orgalim
EUROPE'S TECHNOLOGY INDUSTRIES

POSITION PAPER

Brussels, 11 August 2023

Orgalim position and recommendations on the proposed PFAS restriction

Executive summary

Europe's technology industries are fully committed to reducing the content of hazardous substances in their products to support a more circular economy and a healthier environment. However, the proposed general ban on the production, use, and market availability of per- and polyfluorinated alkyl substances (PFAS) would significantly impact on our industries' ability to produce robust and reliable products. Here are our key messages on the proposed PFAS restriction:

1. **Implementing a blanket PFAS ban will jeopardise the fulfillment of the Green Deal** (climate goals and circular economy): The technology industry offers a wide array of solutions for current challenges, such as semiconductors, lithium batteries, heat pumps, high-temperature seals, specialised refrigeration equipment, technologies for energy transmission and distribution, energy-efficient industrial equipment, and sustainable professional goods. **These products can only be produced today with the use of PFAS** and would not work at all or work significantly less efficiently without it. The current proposal would result in reduced product durability and a substantial increase in waste generation. **Therefore, restricting substances should not be implemented without a differentiated consideration of their uses and the consequences.**
2. A **risk-based and substance-based approach** should be used for PFAS. We consider the proposed blanket restriction of all PFAS, regardless of their toxicity and risk profile disproportionate.
3. Use of **PFAS must remain possible as long as there is no full-scale availability of suitable and technically developed substitutes.**
4. The introduction of an **information obligation for "intentionally added" PFAS** prior to the introduction of targeted restrictions will allow all relevant uses to be included in the assessment in due time and any necessary exemptions to be applied for.
5. A **long-term general derogation with review before expiration** of fluoropolymers without relevant risk is **necessary.**
6. A clearly **defined procedure for the application, review and extension of derogations is crucial**, especially in the case of a broad restriction on previously non-declarable substances. The **derogations currently envisaged are insufficient and do not take into account the relevance of PFAS for a wide range of uses and ongoing innovations in the technology industry**.
7. The **repair-as-produced principle shall be applied.** Indefinite derogations for spare parts, refurbished parts, and equipment as well as products already having been placed on the market for the first time shall be granted.
8. Ensuring effective **enforcement through the market surveillance system** will foster a level playing field.

Introduction

Earlier this year, the competent authorities of five European countries proposed a wide-ranging restriction on per- and polyfluorinated alkyl substances (PFAS) under the European chemicals regulation (REACH). This is the EU's biggest substance restriction to date, and it is a key component of the EU Green Deal's Chemicals Strategy for Sustainability (CSS).

Orgalim represents Europe's technology industries, providing innovative technology solutions which are underpinning the twin green and digital transitions and can unlock a greener, healthier, and more prosperous future for the European Union and its citizens. Our industries are fully committed to reducing the content of hazardous substances in their products to support a more circular economy. Our position and recommendations on the circular economy can be found here, and our comments on the REACH revision roadmap can be found here.

Moreover, we fully support the Commission's Chemicals Strategy for Sustainability, and we believe that individual substances that pose an unacceptable risk due to their properties and use profile should be restricted or regulated based on scientific evaluation. Our technology industries, major downstream users of chemicals and article manufacturers are committed to continuously improving the environmental performance and safety of the products they place on the market.

However, the proposed general ban on the manufacture, use and placing on the market of any kind of PFAS (in substances, mixtures, and articles) would have a massive impact on nearly all our member companies, whose technologies are essential for the energy transition, digitisation, European infrastructure, transport and logistic chains, healthcare, process automation/measurement technology, being the sustainability of these products intricately linked to the use of PFAS.[1]

We see the production, research, and development locations of the European technology industries as well as their global competitiveness, at serious risk in the event of a blanket ban and therefore call for a fundamental revision of the restriction proposal in key areas.

Our recommendations

On the PFAS restriction approach/procedure

Our industries support the **objective of avoiding emissions of hazardous substances into the environment** and an appropriate regulation of uncontrollable risks posed by individual substances. Our industries are committed to continuously improving the environmental compatibility and safety of the products they place on the market.

