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IPC RESPONSE TO THE PROPOSED RESTRICTION OF PFAS

A responsible industry response to a universal PFAS restriction requires more time

These comments are in response to the European Chemical Agency's (ECHA) public consultation on the proposal for a restriction of per- and polyfluoroalkyl substances (PFAS) in the Annex XV Restriction Report from 22 March 2023. IPC respectfully submits these comments on behalf of more than 3,200 companies in the electronics manufacturing supply chain, including printed circuit board (PCB) manufacturers, electronics manufacturing services (EMS), cable and wire harness manufacturers, electronics industry suppliers, and original equipment manufacturers (OEMs). IPC members represent the complex and global supply chain for electronics and adjacent industries including consumer, commercial, and high-reliability products used in aerospace, automotive, defence, medical, and other products found in homes and businesses in the European Union.

The electronics manufacturing industry is committed to continuously improving the environmental performance and safety of all products placed on the market.

The complexity of the supply chain and the intermediate and final products manufactured by that supply chain does not easily lend itself to gathering credible and accurate information on all essential chemicals and materials embedded in electronics manufacturing processes and products (i.e., articles and complex objects). The properties of thermal stability, chemical inertness, and dielectric strength – among many others – qualify PFAS, especially fluoropolymers, as likely candidates for use in a variety of processes and products. These PFAS-containing and potential PFAS-containing electronics have utility in millions of applications, many of which are embedded in everyone's daily operations, enable life sustaining services, and underpin our modern economies.

As of the end of August 2023, more than 150 comments submitted to ECHA by electronics companies or associations state similar findings: the utility of PFAS is important and irreplaceable; the supply chain is geographically broad, multi-tiered, layered, and dynamic; the products manufactured are complex; and their function is governed by laws of physics and chemistry and a wide variety of often-strict performance requirements. The ability to efficiently replace the utility is limited by complexities and time constraints. Therefore, it is critical that ECHA consider a modification to the derogations proposed by the Dossier Submitters. A universal PFAS restriction in electronics could result in inadvertent impacts on the economic well-being of EU companies and residents, and a cascade of potential impacts on transportation, telecommunications, defence, health sectors, as well as a variety of day-to-day operations that primarily rely on electronics like mobile phone use and cloud storage of data. **To effectively minimize harm to the users of electronics, the EU economy, and to the digital and green transition underway in the EU, it is necessary to have a derogation for electronics for the 18-month transition period plus a minimum of 12 years.**

The complex electronics supply chain creates challenges in reliably identifying the presence of PFAS

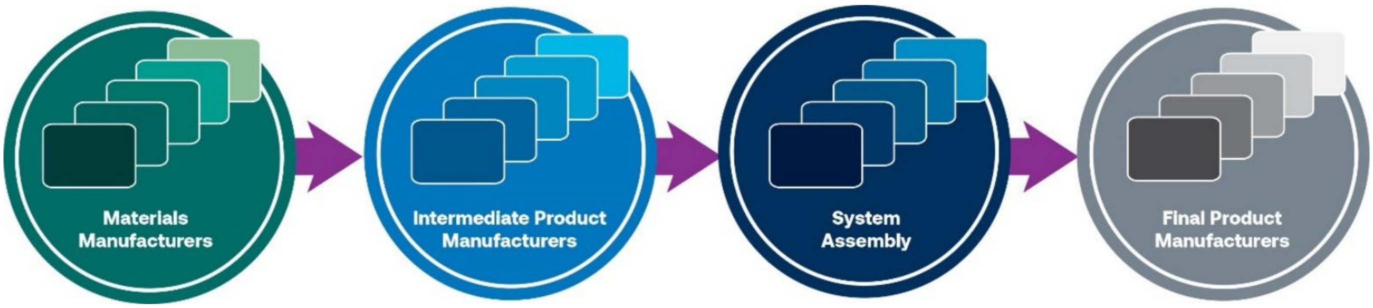

Figure 1. Global Supply Chain for Electronics Products. Each rectangle represents the multitude of companies of varying sizes and capabilities, types of output, and geographies. The supply chain comprises all sizes of companies, almost all countries around the globe, industries and supply chains adjacent to electronics, and thousands of part numbers representing a wide diversity of products.

The global supply chain for electronics products is multi-tiered, with thousands of companies responsible for manufacturing materials (e.g., coatings and laminates) necessary for intermediate products (e.g., semiconductor and passive components, wire and cable, gaskets, and O-rings) that are then assembled and manufactured to become final products (e.g., consumer, commercial, and high-reliability products) that may in turn be incorporated into complex systems containing many related final products (e.g., those in civil, space or defence communication systems). Most of these objects are articles or complex objects as defined by the REACH Regulation. For example, materials and intermediate products are themselves articles (e.g., gaskets). Assembly incorporates articles (e.g., wire and cable assemblies) into final products (e.g., mobile phone, vehicle), which are complex objects. In the electronics industry, intermediate products include those items that do not function on their own but require incorporation into or onto a system to enable performance while final products comprise intermediate products. Companies that participate in this supply chain vary in size, output, products, and geography and yet they are all part of an ecosystem— a complex system of interconnected and interacting components, products, and subsystems that only function when organized into a complete system.

