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White Paper for EU Annex XV Restriction Report and under REACH

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I. Scope: Exclude Fluoropolymers from the Proposed Restrictions on PFASs

The current Annex XV Restriction Report ("Annex XV Report"") proposes to restrict "any substance that contains at least one fully fluorinated methyl (CF3-) or methylene (-CF2-)" (Agency, 2023). This definition is used due to concern with safety profiles of these per- and polyfluoroalkyl substances ("PFASs"). Specifically, that they are, or ultimately transform into, persistent substances; are soluble and mobile in water and thereby able to contaminate surfaces, ground- and drinking water or soil; and are toxic and/or bio accumulative, both with respect to human health as well as the environment (Agency, 2023).

This definition of PFASs communicates that the compounds under this term share the same structural trait of having a fully fluorinated methyl or methylene moiety. However, it does not inform wither a compound presents risk or not. In this broad definition, there are distinct substances with very different properties: polymers and nonpolymers; solids, liquids, and gases; persistent and nonpersistent substances; highly reactive and inert substances; mobile and insoluble; eco-toxic and nontoxic chemicals. In addition, this definition covers a broad range of molecular structures- neutral, anionic, cationic, aromatic, low or high molecular weight- and therefore diverse physical, chemical, and biological properties. It is for all of these reasons that the definition of PFASs is too broad, and the chemicals it covers should be considered in separate groups for risk assessment and management.

One unique category that should be separated out for risk assessment and management is fluoropolymers. Fluoropolymers are a class of materials with high molecular weight. Examples of fluoropolymers are: polytetrafluoroethylene ("PTFE") CAS # 9002-8-0 $(CF_2CF_2)_n$; perfluoroalkoxy alkane ("PFA") CAS # 26655-00-5 $(CF_2CF_2)_n$-$(CF_2CF(OCF_3))_m$,; and fluorinated ethylene propylene ("FEP") CAS # 25067-11-2 $(CF_2CF_2)_n$-$(CF_2CF(CF_3))_m$. Fluoropolymers have unique properties that are a result of their very high molecular weight, generally over 100 kg/mol. Each repeating unit of a fluoropolymer has an extremely strong carbon-fluorine (C-F) bond, in fact the strongest bond that can exist between C and another atom, making them highly stable materials over a very wide temperature range (Olabisi & Adewale). In addition to the thermal stability, fluoropolymers also have high chemical, oxidative, hydrolytic, and biological stability. PTFE is inert inside the body, without degradation, and is commonly used in heart stents and hernia meshes (Ünek, et al., 2019). The size of the molecule makes it impossible for the fluoropolymers to cross cell membranes. In addition, fluoropolymers are inherently non-flammable, and are highly resistant to degradation. The polymeric materials have negligible residual monomer and/or oligomer content, and low to no leachable materials (Gangal & Brothers), making the risk of ground water contamination negligible. As a result, fluoropolymers do not present significant toxicity concerns and cannot degrade into other PFASs.

It has been widely recognized that certain chemical properties, specifically molecular weight, limit the ability of a chemical to cross the cell membrane and therefore limits its bioavailability. Examination over time has resulted in a collection of data to relate the chemical properties and structure of a given chemical to its hazard potential. These factors support the "polymers of low concern" (PLC) criteria as defined by the Organization for Economic Cooperation and Development (OECD) (Development, 1993 Apr), which have been accepted by Australia, Canada, China, Japan, Southern Korea, Philippines, New Zealand, Taiwan, and the United States (Deloitte, 2015). The PLC criteria are detailed in this reference, (Development, 1993 Apr) (Deloitte, 2015), but include molecular weight, ionic character, reactivity, and residual monomer content, to name a few. Fluoropolymers satisfy the PLC criteria and are as such considered to be "low concern" to human health and the environment (Henry, et al., 2018).