Our society is facing major challenges in the energy transition. Mobility and energy supply should become climate-neutral within a few decades and the European economy should do the same by 2050. Europe's technology industries offer a wide range of the solutions required for this transition, such as semiconductors, lithium batteries, heat pumps, high-temperature seals, specialised refrigeration, technologies for energy transmission and distribution, energy-efficient industrial equipment, and sustainable professional goods. All of these **can only be produced today with the use of PFAS** and would not work at all or work significantly less efficiently without it. Additional time is needed to develop durable and

[1] BDI position on the restriction of PFAS, 2021, publication (bdi.eu)

safe alternatives, and to secure enough time for verification and certification etc. of such alternatives to fulfil all other applicable legislations. Therefore, restricting substances should not be implemented without a differentiated consideration of their uses and the consequences.

What is needed is a **more differentiated regulatory approach** that is **risk-based** according to Article 68(1) REACH and **substance-based** according to Article 69 REACH, as proposed by other governments [2] . The proposed blanket restriction of all PFAS, regardless of their individual toxicity and risk profile, does not meet this requirement. Given their enormous importance in the industry, **uses of PFAS must remain possible as long as their risks can be sufficiently managed by appropriate containment measures or in case no suitable substitutes are available**.

It is important to **distinguish between the different PFAS (groups) and the risks from each use**. It is also important to consider whether identified risks can be minimised through targeted measures, e.g. in occupational health and safety/emission control or waste legislation, rather than through a general ban under REACH.[3]

We call authorities to stick to the risk-based approach, meaning that only applications associated with an identified risk and those for which a technically suitable, economically proportionate, and less environmentally and health-damaging alternative exists should be restricted. The alternative would be a long, unmanageable list of very specific derogations or the unnecessary exclusion of products and processes from the European market despite their importance to our competitiveness and climate goals.

Only the **introduction of an information obligation for "intentionally added" PFAS** (e.g. through inclusion in the REACH candidate list) prior to the introduction of targeted restrictions will allow all relevant uses to be included in the assessment in due time, alternatives to be developed and any necessary derogations to be applied for. There is currently no legal basis for the dissemination and communication of information on PFAS in products along the supply chains. Most PFAS are neither classified in a harmonised way according to Classification, Labelling and Packaging (CLP) Regulation nor included in the REACH candidate list. As information on PFAS in products is only fragmentarily available in the complex international supply chains, exhaustive identification, and assessment of PFAS uses, potential alternatives and socio-economic impacts are virtually impossible for downstream users. It will take years to fill these information gaps.

Adequate transition periods of four to eight years after entry into force (depending on use, product life and development times) **for full conversion are needed**, as provided for in other legislation, e.g. RoHS[4]. An 18-month transition period for the full conversion of products and processes, as provided for in the proposal, is insufficient and will disrupt and damage supply chains with long lasting effects on the prosperity of the EU market. Unsatisfactory substitutions must be avoided and too short transition periods will increase the risk of less durable and, in worst case, less safe products being placed on the market. The supply of less durable products is not in line with the EU Green Deal and circularity ambitions and will increase the waste in the EU.

Ensuring effective **enforcement through the market surveillance system** will be of the utmost importance for the success of the PFAS proposed restriction, generating good and fair opportunities for manufacturers, and constituting the most effective regime to reach sustainability objectives in addition to levelling the playing field. However, requesting product information will not help if an adequate working capacity is not allocated by Member States. Increased focus on enforcement with more uniform requirements for the Member States will also foster a level playing field.

[2] https://www.gov.uk/government/publications/environmental-risk-evaluation-reports-per-and-polyfluoroalkyl-substances-pfas/environmental-risk-evaluation-reports-per-and-polyfluoroalkyl-substances-pfas-summary

[3] Report: Government Risk Management Approaches Used for Chemicals Management

[4] cf. amending Directive 2015/863/EU to RoHS Directive 2011/65/EU, inclusion of four phthalates in Annex II with a transition period of 4 or 6 years, depending on the category.