The proposed restriction does not fully consider the cascade of utility PFAS provides in the complex electronics supply chain

PFAS are used because of the properties needed by the intermediate and final products, e.g., inertness, hydrophobicity, dielectric strength. The intermediate and final products that are manufactured by PFAS-containing equipment and that may contain PFAS are complex products that function in part because of the properties of PFAS and these products are used in important and diverse end applications, often with no available substitutes. If PFAS are restricted without the time necessary to responsibly manage a response, then the ecosystem depicted in Figure 1 will become imbalanced and each affected facet of the system will experience its own disruption and the entire ecosystem will be threatened with failure. Furthermore, without proper time to develop, demonstrate performance, and study the environmental and health impacts supply of alternatives, the resulting impact on the system could create additional waste due to product obsolescence or risk to the end user.

IPC has worked for more than three years with companies to determine where PFAS may be present or required in the manufacturing and product support supply chains. However, the complexity of identifying suppliers and understanding what kinds of PFAS exist in products has proven extremely difficult. Due to the specialized processes, lack of supply chain data, and proprietary composition of the electronic components, the supply chain is often unaware of where PFAS are used. Additionally, they are often unsure of their use of PFAS due to the varying definitions of PFAS by various authorities.

It takes a minimum of 12 months to track through the supply chain one well-known chemical or material with well-known uses in an article; it takes longer for chemicals with lesser-known information. Previous proposed REACH Regulation restriction activities on PFAS include C9-C14 PFCAs, their salts, and combinations thereof; PFHxS and PFHxA their salts, and related compounds; and PFAS in firefighting foam. This is the first time an entire class of substances – including those in liquid, solid, and gas form – are proposed for a restriction and the first time a complex multi-functional set of chemicals is targeted. Identifying and tracking tens of thousands of PFAS through the electronics supply chain is practically impossible within the proposed 18-month transition period. Visibility from the OEMs through EMS and PCB manufacturers to the chemical formulators and chemical manufacturers is constrained by the limited ability to connect with and obligate all supply chain partners to reliably collect and accurately report data on the presence or absence of PFAS used in any number of different electronics manufacturing processes and products. In addition, there have been no universal reporting or recordkeeping requirements for all PFAS. As a result, the supply chain does not currently have mechanisms to comprehensively track these substances, especially given that PFAS can be present as an impurity or byproduct.

While the electronics industry continues to determine where and how PFAS are used and thus how critical those uses are, it is anticipated it will take decades to find safer and equally effective alternatives and avoid “regrettable substitution” with alternatives that may pose health, safety, or environmental risks.

By way of example, a large electronics manufacturer of final products with multiple global operations has roughly 44,000 different suppliers. Of these, roughly 70% are small and mid-sized enterprises as defined by EU recommendation 2003/361. They are at a distinct disadvantage in understanding and managing business risks associated with the proposed restriction. To date, the lack of recordkeeping and reporting requirements has meant a shift in resources to ensure supply chain education in a very short period on the many substances that could be covered under a universal PFAS restriction.

PFAS are used in electronics manufacturing processes and products, but the extent of these uses remains unknown and therefore a restriction of PFAS will lead to unintended impacts

Table A.48 in the proposed restriction document provides an overview of uses and properties of PFAS in electronics, but it may be missing uses that have yet to be identified. **Given the challenges of identifying PFAS in the complex electronics supply chain, the industry has only identified some uses. However, what is known so far is that PFAS are necessary to the functionality and safety of electronics products, now and for the foreseeable future.**

Reputable peer-reviewed publications concur that the numerous beneficial and unique properties of PFAS make them a necessary solution for manufacturing processes and products. IPC conducted a survey of companies in the electronics supply chain to determine a baseline of PFAS properties and the results of the survey indicate a breadth of unique and often irreplaceable properties. Almost 67% of industry participants confirmed the functions offered by PFAS are critical to the product and its performance and nearly 90% stated that there are no known chemical alternatives for the properties of PFAS. Some of those properties that make PFAS useful and, for which the extent of all uses remains unknown, include:

- Chemical and Thermal Stability: PFAS are resistant to chemical reactions and can withstand high temperatures without degradation, resulting in stability over time
- Low Surface Tension: PFAS are repellant to liquids and help create nonstick surfaces
- High Thermal and Electrical Insulation: PFAS are useful in electrical components and thermal insulation to manage heat-generating electricity
- Dielectric Strength: PFAS offer higher dielectric strength and better insulation properties for high voltage and high speed applications
- Strength and Toughness: PFAS polymers are abrasion resistant and tear-resistant and can withstand demanding mechanical applications

Table 1 provides examples of PFAS-containing and potential PFAS-containing articles and complex objects where substitution can be complex or there are no known alternatives. This list is not comprehensive or exhaustive.

Table 1. Examples of PFAS-containing and potential PFAS-containing articles and complex objects where substitution can be complex or there are no known alternatives.