The physical-chemical properties of fluoropolymers prevent bioavailability, bioaccumulation, toxicity, and degradation. Fluoropolymers are also not water soluble, and not subject to long-range transport. Due to the large size of these molecules, fluoropolymers cannot cross the cell membrane (Henry, et al., 2018). Based on review and assessment of fluoropolymer toxicity data, human clinical data, and physical, chemical, thermal, and biological data, research has concluded that fluoropolymers are distinctly different from other nonpolymeric PFASs (Korzeniowski, 2023).

Grouping fluoropolymers together with all classes of PFASs for a single approach to structure-hazard assessment based on persistence alone is therefore not scientifically appropriate. For this reason, we strongly believe that a distinction must be made within the definition of PFAS included in the PFAS Proposal, and that the following fluoropolymers should be excluded from the proposed restrictions:

I. **polytetrafluoroethylene ("PTFE") CAS # 9002-8-0 $(CF_2CF_2)_n$;**
II. **perfluoroalkoxy alkane ("PFA") CAS # 26655-00-5 $(CF_2CF_2)_n$-$(CF_2CF(OCF_3))_m$,;**
III. **fluorinated ethylene propylene ("FEP") CAS # 25067-11-2 $(CF_2CF_2)_n$-$(CF_2CF(CF_3))_m$**

This distinction is scientifically supported as large molecule fluoropolymers have been demonstrated to be safe and do not pose significant risk to human health (Korzeniowski, 2023)**.**

II. Missing Specific Uses of PFASs: Request for a Temporary Exemption for the Use of Specific Fluoropolymer PFASs in Aerospace and Defense Applications

There are several aerospace and defense use sectors that utilize PFASs. Polytetrafluoroethylene ("PTFE"), perfluoroalkoxy alkane ("PFA"), and fluorinated surfactants are used in the manufacture of copper clad laminates ("CCL") which are used to make printed circuit boards ("PCBs") including formed or molded components thereof. PCBs are used in diverse applications across a wide array of industries, including aerospace and defense, automotive, wireless communications infrastructure, digital (wired infrastructure), medical, and general industrial equipment. Fluorinated polymers are used as dielectric materials separating conductive copper layers in PCBs. Since PTFE materials are expensive to purchase and fabricate, they are only used when their performance attributes are absolutely essential. **The aerospace and defense applications that utilize PTFE-based materials are mission-critical, requiring superior electrical performance and exceptional stability and reliability in harsh environments. There are no current alternative materials that have been demonstrated to have consistent electrical performance during high temperature excursions and long lifetimes.**

Key Functionalities provided by PFASs: Electronics – Printed Circuit Boards Used in Aerospace and Defense

The Annex XV Report acknowledges that PFASs are commonly used in the production process of electronic components. However, for these applications, it should be emphasized that specific PFASs (PTFE, PFA, FEP) are also the key material constituting the dielectric layer of the PCB itself. The PTFE and PFA are the key enabling constituents of the performance required of such PCBs for mission-critical applications due to their unique combination of properties:

1) Highly ablative, without charring
2) Low modulus allowing them to be formed around surfaces
3) Low dielectric constant and low dissipation factor enabling superior electrical performance.
4) Stable at temperatures above 130°C, enabling stable performance during temperature excursions.
5) Inherently flame retardant

As explained further below these uses of PTFE, PFA and FEP as key constituents of the dielectric layer of PCBs are used in multiple aerospace and defense applications, such as global positioning systems for missiles and defense, airborne communication, missile nose cones, surveillance and airborne radars.