We observe that the definition of PFAS encompasses Hydrofluoroolefins (HFOs) for refrigerants. **HFOs are already alternative substances for refrigerants following the bans imposed by the F-Gas Regulation and the Montreal Protocol**, making them an environmentally-friendly option with a small global warming potential (GWP) compared to certain more harmful fluorinated gases. However, the proposed restriction of PFAS also includes the removal of HFOs, and since they are already covered by both regulations, it is crucial to **avoid double regulation to ensure that there will be alternatives left for refrigerants**. Therefore, the interface with other regulations related to substances meeting the proposed PFAS definition (e.g., upcoming revised F-Gas Regulation) must be clarified.

Overall, the current restriction process of PFAS appears premature, as the present REACH lacks essential provisions necessary to effectively address such a wide range of substance groups. To ensure a comprehensive framework and avoid legal uncertainties, we support the **postponement of the PFAS restriction until the adoption of the REACH revision**, allowing our industries to adapt to potential changes in the REACH requirements.

Derogations

A clearly **defined procedure for the application, review and extension of derogations** is necessary, especially in the case of a broad restriction of previously non-declarable substances. The **derogations currently envisaged are insufficient** and do not take into account the relevance of PFAS for a wide range of uses and innovations needed in the technology industry to fulfil other environmental targets and strategic objectives set out by the EU.

For example, the **semiconductor industry is very reliant upon many applications of materials falling under the definition of PFAS**. Those materials are used in manufacturing process chemistries, in specific functional layers and packages, manufacturing equipment, manufacturing infrastructure, and support equipment in addition to the semiconductor device. Therefore, a blanket ban of PFAS will also mean an important hit to achieve other strategic EU policy objectives, such as the Chips Act to boost R&D and production of semiconductors.

To help prevent such unintended consequences of the proposed PFAS restriction, we want to highlight the following necessary derogations:

- **Spare parts and refurbished products should be excluded from the restriction**. The **repair-as-produced principle** should be applied to the placing of spare parts on the market and wear and used parts for the purposes of sustainability and economic efficiency. Premature replacement due to the non-availability of spare parts or repair services would contradict the sustainability goal of resource efficiency.

  This restriction proposal would also be **contradictory** to various elements of the European Green Deal, notably the **Ecodesign and Right to Repair initiatives**, which emphasize the importance of the circular economy, including the use of these spare parts and the right to repair. Indeed, **PFAS are present in all products currently on the market**, making it seemingly impossible to reuse, refurbish, and repair products with PFAS-free components. **Compatibility between products and spare parts, as well as certain conformity tests, would be compromised without an exclusion from the restriction**.

- **A general derogation is also needed for products that have already been placed on the market for the first time.** Otherwise, they cannot be resold, repaired, maintained, or further processed and placed on the market again as a component of more complex products/articles. The only option would be disposal, which does not bring about any benefit from an environmental perspective. This general derogation should not mean additional burdens for industry (e.g., management plan).

- **A derogation is needed on the presence of PFAS in recycled materials**, in particular for products that do not present a risk of PFAS emissions into the environment during the use phase.

- **Fluoropolymers** meeting the criteria for "polymers of low concern"[5,6] **and safe uses of PFAS in industrial applications, equipment, and components** generally do not cause relevant emissions to the environment when used as intended. Due to the high industrial importance, A **long-term general derogation with review before expiration of fluoropolymers is necessary**, especially if not technically suitable and environmentally safer alternatives are known to allow companies to fulfil the identification, development, and mass production of alternatives. Risks in the manufacturing and waste phase are better addressed in the relevant legislation (emissions/occupational health and safety, waste legislation)