Major Applications of PFAS in Electronics	PFAS Properties Required*	Examples of typical articles (materials and intermediate products) with this type of application of PFAS	Examples of typical complex objects (assemblies and final products) with this type of application of PFAS
Battery materials	Chemical, electrochemical, and thermal stability, mechanical flexibility, adhesion properties, permeation resistance, low surface tension	Binder material for electrodes, lithium salt anions and additives for electrolyte, separator material, sealing and insulation materials	Various electronics, batteries, electronic vehicle batteries, information and computer technology (ICT) equipment
Coatings and thin film materials	Water and oil repellency, chemical resistance, electrical characteristics, dielectric properties resistant to UV radiation, thermal stability, cleanliness, low surface tension, mechanical stability, manufacturability, low transmission loss at high frequencies, wide frequency range, flame retardancy	Printed circuit boards, flexible circuit coatings, semiconductors, small electronic components (e.g., capacitors, resistors, coils, diodes, transistors, switches, connectors, and electrical junction points), motors, voice coils, liquid crystal panels, touch panels, optical sensors, LED, optical fibers, lenses for electronic cameras, projection lenses, polarizers, anti-solder coating, printing applications, epilate in motors	Various electronics, mobile phones, tablets, imaging equipment, cameras, hard disk drives (HDDs), medical devices, ICT equipment
Display materials	Low anisotropic refractive index, low viscosity, low voltage drive, heat resistance, durability, dipole moment, chemical and moisture permeation resistance, low surface tension	Liquid crystal and flat panel display materials and coatings	Various electronics, TVs, monitors, displays
Fire prevention	Dripping prevention, flame retardancy	Thin-wall, light weight polycarbonate and polycarbonate alloy plastic fire enclosures	Various electronics
Heat transfer fluids	Non-flammability	Refrigerant, immersion cooling fluid for data centers	Chillers, refrigerators, heat pumps, data centers
Insulation material	Low dielectric constant, electrical insulation, flame retardancy, chemical resistance, heat resistance, corrosion resistance, crack resistance, durability, machineability, low friction	Insulation on cables, wires, connectors, gas insulated switchgear, and interconnects	Various electronics, cables, monitors, medical equipment, electric appliances, industrial control equipment, printers, ICT equipment, mobile

Major Applications of PFAS in Electronics	PFAS Properties Required*	Examples of typical articles (materials and intermediate products) with this type of application of PFAS	Examples of typical complex objects (assemblies and final products) with this type of application of PFAS
			telecommunication network infrastructure equipment, transformers
Lubricants and additives in lubricants	Lubrication properties, chemical stability, insulation properties, non-stick properties, thermal stability, electrochemical stability, mechanical reliability, uniformity, cleanliness, manufacturability, and hydrophobicity	Motors, tape cartridges, tape drives, tape cells, robotics, surgical instruments, disks in HDDs, wire coatings	Various electronics, cameras, motors, fans, HDDs, electric appliances, medical equipment, industrial control equipment, tape libraries
Mechanical parts	Lubricity and abrasion resistance, low coefficient of friction, flame retardancy, durability, physical properties, dielectric properties low water absorption, low moisture permeability, cleanliness, low stickiness, and manufacturability	Sliding parts, gears, bushings, guides, pistons, seals, bumpers, stops, motors, tubing, protective coatings, image forming parts of printers, industrial brakes	Various electronics, motors, fans, printers, HDDs, industrial equipment, cameras, displays, high frequency communication devices
Membranes (textiles) for gas and particle filtration (vents)	Cleanliness, formability, manufacturability, particle filtration efficiency, impermeability to water and organic vapors, thermal stability, chemical stability, signal transmission with low loss, low mass/thin membranes for constant and consistent gas exhaust needed to maintain longevity of components and battery cells	Filter membranes, filter assemblies, vents	Various electronics, imaging equipment, computers, HDDs, mobile phones, smart watches, ICT equipment
Optical materials	Water and oil repellency, flame retardancy, high transmissivity of light, low refractive index	Optical fiber, plastic optical fiber, optical lens, LED, monitors, panels, fiberglass, optical adhesive, protective coating material, anti-reflective material	Various electronics, mobile phones, cameras, lighting, monitors, panels, optical cable, ICT equipment
Piezoelectric materials	Piezoelectricity, durability, heat resistance, flexibility, manufacturability	Films in speakers, microphones, touch panel, sensors, actuators	Various electronics, touch panels, speakers, sensors, microphones
Printed circuit board materials, including laminates	Flame retardancy, dielectric properties, electrical performance characteristics, temperature stability (high and low), low water absorption, mechanical	Printed circuit boards (rigid, flexed, hybrid) - various uses especially in high speed/frequency applications	Various electronics, transportation/mobility, ICT equipment, base stations, aerospace

Major Applications of PFAS in Electronics	PFAS Properties Required*	Examples of typical articles (materials and intermediate products) with this type of application of PFAS	Examples of typical complex objects (assemblies and final products) with this type of application of PFAS
	characteristics, repellency, surface tension		
Printing materials	Low surface tension, electrical insulation, water repellency, oil repellency, chemical resistance, surface activity, high negative charge	Toner additives, Ink additives, Developer additives	Imaging equipment
Radome cover materials	Low dielectric constant, low dissipation factor, high and low temperature resistance, low coefficient of friction, UV resistance, chemical resistance	Reinforced or unreinforced planar or curved structures transparent to the radio frequency systems and protect the electronic equipment	Radar antennas, flexible planar radomes, microwave communication antennas
Sealing	Chemical resistance, heat resistance, crack resistance, durability, machineability, low coefficient of friction	Tubing, seals, O-rings, gaskets	Various electronics, printers

As noted earlier, as of late August 2023, more than 150 electronics companies and associations responded to the consultation on the proposed restriction. IPC evaluated the submission content, information on uses, requests for derogation or exemption; IPC's response aligns with many of the responses already offered. These include the comments provided by W.L. Gore (submission 4489) on wires and cables for electronics and the very detailed response from the coalition of Japanese electronics industry associations (submission 4543) on the feasibility of alternatives and the use of PFAS in electronics and semiconductors. **We encourage ECHA to consider electronics industry submissions in conjunction with IPC's response to more fully understand the ecosystem of electronics and the cascade of utility, from PFAS to articles to complex objects.**