PFASs Use Application: Global Positioning Systems for Missiles and Defense

PTFE's superior electrical and thermal properties are not the only reason it is the preferred polymer for many of the most demanding applications. The molecular structure of PTFE is a linear and non-polarizable, making it highly inert and non-reactive with other materials. The fluorine atoms making up the PTFE polymer chain make the material highly hydrophobic, minimizing water uptake during use. Water absorption is highly detrimental to the electrical properties and will change the Dk and Df of the material if absorbed into a PCB. **It is this performance criteria that has made PTFE-based PCB boards the main source of global positioning systems ("GPS") guidance systems for missiles and other defense applications globally.** GPS systems, at a high level, have 3 components: satellites, grounds stations, and receivers. Satellites act like the 'north star', and their position is supposed to be known at any given time. The ground stations use radar to make sure the satellite coordinates are correct. A receiver is then constantly listening for a signal from the satellites, and then determines the distance between the receiver and the satellite (Erickson, 2019).

The radar system in the ground stations, and their communication with orbiting satellites is key to being accurate. Radar – which is an acronym that stands for Radio Detection and Ranging – is a detection system that uses radio waves to locate and track objects that may not be visible by the naked eye. In national defense, they are imperative to security as they provide early warning against adversarial threats, such as ballistic missiles, cruise missiles, unmanned air vehicles and aircraft, etc (Lockheed Martin, 2021). The radar transmits a signal, in the form of bursts of electromagnetic waves. Those waves can then be intercepted and reflected by objects, such as a plane, a missile, or precipitation. A receiver accepts the returned energy of the radio waves and measures the time elapsed since the transmission. Using the reflection data, a radar operator can calculate the distance / direction / speed / shape of the object (Lockheed Martin, 2021). The antennas that transmit and receive the signal has a radiating element that determines the antenna's bandwidth and gain. The antenna ground place influences the radiation pattern of the antenna. A power amplifier is very often required to produce a signal that is strong enough to detect objects at a useful distance. The antenna also contains a radome, which encloses the antenna and influences its phase center. This phase center is important for location as the position reported by a receiver refers to where the antenna captures the signal. To function, the antennas have high gain, low directivity, and minimal signal losses (Hardesty, 2020). To achieve the highest gain, and lowest return loss, a unique material is needed: PTFE (Ammanagi, Khadilkar, Harwani, Budhlani, & Dembla, 2014). The gain and return loss must be stable over varying environmental conditions including large temperature excursions and large humidity ranges, to ensure that the same accuracy can be consistently achieved, requiring a material that does not change performance in those conditions. The material also needs to be able to handle the high powers required to enable the earliest detection at the farthest ranges without breakdown or burning. PTFE is uniquely suited to meet all of these requirements, and is the enabling material for reliable and consistent performance in this application.

PFASs Use Application: Airborne Communication

PTFE has very low outgassing. This makes it uniquely suited for applications in space as any outgassing after launch can create failures. For this reason, PTFE-based PCB's have been used to support communication systems on the majority of western spacecraft since the dawn of the Space Age. PTFE is also stable to UV light, has high breakdown voltage and excellent surface and volume resistivity. In addition, PTFE has excellent thermal stability in both very cold (-196°C) and hot environments (130°C+), making PTFE-based PCBs highly reliable and uniquely suitable to withstand the temperature excursions that airborne communications units will experience during use.

These applications also require electrical performance, especially a sufficiently low dielectric loss to maintain signal integrity throughout the intended use period and drastic temperature range. The systems in which these PCBs are used are often deployed in extreme environmental conditions where reliability is paramount. For instance, PTFE-based materials are utilized in both the Voyager

1 and Voyager 2 spacecraft to enable and ensure reliable communication through NASA's Deep Space Network (Dunbar D. , 2023) a galaxy away from Earth, 45 years after launch (Nelson, 2023). It is the unique combination of application requirements discussed here that make PTFE uniquely suited for the most demanding aerospace and defense applications.