Monitoring/Conformity

Existing **laboratory capacity, availability/usability of analytical methods and the burden on businesses** (staff, time, equipment) must be taken into account when setting transition periods of the PFAS restriction proposal as verification of compliance for incoming products and materials, as well as finished manufactured goods, is a time-consuming process. Furthermore, testing is occasionally necessary after specific manufacturing steps and these procedures escalate production costs, necessitating expenditure on testing equipment or external testing services. Orgalim calls for **longer transition periods.**

Compliance with the proposed restriction cannot be verified for all uses with currently available analytical methods and in the absence of a complete substance list. We emphasise the necessity of having **practical and standardised analytical and extraction methods for all the restricted substances and their various applications prior to the imposition of any legal restrictions on PFAS.** A potential solution suggested by Orgalim involves **restricting only well-defined substances that can be precisely analysed and identified within complex articles**, even under streamlined customs control conditions.

Recognising the potential distortions of competition within the Single Market that may occur in practice, **market surveillance needs to be strengthened**, especially at external borders, but also within the EU to identify PFAS 'free riders'. We question the ability of inspection bodies to assess the presence of numerous PFAS in imported product, especially in complex products. The European Chemicals Agency (ECHA) should carry out an **impact assessment to examine the capacity of ECHA and national enforcement authorities to inspect the conformity** of products entering the European market and being manufactured within the EU, quantifying the supplementary resources required to effectively enforce the proposed PFAS restriction as it stands. **Only enforceable restrictions should be established.**

➢ **Please check the Annex for technical and scientific data supporting our key messages.**

[5] Henry, B. J; Carlin, J. P; Hammerschmidt, J. A; Buck, R. C; Buxton, L W.; Fiedler, H.; Seed, J.; Hernandez, O. A Critical Review of the Application of Polymer of Low Concern and Regulatory Criteria to Fluoropolymers. Integr. Environ. Assess. Manage. 2018, 14 (3), 316-334.)

[6] Korzeniowski SH, Buck RC, Newkold RM, Kassmi AE, Laganis E, Matsuoka Y, Dinelli B, Beauchet S, Adamsky F, Weilandt K, Soni VK, Kapoor D, Gunasekar P, Malvasi M, Brinati G, Musio S. A critical review of the application of polymer of low concern regulatory criteria to fluoropolymers II: Fluoroplastics and fluoroelastomers. Integr Environ Assess Manag. 2023 Mar;19(2):326-354. doi: 10.1002/ieam.4646. epub 2022 Aug 9. PMID: 35678199.

Annex – PFAS uses of Orgalim's Industries

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Annex I – Committee for European Construction Equipment (CECE)

COMMITTEE FOR EUROPEAN CONSTRUCTION EQUIPMENT

F-Gases

Refrigerants, such as R-134a and R-1234yf, are used for heating, ventilation, and air conditioning (HVAC) systems. The construction equipment industry utilizes refrigerants (containing PFAS) to fulfil various health, safety and ergonomic requirements to cool down operator stations. These fluorinated gases (especially R-1234yf) present non-corrosive and non-toxic characteristics with a low global warming potential (GWP), zero ozone depleting potential (ODP) and a low boiling point.

a. Refrigerants

The EU regulatory framework already provides for the control and prevention of exposure, including leakage, in addition to requiring proper service personnel training. All currently available solutions are either intended to be banned or present an extreme risk to health and safety of the machine operator due to their flammability (e.g., ammonia, propane, and isobutane). First estimates by our industry foresee a 7-year timeframe needed to develop a commercially viable and available alternative (cf. below table)[7]. CO2-based air conditioning systems are being explored by the automotive industry, but the viability for production in the near future has not yet been demonstrated. For lack of drop-in substitute for PFAS, our industry estimates that, upon identification of a suitable alternative, a 20 to 25-year timespan is needed to make any alternative substance operational across our complex supply chains. This alternative development process entails lengthy steps such as the revision of data collection and information exchange systems, training, formatting of information, testing, validation, and certification among others.