- Submission 4060 from Information Technology Industry Council (ITI) on information technology
- Submission 4349 from the Japanese Electric Wire & Cable Makers' Association (JCMA) on wire and cable
- Submission 4394 from Infineon Technologies AG on electronics and semiconductors
- Submission 4489 from W.G. Gore and Associates GmbH on wire and cable
- Submission 4543 from Japanese Electronics and Information Technology Industries Association (JEITA) on information technology
- Submission 5927 from DIGITAL EUROPE on spare parts for electronics equipment
- Submission 5991 from an anonymous source on electronics connectors
- Submission 6006 from Rogers VB on PCB and PCB laminates
- Submission 6253 from an anonymous source on information technology
- Submission 6301 from W.L. Gore and Associates GmbH on aerospace and defence
- Submission 6362 from the Test and Measurement Coalition on industrial monitoring and control instruments
- Submission from Claigan Environmental and the environmental-related comments
- Submission from DIGITAL EUROPE on electronics industry applications

Sufficient time to enable alternatives assessment is crucial to ensure safer options and avoid regrettable substitution for all uses

As noted, the electronics manufacturing industry is committed to continuously improving the environmental performance and safety of all products placed on the market. Given the increased international focus on PFAS, the electronics industry has taken steps to consider alternatives. Even when alternatives are identified, qualification and validation of life sustaining, and mission critical applications can take years to complete adequate testing to eliminate the risk of unintended consequences. Furthermore, regulatory and end-use approval can take years to complete. Finally, given the industry's multi-tiered and complex supply chain, information gathering can be incredibly burdensome, particularly for small- and medium-sized enterprises. While the electronics industry aims to undergo thorough alternative assessments in alignment with accepted alternatives assessment methodologies[1], the proposed transition period does not allow adequate time. The electronics industry will need substantial time to undergo an alternatives assessment to ensure safe alternatives and avoid regrettable substitution.

Due to the potential widespread and varied nature of PFAS used in the electronics ecosystem, broad generalizations about availability of alternatives are not reasonable or valuable to the process of eliminating these substances in products. Replacement of these substances must be undertaken on a case-by-case basis as they are selected for their specific properties that ensure product reliability, safety, and efficiency. For most uses of PFAS in electronics, there are no drop-in solutions that provide the same properties without also possibly introducing unacceptable risks. Because of this, more research must be conducted on alternatives based on use case and industry must have more time to investigate alternatives.

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[1] An example of alternatives assessment methodologies is the Synthesis Report from the OECD Workshop on Alternatives Assessment and Substitution of Harmful Chemicals from the OECD Environment Directorate, Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology, 07-Jan-2016 available from https://one.oecd.org/document/env/jm/mono(2015)53/en/pdf

Though alternatives to PFAS have been suggested for acceptable use, the potential PFAS-containing applications are not known and, therefore, it is risky to claim all uses can be replaced with a PFAS-free alternative. As an example, a market resource “BusinessAnalytiq” explains that PTFE resin currently costs EUR 16,84/kg in the EU while suggested “alternatives” for PTFE in electrical wire insulation such as PVC, PET, and Nylon are commodity materials that cost less than EUR 1,50/kg. The more expensive PTFE is selected because of the properties that it contributes to product performance and safety and the alternatives, although less expensive to purchase, do not offer those properties. Similar decisions have been made by industry when choosing fluoropolymer lubricants and seals. Changing to an alternative material in these cases will compromise the function or life cycle of the device. Ultimately, this can lead to more waste and unwanted and unnecessary environmental impacts.

The whitepaper “Check Your Tech: A Guide to PFAS in Electronics” from ChemSec in April 2023, states:

“There are, according to industry, still also several specialized uses of PFAS that currently do not have viable alternatives at the time of the drafting of this guide. These include printed circuit boards for high-speed telecommunication network infrastructure, wiring and cable insulation for high voltage, lubrication and coatings in information and communication technology (ICT) equipment, acoustic equipment for challenging environments, touchscreen displays with haptic feedback as well as several uses in the production of semiconductors.”[2]

These uses will need extensive time to research alternatives. Listed alternatives by ChemSec that are technically feasible are different to alternatives that are practically feasible, especially in high-reliability applications. Technically feasible alternatives that have not been researched in use are not actually alternatives. More research must be conducted to assist industry with this transition and enable safe use.

PFAS-containing and potential PFAS-containing electronics provide irreplaceable utility and enable the EU’s digital and green transitions

Table 1 identifies the interconnected relationships of PFAS-containing electronics, providing a cascade of utility through increasing levels of product complexities. Likewise, Figure 2 illustrates the interconnected nature of the electronics supply chain, the manufacturing entities, and the articles and complex objects: a cascade of utility.

The interconnected nature of electronics and the cascade of utility of electronics in complex objects means that **a lack of a workable and achievable transition time will force the electronics industry to withdraw electronics investment and facilities from EU member states, impacting the economic stability of all Member States.** A broad restriction of PFAS affects the materials necessary for making components, assemblies of components, the final products developed from component products, and any systems composed of assemblies of interdependent final products. IPC estimates it would cost the electronics industry between EUR 200M and 400M to reliably identify PFAS across the complex electronics supply chain.

In a report commissioned by IPC from Decision Etudes & Conseils, it was noted that electronic systems are a driver for economic growth. Moreover, 2019 figures from that report showed that the European electronics manufacturing industry has a direct impact on approximately 20% of the European GDP, or nearly EUR 3800B, when considering the industry’s end-user industries (transport, industrial, aerospace/defence/ security, IT, telecommunication and health and care products and services).[3] The importance of electronics will grow as all industrial sectors increasingly look to electronics manufacturers as key enablers for product innovation, EU’s digital and green transitions, and for regional technological sovereignty. Ultimately, the continued availability of electronics is foundational to the EU’s political and societal objectives.