The use of PTFE laminates in space flight systems and applications has provided highly-stable RF/microwave signal integrity and reliability over many years, meeting the demanding challenges associated with solar and outer space radiation effects on satellite payloads, and the stability required to meet extreme thermal profiles present in these systems. There have been no identified materials available in the RF/microwave spectrum which provide the same unique performance attributes that PTFE materials provide today. The payloads and satellite bus systems are providing a wide spectrum of services to humanity, from global weather monitoring and forecasting through use of advanced radar systems, to critical communication links from satellite-based transceivers relaying information to millions of people around the world. **With the impact to the Earth's population in mind, it is critical that these systems maintain the highest level of reliability to enable accurate and timely forecasting of weather patterns and provide advanced warnings to protect citizens and infrastructure from any calamitous event.** Global navigation satellite systems ("GNSS") and GPS are also critical for day-to-day activities (U.S. Space Force, 2023). These systems operate off a constellation of orbiting satellites and depend on PFAS-containing materials to reliably perform (European Union Agency for the Space Programme, 2023). **Elimination of PTFE materials from space and satellite applications would endanger our populations.**

Satellite systems also provide terrain mapping and monitoring services for climate impact, such as foliage and grassland coverage, coastal erosion monitoring and forecasting, and other key monitoring platforms used for missile defense applications (Dunbar B. , 2014). **A single point of system performance degradation or failure could inhibit the early detection of missile launches, and impact the ability of nations to ready adequate defenses in response to attack.**

Critical SATCOM systems could also be compromised by degradation, impacting nations' ability to communicate effectively and quickly, relaying vital and timely communications links to millions of people. Satellite data links enable the only effective means of communication in some parts of the world. Satellite systems provide our entertainment and global awareness through radio, broadband internet, and television transmission services both in GEO (Geostationary Equatorial Orbit) and LEO (Low Earth Orbit) applications. Many of these data links operate in the RF/microwave spectrum, which would be impacted negatively by removal of PTFE Laminates from these applications, in both lower performance as well as faster degradation of materials requiring far more frequent satellite replacements.

PFASs Use Application: Missile Nose Cones

The aerospace and defense market worldwide has heavily relied on the use of PTFE laminate materials for their superior performance and reliability in space flight, as well as in airborne and terrestrial applications. Many aerospace and defense applications require materials with a low enough modulus to be bent or molded into shape, such as the nose cone that is wrapped around a missile. In addition to being formable, PTFE will ablate without carbon charring, retaining electrical properties for any materials the PTFE is covering. Ablation, or slow erosion of material, is an important property for many defense-related applications. The outer layer of the nose cone will erode away at a predictable rate without charring during the high temperature excursion (which exceeds 1600°F) of launch and re-entry into the atmosphere (Winters, Witte, Rashis, & Hopko, 1962). This insulates all of the internal components from the elevated temperatures of travel and re-entry (Heppenheimer, 2007).

PFASs Use Case: Surveillance

Aerospace and defense platforms rely on the stability and long-term reliability of PTFE laminates and materials to provide surveillance without equal. It is essential that spacecraft function repeatably across a wide temperature range to transmit data and telemetry to Earth, receive commands from Earth, and relay information from one craft to another (Caldwell, 2023). To eliminate PTFE-based materials in spacecraft would potentially lead to early failure or system degradation in signal performance, reducing life expectancy of the units and causing blackouts in communication. There is no alternate material today in the RF/microwave PCB market which demonstrates this level of demonstrated performance, including high signal integrity and low outgassing in space conditions.