ACTIVITY	TIME
IDENTIFICATION	
IDENTIFY ALL SUBSTANCES CLASSIFIED AS PFAS FROM REG. LIST	1 months
IDENTIFY HIGH RISK COMPONENT TYPES	6 months
CREATE LIST OF AT-RISK PARTS AND SUBCOMPONENTS	6 months
UPDATE INTERNAL DATA COLLECTION AND COMPLIANCE SYSTEMS	9 months
SUPPLIER COMMUNICATION AND TRAINING	3 months
REQUEST DATA FROM SUPPLIERS	12 months
FORMAT DATA, CHECK ACCURACY & STORE DATA	1 months
TOTAL	38 months
VALIDATE AND TEST	
VALIDATE PIP PFAS PRESENCE WITH SUPPLIER	1 months
INVESTIGATE ALTERNATIVE MATERIAL	6 Months
PROCURE PROTOTYPE MATERIALS	6 Months
COMPONENT VALIDATION OF NEW MATERIAL	6 Months
PRODUCT VALIDATION WITH NEW MATERIAL COMPONENTS	12 Months
TURN INVENTORY TO PURGE SUPPLY CHAIN & ENSURE COMPLIANCE	6 Months
TOTAL	37 months
RECERTIFICATION	
RECERTIFICATION	12 Months
TOTAL	87 Months

Table enumerating the logistical challenges in case of PFAS general prohibition

b. Air conditioning

[7] AEM, 2023, *The Essential Societal Benefits of Per- and Polyfluoroalkyl Substances in Non-Road Equipment* (Accessible upon request only)

Air-conditioning systems are vital to provide operators of construction machinery with a controlled temperature in the cabin, allowing them to operate machinery in a safe way without adverse effects to their health. There are currently no commercially viable alternatives meeting our HVAC system requirements. The continued usage of R134a or R1234yf is necessary. The derogation for those systems is crucial. With no derogations, the construction equipment industry will have no choice but to place machines without air conditioning on the European Union market, which would be extremely detrimental to the health of operators. Therefore, the safe operations of the machine may be at risk due to an unhealthy and unsafe working environment.

Sales of machines without air conditioning would be seriously impacted both in the EU and in non-EU countries. Most markets require air conditioning for their operators' comfort and safety. All over the world, the EU-manufactured construction equipment is oftentimes a critical equipment which is solely dependent on the import market for these countries. Without air conditioning, our exports to these countries, with extremely hot temperatures all year long, would be brought to a halt almost overnight.

The research costs and development time for alternatives is still unknown to us, but to verify innovative solutions into our equipment would have an estimate cost of €25M, in the case of a large enterprise, and the time for development and verification will span over seven years upon making an alternative available. CECE stands for an extensive derogation period. As in most other sectors engineering resources are scarce hence the resources that will have to be mobilized to redevelop air-conditioning systems will adversely affect the development of battery-electric machines alongside other green transition technologies. Out of the €25M approximately, €15-20M are related to workforce, and the remainder lies in testing and prototypes. Additionally, testing capacities of manufacturers and independent testing companies will be overloaded due to the new requirements which can result in unwanted delays in deliveries and in loss of business for the end user.

The usage of F-gases in the machinery is not only needed for HVAC, but also for cooling batteries and electrical cabinets in the larger battery-electric machines. This application needs to benefit from a similar derogation as well.

c. Coherence of the EU regulatory framework on fluorinated gases

A derogation was rightly proposed for refrigerants in mobile air conditioning (MAC)-systems in combustion-engine vehicles with mechanical compressors until 6.5 years after entry into force (cf. derogation 'p.') in addition to refrigerants in transport refrigeration other than in marine applications until 6.5 years after entry into force (cf. derogation 'q.'). As stated above, a seven-year transition period is required to develop safe alternatives. The 5-year derogation falls short of these technical challenges.

Recommendation :
CECE calls upon ECHA to level the playing field between industries that share supply chains and technologies and request ECHA to grant the construction equipment industry, at the very least, the same derogations for the applications of refrigerants as the ones granted to the automotive industry.

