimated IAMC Annual Tonnage in EU (Tons)
Liners	PTFE, PFA, FEP, ETFE	288
Seals, Diaphragms	FKM, FFKM, PTFE, PCTFE	1,662
Valve Packing	PTFE	239
Valve Seat	PCTFE, PTFE, ETFE	154
Cable & Wiring Insulation	PTFE, PFA, FEP	<10
Electronics	PTFE	<10
Total		**2363**

Assuming an 8% CAGR for the IAMC market[2], tonnage of fluoropolymers is expected to grow to approximately 8k tons per annum by 2038, the duration of the 12-year derogation period.

Emissions

Precise IAMC fluoropolymer emissions are more difficult to assess because they take place at the end of a 15+ year life. Both the benefits and impacts must be considered. On the positive side, fluoropolymer valve packing prevents emissions to the environment due to increased seal efficiency over competing materials. On the negative side, negligible and non-toxic emissions may be released over the entire life cycle of the fluoropolymer product. Despite the relatively small emissions in the IAMC sector, there are further mitigating factors that tend to reduce the concern about emissions even more. The useful lives of IAMC equipment and components are very long, often greater than 15 years. This is in contrast to single use and/or limited lifetime consumer products that reach their end-of-life stage more quickly. Moreover, due to the closed-loop and sealed structure of IAMC equipment, the risk of environmental or human exposure is very limited during the use phase. Even equipment operators are unlikely to come in contact with the fluoropolymers in the system, as the fluoropolymers are utilized in discrete, solid plastic parts that are embedded or lined inside the components of the final end-products.

Concerns related to PFAS emissions during the manufacturing of fluoropolymers are expected to be addressed and should be manageable in a reasonable and defined timeframe, per feedback received in a recent inquiry. Implementation of various abatement technologies/emission control methods to reduce the environmental footprint are necessary and we intend to continue maintaining a responsible supply chain.

Another option for estimating IAMC emissions is to leverage the similarities to the Petroleum and Mining use sector and assign values that are on the same order of magnitude.

8.0 Socioeconomic Implications

Exclusion of IAMC as a use sector and implementation of an all-PFAS ban will have significant socioeconomic implications on the European economy. Industrial automation alone represents about 3-5% of major infrastructure capital; additional to this impact it needs to be noted that the number of essential products and services coming out of those facilities is orders of magnitude larger. Examples of essential products and services are defined in Table 4 of Section 4.0. Furthermore, Emerson employs over 7,000 people at 17 manufacturing sites, across 13 Member States. If the REACH PFAS restriction proposal is enacted as written today, IAMC equipment will be eliminated for all use sectors except for the 14 defined in the restriction proposal, which will result in devastating cuts at Emerson and a direct reduction to the European economy based on elimination of most of the chemical processing industry alone.

Furthermore, through the possible elimination of IAMC and fluoropolymers, the EU could fall behind other countries on technology competitiveness, especially in the area of chemical processing. Potential outcomes include reduction in manufacturing operations resulting in higher imports for everything from food to pharmaceuticals. The materials used in IAMC equipment are also used in the production of water and carbon sequestration equipment all of which are vital for long term sustainability success. Moreover, material limitations will continue to narrow the scope of technology-related activities that can be accomplished including those critical to Europe’s future, namely alternative energy, transportation, and battery manufacturing. Materials are critical enablers of these technologies, and a derogation of fluoropolymers will enable Europe to maintain a level playing field, increasing the probability of achieving a successful outcome.

Number of Companies Affected by a PFAS Ban

All companies who manufacture IAMC equipment will be affected by the restriction. Emerson estimates this number to be around 1,000 for Europe. Additionally, Emerson has 50,000+ global customers that will be impacted given the large installed base and not viable replacement options.