Specifically, many of the surveillance units have a radar component. Radar – which is an acronym that stands for Radio Detection and Ranging – is a detection system that uses radio waves to locate and track objects that may not be visible by the naked eye. In national defense, they are imperative to security as they provide early warning against adversarial threats, such as ballistic missiles, cruise missiles, unmanned air vehicles and aircraft, etc (Lockheed Martin, 2021). The radar transmits a signal, in the form of bursts of electromagnetic waves. Those waves can then be intercepted and reflected by objects, such as a plane, a missile, or precipitation. A receiver accepts the returned energy of the radio waves and measures the time elapsed since the transmission. Using the reflection data, a radar operator can calculate the distance / direction / speed / shape of the object (Lockheed Martin, 2021). The antennas that transmit and receive the signal has a radiating element that determines the antenna's bandwidth and gain. The antenna ground place influences the radiation pattern of the antenna. A power amplifier is very often required to produce a signal that is strong enough to detect objects at a useful distance. The antenna also contains a radome, which encloses the antenna and influences its phase center. This phase center is important for location as the position reported by a receiver refers to where the antenna captures the signal. To function, the antennas have high gain, low directivity, and minimal signal losses (Hardesty, 2020). To achieve the highest gain, and lowest return loss, a unique material is needed: PTFE (Ammanagi, Khadilkar, Harwani, Budhlani, & Dembla, 2014). The gain and return loss must be stable over varying environmental conditions including large temperature excursions and large humidity ranges, to ensure that the same accuracy can be consistently achieved, requiring a material that does not change performance in those conditions. The material also needs to be able to handle the high powers required to enable the earliest detection at the farthest ranges without breakdown or burning. PTFE is uniquely suited to meet all of these requirements, and is the enabling material for reliable and consistent performance in this application.

PFASs Use Case: Airborne Radar

Airborne platforms, including airplanes, helicopters, unmanned aerial systems (UAS) and other means of airborne observation, provide both commercial and defense services throughout the world. Commercial application in aircraft rely on radar systems for weather monitoring in flight, broad-band internet services for flight passengers, critical communication links to pilots and ground stations, and other avionic systems. Defense applications rely on critical communication links to monitor and avoid conflict between adversarial forces, providing deterrence and stability in global conflict. As aircraft and other system velocities continue to increase, **the unique properties of PTFE materials provide critical thermal protection solutions in high-speed airborne applications that could not be easily or inexpensively replaced today**. The extreme thermal challenges present in today's airborne applications rely on RF/microwave signal management and long-term reliability available with the use of PTFE solutions to meet mission requirements. Elimination of PTFE in airborne avionics, radars, and communication systems would place the entire air traffic management of our commercial fleets at risk.

By providing electrical reliability in extreme operating temperature ranges over years of use, PTFE laminates and solutions meet demanding requirements in many terrestrial applications, from SATCOM up/down linking systems, to weather monitoring radar systems, to homeland protection from adversarial forces. Radar systems for early warning missile defense rely on the performance attributes and reliability of PTFE laminates to meet these requirements (Withingon, 2020). Ground-based communications systems relaying critical infrastructure through the RF/microwave spectrum would be impacted negatively from the elimination of this critical material solution (Esper, 2020). Alternative solutions featuring degraded performance or potential reduced life expectancy could lead to costly and/or early replacement of systems at an accelerated rate, impacting financial stability throughout the world.

Radar – which is an acronym that stands for Radio Detection and Ranging – is a detection system that uses radio waves to locate and track objects that may not be visible by the naked eye. In airborne radar, they are used to detect other aircraft, weather patterns, and some in-flight programming. The radar transmits a signal, in the form of bursts of electromagnetic waves. Those waves can then be intercepted and reflected by objects, such as a plane, a missile, or precipitation. A receiver accepts the returned energy of the radio waves and measures the time elapsed since the transmission. Using the reflection data, a radar operator can calculate the distance / direction / speed / shape of the object (Lockheed Martin, 2021). The antennas that transmit and receive the signal has a radiating element that determines the antenna's bandwidth and gain. The antenna ground place influences the radiation pattern of the antenna. A power amplifier is very often required to produce a signal that is strong enough to detect objects at a useful distance. The antenna also contains a radome, which encloses the antenna and influences its phase center. This phase center is important for location as the position reported by a receiver refers to where the antenna captures the signal. To function, the antennas have high gain, low directivity, and minimal signal losses (Hardesty, 2020). To achieve the highest gain, and lowest return loss, a unique material is needed: PTFE (Ammanagi, Khadilkar, Harwani, Budhlani, & Dembla, 2014). The gain and return loss must be stable over varying environmental conditions including large temperature excursions and large humidity ranges, to ensure that the same accuracy can be consistently achieved, requiring a material that does not change performance in those conditions. The material also needs to be able to handle the high powers required to enable the earliest detection at the farthest ranges without breakdown or burning. PTFE is uniquely suited to meet all of these requirements, and is the enabling material for reliable and consistent performance in this application.