Furthermore, given the multiplicity of PFAS definition globally, refrigerants are classified as PFAS by several competent authorities. R-134a and R-1234yf, the most relevant refrigerants to our industry, are covered by this restriction proposal albeit presenting no chemical or hazard characteristics that would justify such a prohibition. A thorough (re-)evaluation of these substances, drawing on latest research, would contribute to making a more proportionate decision on fluorinated gases.

As argued by EUROMOT, the European Association of Internal Combustion Engine and Alternative Powertrain Manufacturers, in their feedback submission to ECHA, potential alternatives such as ammonia, propane, or isobutane are not adequate for applications with an ignition source because of their flammability. Therefore, their use in engine systems is ruled out on the grounds that there is a high risk of catastrophic failure. Further refrigerants, such as carbon dioxide, adequate for other industries, require a considerable product redesign and often translates into comparatively larger systems which jeopardizes their use in engines. The design of refrigeration systems is long and technically complex considering the strict safety requirements. As a consequence, the use of these fluorinated gases will be necessary over time.

In addition, the coherence of the EU regulatory framework on fluorinated gases needs to be prioritized. The overlap between the future Commission decision on the PFAS restriction proposal and the future F-Gases Regulation has to be clarified and defined.

Considering the most recent developments, the inter-institutional negotiations on the Revision of the F-Gases Regulation may not be concluded by the end of the EU legislature and may be carried over to the next EU legislature (as of late 2024) thereby adding to the legal uncertainty surrounding the future use of fluorinated gases in refrigeration applications and for HVAC systems.

General comments on proposed restriction of Fluoropolymers (including fluoroelastomers and polytetrafluoroethylene)

a. The essential use of fluoropolymers to comply with safety requirements

Under this restriction proposal, it is regrettable that fluoropolymers and perfluoropolyethers, as potential derogations, were only marked for reconsideration regarding applications affecting the proper functioning related to the safety of transport vehicles, and affecting the safety of operators, passengers or goods until 13.5 years after entry into force (potential derogation 'o.'). More concerning is the narrow scope of this potential derogation inasmuch as construction equipment was omitted despite sharing supply chains and technologies with the automotive industry.

As AEM, the North American Association of Equipment Manufacturers, pointed out in their position paper, fluoropolymers in seals and hoses guarantee that hydraulic systems keep pressure. Unexpected hydraulic hose failures bring about pressure losses which, in turn, may result in loads falling abruptly on a jobsite, potentially causing severe harm to workers[8].

In the same way as vehicles, construction equipment functions at hot temperatures. These regular operations are conducive to fires which can only be prevented with the use of PFAS.

Recommendation:
CECE calls upon ECHA to level the playing field between industries that share supply chains and technologies and request ECHA to grant, at the very least, the same derogations for the use of PFAS in applications affecting the proper functioning related to the safety of construction equipment, its operators, workers/users, and goods in addition to proposing a 13.5-year derogation after entry into force.

b. The relevance of waste practices as opposed to a general prohibition

CECE is of the view that fluoropolymers should be excluded from the PFAS restriction proposal or, at least, should be dealt with in a more proportionate fashion. Plastics Europe's Fluoropolymers Product Group (FPG) rightly argued that

[8] *Op. cit.* p.14

concerns of persistence can be appropriately mitigated by regulating manufacturing and waste practices in lieu of a blanket ban[9].

Based on an industry-supported study, fluoropolymers should be differentiated from other PFAS as they meet the criteria to be classified as polymers of low concern due to their high molecular weight, narrow molecular weight distribution, and negligible oligomer content in addition to their organic and inorganic leachability[10]. The study demonstrated that PTFE does not present any acute or sub-chronic systemic toxicity, irritation, sensitization, local toxicity on implementation, in vitro and in vivo genotoxicity, hemolysis, complement activation, or thrombogenicity.