[2] Check Your Tech: A guide to PFAS in electronics, published by ChemSec 25 April 2023, available from https://chemsec.org/reports/check-your-tech-a-guide-to-pfas-in-electronics/

[3] Decision Etudes & Conseils report from 2019, available here http://www.decision.eu/wp-content/uploads/2021/04/StudyEMSPCB.pdf

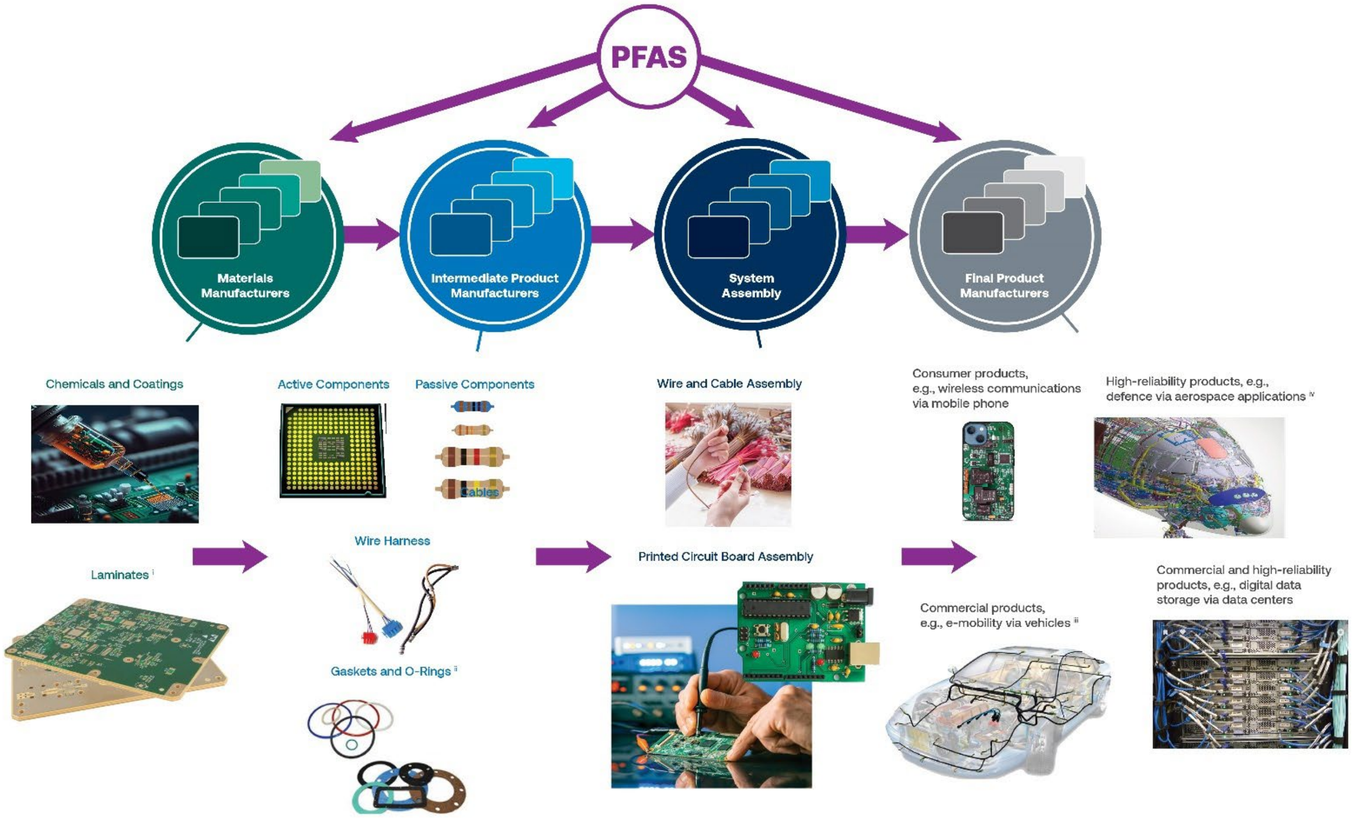

Figure 2. Utility of PFAS-containing electronics materials, assemblies, and products. The restriction of PFAS in electronics affects the supply chain composed of materials manufacturers, system assembly, and intermediate and final product manufacturers and the articles and complex objects that contain or potentially contain PFAS. Restricting PFAS can impact one or many aspects of this ecosystem leading to system failure [4]

It takes all aspects in the electronics supply chain, from silicon to system, to enable electronics systems to function efficiently, safely, and reliably and to drive the technological advances that enable the digital and green transitions.

Semiconductors function only if assembled onto functioning electronics systems

Semiconductor chips have no functionality of their own. They gain functionality by being placed, along with many other components, on PCBs by electronics assemblers to create final products and systems of products. These electronics systems feature prominently in the defence and aerospace, high performance computing, information technology, automotive, and medical sectors, but electronics are increasingly important to every industry and are,

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[4] Figure 2 citations for images. Image i: Laminates image from "PTFE vs FR4 PCB laminate materials – Cost and Performance Options" blog 15 June 2022 available https://blog.epectec.com/ptfe-vs-fr4-pcb-laminate-materials-cost-and-performance-options; Image ii: Gaskets and O-rings image from "What is the difference between O-Ring and Gasket Seals?" article 10 December 2019 available https://www.abbeyseals.ie/what-is-the-difference-between-o-ring-and-gasket-seals/; Image iii: Vehicle image from the Performance Fluoropolymer Partnership presentation on 23 March 2022; Image iv: Aircraft system image from "Aircraft design with high standards of efficiency and safety" website available https://aertecsolutions.com/en/aerospace-industry/aircraft-electrical-design/. Use of these images does not mean that PFAS are used in these materials or products. All images are being used to visually represent the materials and intermediate and final products.

indeed, central to each industry's digital transition. In turn, electronics are increasingly enabling Europe's green transition, from electric cars and smart meters to the technologies driving more efficient energy use.