9.0 End-Of-Life

IAMC equipment can be disassembled and separated at the end-of-life for processing or re-use in a circularity methodology. The fate of fluoropolymers at the end-of-life in this business sector is controllable and can be any one or more of the following:

- **Recovery and Recycling:** Fluoropolymers can be chemically returned back to their building blocks for reconstruction without damage to their properties. Melt-processable fluoropolymers, which excludes PTFE, can be recycled through traditional mechanical methodologies. The challenge for non-melt processable fluoropolymers like PTFE is identifying ways to return materials to a facility that can perform chemical recycling. This is a difficult problem, but not insurmountable.
- **Incineration:** There are available studies that strongly suggest that PTFE, the most stable fluoropolymer, undergoes complete thermal decomposition at a temperature of about 800°C and is safe for incineration at municipal incineration facilities[5]. Therefore, it is assumed that most other fluoropolymers also thermally decompose within similar parameters and are also safe for incineration at most typical municipality incineration facilities.
- **Landfills:** Fluoropolymers are inherently safe, non-mobile, non-bio accumulative and non-toxic. Waste is chemically inert and therefore, fluoropolymers disposed in landfills do not pose any substantive threat to human health and the environment.

10.0 Ending Statement

In closing, our derogation request is two-fold, as follows:

1. Incorporation of IAMC equipment as a missing use, and
2. A 12-year derogation of fluoropolymers for use in IAMC equipment.

Fluoropolymers are clearly differentiated from other substances in this very broad group of PFAS chemicals. There is strong evidence that suggests that these materials will not give rise to situations of concern for human health or the environment, acknowledging as well that industry continues to make significant progress to limit the use of PFAS polymerization aids and to introduce adequate abatement techniques to keep emissions of potentially harmful fluorinated by-products under adequate control.

Fluoropolymers are known for providing many beneficial properties simultaneously (combined in single products) that allow the continued development of applications critical to society, not only related to technological progress, but specifically in terms of safety to the population and development of green energy alternatives.

In conclusion, Emerson recommends incorporation of IAMC as a new use sector and a 12-year derogation for fluoropolymers for use in IAMC equipment as part of the upcoming REACH PFAS restriction. This position is consistent with Emerson's continued commitment to preserving environmental sustainability and human health and as an advocate of restricting the use of harmful substances. Emerson is also committed to compliance with all relevant environmental laws and regulations in the countries in which we operate.

This submission summary precedes Emerson's full derogation request, which will follow within the timing of the open comment period.

We appreciate the opportunity to provide this information and invite you to reach out to us for additional information or discussion regarding our request.

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References

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[1] Korzeniowski, S.H., Buck, R. C., Newkold, R. M., El kassmi, A., Laganis, E., Matsuoka, Y., Dinelli, B., Beauchet, S., Adamsky, F., Weilandt, K., Soni, V. K., Kapoor, D., Gunasekar, P., Malvasi, M., Brinati, G. Musio, S. (2022) A Critical Review Of The Application Of Polymer Of Low Concern Regulatory Criteria To fluoropolymers II: Fluoroplastics, and fluoroelastomers, Integrated Environmental Assessment and Management, 19(2), 326. https://doi.org/10.1002/ieam.4646

[2] www.precedenceresearch.com, Report Code: 2170; Category: Semiconductor and Electronic; Publishd 2022

[3] E. Alfredo Campo, 3 - Thermal Properties of Polymeric Materials, Editor(s): E. Alfredo Campo, In Plastics Design Library, Selection of Polymeric Materials, William Andrew Publishing, 2008, pp. 103-140. ISBN 9780815515517. https://doi.org/10.1016/B978-081551551-7.50005-X

[4] Akram, W., Farhan Rafique, A., Maqsood, N., Khan, A., Badshah, S., & Khan, R. U. (2020). Characterization of PTFE film on 316L stainless steel deposited through spin coating and its anticorrosion performance in multi acidic mediums. Materials, 13(2), 388. https://www.researchgate.net/publication/338614979_Characterization_of_PTFE_Film_on_316L_Stainless_Steel_Deposited_through_Spin_Coating_and_Its_Anticorrosion_Performance_in_Multi_Acidic_Mediums.

[5] Aleksando, K., Gehrmann, H-J., Hauser, M., Matzing, H., Pigeon, D., Stapf, D., Wexler, M. (2019). Waste Incineration of Polytetraluoroethylene (PTFE) to Evaluate Potential Formation of per- and Poly-Fluorinated Alkyl Substances (PFAS) in Flue Gas. https://reader.elsevier.com/reader/sd/pii/S0045653519306435?token=C28A68B6BA19186C7EB4F1E09BCDA2C9C84A214D3983E5D75466538CB7B1B878A8DE1A4EF7A7849515099480AECD99AB&originRegion=us-east-1&originCreation=20230509140121