Availability, Technical and Economic Feasibility of Alternatives

Although there are multiple polymeric materials available as the dielectric layer, the performance attributes of PFASs are required in many applications. The choice of dielectric material in PCB manufacture is based on the electrical and mechanical requirements, the frequency of use, and the expected usage temperatures for the application. The most important electrical parameters in this regard are dielectric constant ("Dk") and loss tangent, which is commonly reported as dissipation factor ("Df"). Dk is important because it moderates the signal transmission rate. Signal transmission rate is inversely proportional to the square root of the dielectric constant. Therefore, lower Dk results in higher speed transmission and this is particularly important at higher operating frequencies. Df is a measure of signal loss in the circuit board and lower Df minimizes attenuation of the transmitted signal during operation. All loss of the signal is generated heat, which can further reduce performance.

At frequencies up to about 1 gigahertz (GHz), FR4 (woven fiberglass coated with an epoxy resin) is the most commonly used material because it meets the electrical requirements of the application and is cost effective (costing ~€8/square meter). However, it has a high dielectric constant, of about 4.5, and most notably a high dielectric loss (of about 0.01). It is also not thermally resistant at temperatures above about 90°C, and in addition, the high dielectric loss generates heat in the application. Thermosetting hydrocarbons (polyphenylene oxide ("PPO") and polybutadiene ("PBD") coated on fiberglass) is another class of materials. These are generally used for applications up to 25 GHz. These products have dielectric constants around 3.5, dielectric loss around 0.004, and can operate continuously at temperatures approaching 100°C. At frequencies exceeding 10 GHz, and higher maximum operating temperature ("MOT") use expectations, PTFE is the required choice because of its superior and stable electrical and mechanical properties. This choice is made based purely on performance requirements, as the PTFE materials are roughly two times the cost of the initial PCB material, and cost about three times more to fabricate into circuits. PTFE's dielectric constant is very low (about 2.2) and is stable over a wide frequency range. In addition, PTFE's Df is less than about 0.002 due to its non-polarizable linear structure. This low loss reduces circuit trace heating, and lowers the amount of heat that must be dissipated in the end device. PTFE can be used in applications with operating temperatures of 130°C or higher. **These characteristics make PTFE the material of choice for defense applications where consistent electric performance is required over 10+ years, and where operating temperatures exceed 130°C.** These properties are summarized below, in Tables 1 and 2.

PTFE dielectrics can be coated onto fiberglass or used as a stand-alone dielectric layer. These dielectrics are usually filled with ceramics to adjust Dk and help reduce the coefficient of thermal expansion. Radio frequency ("RF") systems used in the defense electronics industry required dielectric materials with a Dk in the range of 2.5 to 10. The materials for the circuit boards are formulated to meet all the expected Dk variations required by the defense electronics industry.

Table 1. Comparison of key electrical properties for PFAS and alternative material PCBs.

Material Solution	Dk	Df	Freq. Range (GHz)	MOT (°C)
FR4 (epoxy)	~4.5	0.01	< 1	90
Thermoset - PBD	3.5 - 10	0.004	≤ 25	90
Thermoset - PPO	3.5 - 10	0.002-0.004	≤ 25	100
PTFE/ PFA / FEP	2.2 - 10	0.001-0.002	≤ 77	130 +

Table 2. Comparison of additional key properties for PFAS and alternative material PCBs.