The importance of semiconductors in fueling the EU's dual transition as well as regional technological sovereignty and leadership is well recognized. The recently adopted European Chips Act provides an important first step in ensuring access to needed technologies. Initial discussions on potential PFAS derogations further highlight semiconductors as a potential derogation use. It is, however, critical to recognize that the electronics industry is a complex, interdependent industry. A derogation for semiconductors is not fruitful if the system in which the semiconductor functions does not exist due to an unavailability or unreliability of needed parts, components or elements which constitute the full electronics system.

Printed circuit boards provide the backbone for functioning electronics systems

Printed circuit boards are made of laminates. Some laminates and PCBs intended for high frequency and high-performance applications use PFAS to provide necessary functionality. Because of the ubiquity of PCBs and the lack of full understanding of PFAS uses in all laminates and PCBs, a PFAS restriction can lead to catastrophic impacts to many critical industry sectors the extent of which remains unknown. PCBs are the foundation of all electronics, and as such, they are used in consumer, commercial, and high-reliability products, some of which may need the high-performance properties offered by PFAS. Some examples of where PCBs are used include:

- Medical devices including medical imaging systems, monitors, infusion pumps and internal devices
- Light Emitting Diodes (LEDs) that are used in residential lighting, storefront lighting, automotive and aerospace displays, computer displays, and medical lighting
- Consumer electronics including communication devices such as smartphones, smartwatches, tablets, computers, and home appliances
- Industrial equipment such as manufacturing equipment, power equipment, and test and measuring equipment
- Automotive equipment including entertainment and navigation systems, control systems and sensors
- Aerospace equipment including multifunctional flight displays and controls, power supplies, monitoring equipment and communication equipment
- Maritime commercial and defence applications including navigation systems, communication systems and control systems
- Telecommunications equipment such as telecom powers, office communication equipment and LED displays and indicators
- Military and defence applications including command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) equipment, including related instrumentation

PFAS are critical to electronics used in aerospace and defence applications

The aerospace and defence industry (A&D) is reliant on electronic equipment, parts, and components. Whether it be flight controls with interconnected specialty electronics and wiring within a commercial or military aircraft, printed circuit boards on naval vessels, wiring and cabling for a weapon or radar system, or the photovoltaic cells on a satellite, A&D demands electronic products attain and maintain the highest level of performance and resiliency towards the harsh environments in which these products operate.

The electronic equipment, parts, and components that are procured must be able to perform not only the first time, but every time without failure in airborne, space, marine, and terrestrial systems and must be able to withstand extreme environmental conditions for 40 years and beyond to avoid disastrous outcomes related to public safety and national security. In aircraft, space applications, and in a wide variety of military systems, therefore, products must meet the most stringent standards of operational efficiency, safety and reliability over their life cycles. Failure is simply not acceptable.

To meet these stringent requirements, A&D companies must have access to the top performing products, materials and chemistries needed to achieve its targeted objective within the boundaries of strict qualification, standardization, and performance. In many cases, PFAS are uniquely able to provide the necessary chemical and physical properties required to ensure these objectives. Chemical resistance, thermal stability, low surface tension, non-reactive, residue free, and dielectric properties are just a few of the material characteristics that enable PFAS-containing electronic to conform with the required performance elements and standardization needs. Alternative materials, including other halogenated materials do not provide an acceptable level of performance or the ability to satisfy conformity requirements for the industry's numerous commercial, defence and security customers.

The A&D supply chain, accordingly, is very complex and composed of many (thousands of) parts that are designed and manufactured globally, with complex products often procured from long supply chains where A&D companies are often at or near the end of those supply chains. A&D procures specialty electronic equipment, parts, and components as well as general industrial products such as cabling, wire harness assemblies, and finished off-the-shelf products that may not be specifically designed or supplied with the A&D sector in mind. For example, the same laminated FR4 printed circuit board found in consumer products may also be used in an aircraft or a piece of military hardware.

As noted previously by RAC and SEAC in an opinion on a proposed restriction on hydrogenated terphenyl in March 2023[5]: "the aerospace supply chains are long and complex with many actors involved at different levels – including suppliers (importers, formulators, and distributors), downstream users (OEMs, design to build (DtB)) or maintenance, repair, and overhaul (MRO) providers (civilian and military) within the industry."

The complexity of the supply chain often makes it difficult for A&D manufacturers, OEMs, or MRO companies to identify where substances are used within final parts or assemblies (or in the early stages of their production). This is particularly challenging when dealing with a very large group of substances like PFAS (~10,000 individual substances covered in the restriction proposal). Further, as with many other industries, PFAS use has not been communicated through the A&D supply chain, starting with the basic article manufacturers that often have little knowledge of the PFAS contained in the formulations they are using to make their products. In fact, many in the A&D supply chain also have little knowledge of essential PFAS contained in the production equipment used to make those products.

Aside from performance-driven requirements and identification challenges of PFAS in the complex supply chain, A&D manufacturers must conform with the strictest qualification and safety protocols across all of industry. Before the production of a part can begin, qualification, certification, and industrialization/implementation (including customer acceptance) must take place. Certification is a key process to ensure that aircraft, military hardware, or any other equipment parts comply with the required strict levels of safety and performance. Requalification may take several years to decades to identify/investigate, test, select and qualify a new piece of A&D hardware constructed with a different material or chemistry; there is no guarantee of success and failure at any point may require a completely new effort. Further, existing equipment including spare parts used in legacy A&D finished products must be preserved to ensure the viability of those legacy programs. It is not feasible to recertify or requalify new equipment, materials or parts used in sustainment because of EU regional restrictions on the use of PFAS.

PFAS are critical to electronics used in automotive applications

Electronics are necessary and critical to current and future automotive uses. Automotive electronics is one of the most important components for today's mobility and the mobility of the future. Future trends such as e-mobility, autonomous driving, connectivity or networking of vehicles with each other, with devices or with the traffic infrastructure and the increasing number of infotainment systems cannot be realized without reliable and powerful electronics.

"Whether it is electric-drive vehicles, advanced safety systems, autonomous vehicles or connected services, the technologies and innovations shaping the future of our industry require an increasing number of diverse semiconductors – from mature to leading edge nodes."[6] The digitization of vehicles can only make an active contribution to climate protection and energy efficiency through efficient road usage and resource allocation.

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[5] Available from https://echa.europa.eu/documents/10162/ec938800-0137-44f3-a329-c227f837a2fc

[6] https://www.autosinnovate.org/posts/letters/Auto%20CEO%20Letter%20on%20Competition%20Legislation%20June%2022%202022.pdf

At present there are no means of replacing the PFAS used in the manufacture of high-performance semiconductors. Modern automobiles cannot achieve the safety and performance requirements necessary for current and future transportation needs without a diverse variety of semiconductors. Modern vehicles are a complex mobile system, and the number of control units, sensors, actuators, and communication devices is growing from vehicle generation to vehicle generation. A modern vehicle can use as many as 3,000 individual semiconductor chips[7]. Automotive products provide a variety of mobility and transportation applications that greatly benefit society. Modern automobiles cannot achieve the reliability, safety, and performance requirements necessary for current and future transportation needs without a diverse variety of semiconductors. The number of chips and complexity of the overall electronic systems in a vehicle will continue to grow as vehicles become more integrated with each other and the ground-based traffic control systems.

Cable harnesses in current vehicles are highly complex technical products and act as a central interface and are ultimately essential for a wide variety of functions (safety, control, assistance, comfort, communication, etc.). The cable harness consists of up to 5 km of cables and can therefore weigh over 50 kg.

PFAS, particularly fluoropolymers, are found in most electronics components in today's vehicles including cables and wire harnesses for a wide range of applications including safety, printed circuit boards, semiconductors, brackets, touch panels, LCD modules, wiring of EM modules, electrolytic capacitor encapsulation, film capacitors, microcontrollers, spools, SMD connectors, diodes, and switches.

In contrast to requirements for electronics in the consumer sector, the requirements in the automotive electronics are significantly more robust. For example, electronics must work in a temperature range of -60 °C to +135 °C (reliable for 20 years) and withstand high shock and vibration loads. In addition, there is an increasing need for relatively high-bandwidth, broad-spectrum networks (from audio to 70 GHz radar operations - including GPS, Bluetooth, and wireless Ethernet).

The high demands on automotive electronics can only be guaranteed with the help of the special properties of PFAS, particularly fluoropolymers. Fluoropolymers have high resistance to aggressive media and degradation processes in combination with high mechanical, thermal, dielectric and long-term properties. There are no materials with comparable property profiles available on the market today. We have not identified any suitable alternatives with the same reliability and lifetime for automotive electronics.

PFAS are necessary to specialized components and assemblies in data storage products

Electrical, electronic, and mechanical components and assemblies containing PFAS are widely used in computing and data storage products, including hard disk drives (HDDs) and data storage systems used in edge, cloud, and datacenter applications. Most of the world’s data is stored on HDDs, which provide a cost-effective, high performance, secure platform for mass capacity storage in highly reliable electronic devices with long product lifetimes. HDDs are electro-mechanical magnetic data storage devices where data are written and read at the nanoscale on recording media surfaces of rotating platters by precisely positioned read/write heads flying <5 nm above the disk surfaces in a sealed, environmentally controlled, inner HDD chamber.

To meet the challenging functional, reliability and product lifetime requirements of HDDs, multiple PFAS-based materials are used in critical, highly specialized components and assemblies (e.g., disk lubricant, gas and particle filtration membranes, crash stops, and others) found in the unique sealed inner HDD chamber to provide the necessary cleanliness, physical properties, thermal stability, and durability. PFAS-free alternatives that may be acceptable for similar functions in other products, for example silicone as a lubricant or elastomer, are unacceptable for use in components in the closed internal HDD chamber where silicone contamination is known to lead to product failure.

[7] From the 2021 article “A Computer Chip Shortage Has Hobbled the Auto Industry” from The New York Times available https://www.nytimes.com/2021/04/23/business/auto-semiconductors-general-motors-mercedes.html

Other standard electronic components and assemblies containing PFAS (e.g., passive components, robotics, capacitors, integrated circuits, wires, cables, connectors, power supplies, fans, plastic optical fibers, and others) are used in data storage systems (servers, expansion shelves, JBODs, disk arrays, tape libraries, and others), where the PFAS-based materials are required to meet safety, performance, and reliability requirements.

Insufficient transition times for electronics can have dire consequences and undermine the EU's sustainability goals

IPC has sought to highlight that it takes all aspects of the supply chain to enable electronic systems to function and drive the technological advances that enable Europe's digital and green transitions.