Material Solution	Flame Retardant	Formable
FR4 (epoxy)	Only with FR additive	No
Thermoset - PBD	Only with FR additive	No
Thermoset - PPO	Only with FR additive	No
PTFE/ PFA / FEP	Yes	Yes

Development of an alternative for even a single application would require significant investment in both time (a minimum of 5 years to invent a replacement, with an additional 5-10 years required to scale to commercial levels and demonstrate reliability) and materials (alternative resins that show comparable electrical and mechanical behavior are not currently commercially available). These materials would need to be new thermoset solutions that have a higher thermal stability than current thermoset solutions, enabling stable electrical performance during temperature excursions from -55°C to more than 130°C. In addition, these new resins would need to be compatible with flame retardants to ensure that flame retardancy requirements are met. No thermosets currently available are inherently flame retardant. The solution would also need to be formable. No thermoset currently commercially available meets all of these requirements.

In addition to time, this is a minimum of €1.5M required investment per application to develop such alternative, and a minimum of €250k per customer, per application, to qualify such an alternative, if in fact, the alternative can be qualified at all. The >50 year history of PTFE materials in space applications provides a track record that makes PTFE the only material that can be counted on for today and tomorrow's critical missions. In addition, it is very unlikely that a 'one size fits all solution' will be identified as a PTFE-replacement, as it used in a wide variety of electronic applications. The authors, along with the rest of the PCB industry, have been evaluating PTFE alternatives for over 30 years and have not found a single suitable replacement product that would meet all the requisite application needs detailed in this paper.

Socio-economic Impact of the proposed restrictions on PFASs on the European Aerospace and Defense Sector

The European aerospace and defense industry has a very large impact to Europe's economy and economic health. Across the European Union, there were 942,000 direct jobs in the aerospace and defense industry in 2022, which represented 1.3% of the total employment across the region in such period. In addition to direct jobs, the total employment level supported by the aerospace and defense industry in 2022 was 3.57 million people due to indirect and induced jobs. The total 2022 EU revenue was €578 billion, including direct, indirect, and turnover. This means that every Euro in the aerospace and defense sector generates €0.99 of GDP. This industry also supports €141.3 billion in overall wages (Pie, 2022).

PFASs Use Case: European Defence Agency Strategic Goals

In addition to the critical material applications set forth above, PFAS-containing materials are also essential to meet Europe's strategic goals. According to the European Defense Agency's 2022 Annual Report (Šedivý, 2023), the year 2022 presented a "paradigm shift for security and defense in Europe with the return of all-out war to European soil." To support the invasion of Ukraine, the EU has provided the country with weapons and support. These resources will need to be continually replenished to maintain EU defense readiness. Certain of **these weapons contain PFASs in the form of the radar and communication networks and ablative nose cones for effective targeting of missiles, among others. To be successful, and maintain defense readiness, the EU needs to have continued access to PFASs and PFAS-containing components.**

Other active programs include the Safe Autonomous Flight Termination program to integrate unmanned aircraft systems with weapons into the European airspace. The drones themselves rely on PFAS-containing materials to function. These include radar systems and GPS systems for positioning and guidance, as well as communications systems that need to operate around the world under various weather conditions. The PFAS materials for radar allow for the widest field of view, and allow for detection of objects at the farthest distance (Šedivý, 2023).

In addition to supporting immediate needs, PFAS-containing materials support a variety of projects that have been identified as 2023 strategic initiatives within the European Union. The European Defense Agency is implementing four Permanent Structured Cooperation ("PESCO") projects: Chemical, Biological, Radiological Nuclear Surveillance as Service ("CBRN SaaS"); Deployable Modular Underwater Intervention Capability Package ("DIVEPACK"); European Patrol Corvette ("EPC"); and Cyber and Information Domain Coordination Centre ("CIDCC"). The goal of these projects is to reinforce and modernize the EU's armed forces (Šedivý, 2023). To be successful, these programs will rely on PFAS-containing electronic components to incorporate high performance, high reliability data communication. Additionally, the sensors used for the CBRN SaaS program will likely require PFAS components to ensure that they do not degrade, and can deliver the essential data for the exact materials such sensors are surveilling.