As stated, the electronics manufacturing industry is committed to continuously improving the environmental performance and safety of all products placed on the market. The industry is also committed to replacing PFAS in products and processes where feasible and in a responsible manner. We do this in concert with other policy drivers regarding chemical substances in electronics; electronics are regulated in a wide range of evolving EU-based legislation including the Restriction of Hazardous Substances in Electrical and Electronic Equipment (ROHS) Directive, the Waste from Electrical and Electronic Equipment (WEEE) Directive, and the REACH Regulation. These drivers have governed the use of chemicals and materials in the life cycle of electronics in the EU and have and continue to have dramatic impacts on the world economy. In addition, emerging policies promote circularity and awareness of impacts from the chemical inputs across the product life cycle, e.g., the EU's Ecodesign for Sustainable Products Regulation and the Corporate Sustainable Reporting Directive.

In stakeholder submissions to this public consultation, electronics companies and associations have identified multiple critical uses of PFAS in multiple electronics materials, intermediate products, assemblies, and final products (and their systems) that require a minimum 12-year derogation specifically for electronics. Differentiating specific uses (e.g., singling out semiconductors separately from laminates, PCBs, or the final products that rely on these materials and intermediate products) for derogation ignores the important nature of the complex system of interconnected and interacting parts that individually are not as useful as when they are organized into a system. Central to this concept is the provision of a workable, consistent derogation period for electronics with transition times enabling safe product re-design. We highlight that the absence of a workable transition time risks and ultimately risks undermining unintended consequences and undermines the EU's sustainable aims.

Appendix: IPC Submission to the Online "Comments for Annex XV restriction report"

IPC responded to the online "Comments for Annex XV restriction report."[8] The information provided in that responses is repeated here.

Section III. Non-Confidential Comments

General Comments

IPC respectfully submits these comments on behalf of more than 3,200 companies in the electronics manufacturing supply chain, including printed circuit board (PCB) manufacturers, electronics manufacturing services (EMS), cable and wire harness manufacturers, electronics industry suppliers, and original equipment manufacturers (OEMs). IPC members represent the complex and global supply chain for electronics and adjacent industries including consumer, commercial, and high-reliability products used in aerospace, automotive, defence, medical, and other products found in homes and businesses in the European Union.

The complexity of the supply chain and the intermediate and final products manufactured by that supply chain does not easily lend itself to gathering credible and accurate information on all essential chemicals and materials embedded in electronics manufacturing processes and products (i.e., articles and complex objects). The properties of thermal stability, chemical inertness, and dielectric strength – among many others – qualify PFAS, especially fluoropolymers, as likely candidates for use in a variety of processes and products. These PFAS-containing and potential PFAS-containing electronics have utility in millions of applications, many of which are embedded in everyone's daily operations, enable life sustaining services, and underpin our modern economies.

To effectively minimize harm to the users of electronics, the EU economy, and to the digital and green transition underway in the EU, it is necessary to have a derogation for electronics for the 18-month transition period plus a minimum of 12 years.

In summary, IPC highlights the following points:

- A responsible industry response to a universal PFAS restriction requires more time
- The complex electronics supply chain creates challenges in reliably identifying the presence of PFAS
- The proposed restriction does not fully consider the cascade of utility PFAS provides in the complex electronics supply chain
- PFAS are used in electronics manufacturing processes and products, but the extent of these uses remains unknown and therefore a restriction of PFAS will lead to unintended impacts
- Sufficient time to enable alternatives assessment is crucial to ensure safer options and avoid regrettable substitution for all uses
- PFAS-containing and potential PFAS-containing electronics provide irreplaceable utility and enable the EU's digital and green transitions
- Insufficient transition times for electronics can have dire consequences and undermine the EU's goals

Specific Information Requests

Question 1: Sectors and (sub-)uses: Please specify the sectors and (sub-)uses to which your comment applies according to the sectors and (sub-)uses identified in the Annex XV restriction report (Table 9). If your comment applies to several sectors and (sub-)uses, please make sure to specify all of them.

Response to Question 1: IPC's comments address the Electronics (Annex E.2.11.) sector as listed in Table 9 in the Annex XV Restriction Report.[9]

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[8] https://comments.echa.europa.eu/comments_cms/AnnexXVRestrictionDossier.aspx?RObjectId=0b0236e1885e69de

[9] https://echa.europa.eu/documents/10162/f605d4b5-7c17-7414-8823-b49b9fd43aea

Question 6: Missing uses – Analysis of alternatives and socio-economic analysis: Several PFAS uses have not been covered in detail in the Annex XV restriction report (see uses highlighted in blue and orange in Table A.1 of Annex A of the Annex XV restriction report). In addition, some relevant uses may not have been identified yet. For such uses, specific information is requested on alternatives and socio-economic impacts, covering the following elements:

b. The key functionalities provided by PFAS for the relevant use.

Response to Question 6: The electronics industry relies on PFAS in its materials, components, and products for its critical functions. Some of those properties that make PFAS useful and, for which the extent of all uses remains unknown, include:

- Chemical and Thermal Stability: PFAS are resistant to chemical reactions and can withstand high temperatures without degradation, resulting in stability over time
- Low Surface Tension: PFAS are repellant to liquids and help create nonstick surfaces
- High Thermal and Electrical Insulation: PFAS are useful in electrical components and thermal insulation to manage heat-generating electricity
- Dielectric Strength: PFAS offer higher dielectric strength and better insulation properties for high voltage and high speed applications
- Strength and Toughness: PFAS polymers are abrasion resistant and tear-resistant and can withstand demanding mechanical applications