The European Defense Agency's 26 Member States allocate a large share of their economic resources to the defense sector. In 2021, the total value was €214 billion, or 1.5% of the gross domestic product (GDP). This value and percentage have been relatively stable in Europe since the end of the Cold War. The total percentage has also been relatively low due to the relative stability in the area. As a result, the EU armed forces have "suffered in terms of their equipment and readiness which now needs to be rapidly reversed in face of Russia's war of aggression against Ukraine." (Schoeffmann, 2022) **The total defense budget is therefore expected to grow in the next several years, and with it, the need for PFAS-containing electronics and components to support reliable defense applications.**

Summary and Comments on Derogations

For the aerospace and defense applications described herein, no derogation is currently proposed in the Annex XV Proposal. This is untenable, as alternative materials are not currently available and are unlikely to become available for these mission-critical applications that require high-performance materials and proven temperature reliability.

Therefore, we request:

I. The exclusion of the following fluoropolymers from the proposed restrictions of the Annex XV Report on PFASs:

a. polytetrafluoroethylene ("PTFE") CAS # 9002-8-0 $(CF_2CF_2)_n$;
b. perfluoroalkoxy alkane ("PFA") CAS # 26655-00-5 $(CF_2CF_2)_n$-$(CF_2CF(OCF_3))_m$,;
c. fluorinated ethylene propylene ("FEP") CAS # 25067-11-2 $(CF_2CF_2)_n$-$(CF_2CF(CF_3))_m$

These fluoropolymers are critical to a broad array of electronic and communication components used in the aerospace and defense industry due to a unique combination of properties.

a. Highly ablative, without charring
b. Low modulus allowing them to be formed around surfaces
c. Low dielectric constant and low dissipation factor enabling superior electrical performance.
d. Stable at temperatures above 130°C, enabling stable performance during temperature excursions.
e. Inherently flame retardant.

Due to this unique *combination* of properties, PTFE-based materials are extremely difficult to substitute in current aerospace and defense designs without tradeoffs in performance and lifetime as there are no known alternatives that meet all of these performance criteria. In addition to the application performance criteria, PTFE-based materials have low impact to human health and the environment.

II. Request for a temporary exemption for use of specific fluoropolymer PFASs in defense and aerospace applications

a. We request that the proposed restrictions on PFASs provide a temporary exemption for "aerospace and defense applications" of at least 15 years for:
    i. polytetrafluoroethylene ("PTFE") CAS # 9002-8-0 $(CF_2CF_2)_n$;
    ii. perfluoroalkoxy alkane ("PFA") CAS # 26655-00-5 $(CF_2CF_2)_n$-$(CF_2CF(OCF_3))_m$,;
    iii. fluorinated ethylene propylene ("FEP") CAS # 25067-11-2 $(CF_2CF_2)_n$-$(CF_2CF(CF_3))_m$

PFASs, and in particular the fluoropolymers listed above, are critical to a broad array of electronic and communication components used in the aerospace and defense industry due to a unique combination of the following properties:

a. Highly ablative, without charring
b. Low modulus allowing them to be formed around surfaces
c. Low dielectric constant and low dissipation factor enabling superior electrical performance.
d. Stable at temperatures above 130°C, enabling stable performance during temperature excursions.
e. Inherently flame retardant.

PFASs are critical to a wide variety of everyday life impacts, from weather forecasting to national safety. In addition, elimination of PFASs would have a significant impact to the EU aerospace and defense industry and a direct impact to the EU GDP. There is currently no clear path toward the identification and development of suitable PFAS-free alternatives that would meet the demanding criteria required for successful substitution. In addition, an extensive qualification process will be required for any new materials, where reliable performance over the long term will need to be thoroughly examined and verified.

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