It is noteworthy that the European Commission's Joint Research Centre (JRC) recently released a study that acknowledges the importance of fluoropolymers in the supply chains of strategic technologies and sectors in the EU[11]. Regarding Li-ion battery technology, the JRC interestingly classified two fluorinated polymers, PVDF (Polyvinylidene Fluoride) and PTFE, as precursor materials for battery components and key intermediate materials to produce battery precursors (cf. p.243). Polytetrafluoroethylene and expanded polytetrafluoroethylene were also identified, among other PFAS, as materials for electrolysers, data transmission networks and robotics. In addition, another fluorinated polymer, optical fiber cladding material, was singled out as processed materials for data transmission networks alongside data storage and servers.

Recommendation:

CECE stands for an exclusion of fluoropolymers (including fluoroelastomers and polytetrafluoroethylene) from the restriction proposal or, at the very least, a 13.5-year derogation after entry into force for our essential fluoropolymers uses on O-rings, seals, coatings, hoses, clutch plates alongside brake friction disks. CECE invites ECHA to work on restrictions of high-risk PFAS instead of adopting the Dossier Submitters' 'one-ban-fits-all' approach.

Comments on proposed restriction of Family of Fluorocarbon-based Fluoroelastomer Materials

Fluorocarbon-based fluoroelastomers, such as FKM products, are often used within high-temperature systems with upper usage limit around 230-250°C, depending on the sealing material applied, whilst maintaining strong chemical resistance.

Fluoroelastomers are also used as a vulcanizing agent which is vital for the performance of rubber-based products. Today, no PFAS-free alternative is capable of performing at temperature and chemical resistance requirements for mobile machinery products. Mobile machinery products are exclusively used in an industrial setting. Recycle, Rebuild and Reuse processes are in place to control the use and waste of this type of product. Considering the applications review in the below sub-sections, a blanket ban on Fluorocarbon-based Fluoroelastomers proves to be disproportionate. A recent

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[9] https://fluoropolymers.plasticseurope.org/application/files/8716/7991/0281/21_March_FPG_Statement_on_the_PFAS_REACH_restriction_report.pdf

[10] Henry BJ, Carlin JP, Hammerschmidt JA, Buck RC, Buxton LW, Fiedler H, Seed J, Hernandez O. A critical review of the application of polymer of low concern and regulatory criteria to fluoropolymers. Integr Environ Assess Manag. 2018 May;14(3):316-334. doi: 10.1002/ieam.4035. Epub 2018 Mar 30. PMID: 29424474.
[Accessible from: https://doi.org/10.1002/ieam.4035]

[11] Carrara, S., Bobba, S., Blagoeva, D., Alves Dias, P., Cavalli, A., Georgitzikis, K., Grohol, M., Itul, A., Kuzov, T., Latunussa, C., Lyons, L., Malano, G., Maury, T., Prior Arce, A., Somers, J., Telsnig, T., Veeh, C., Wittmer, D., Black, C., Pennington, D. and Christou, M., Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/334074, JRC132889.
[Accessible from: https://op.europa.eu/en/publication-detail/-/publication/9e17a3c2-c48f-11ed-a05c-01aa75ed71a1/language-en]

industry-conducted study notably concentrated on the health and environmental impacts of fluoroelastomers and concluded that they are stable from a thermal, biological and chemical perspective, negligibly water-soluble, nonmobile, nonbioavailable, nonbioaccumulative and nontoxic[12]. Additionally, the study found that fluoroelastomers meet the polymer hazard assessment criteria to be regarded as polymers of low concern. Therefore, CECE would like to invite ECHA to take fluoroelastomers out of the scope of this restriction proposal on the grounds explained above and based on the essential sector-specific applications detailed below.

O-rings and sealings, containing FKM, are operating in harsh conditions and hot temperatures and pressures where no alternative exists thus far. We have estimated that construction machinery uses over 10 000 parts containing PFAS, the majority of these being O-rings, sealings, hoses, wirings and PTFE coated parts (e.g., screws, bearings and friction plates).

For parts and components operating in harsh environments, suppliers need to develop alternatives and, as Original Equipment Manufacturers (OEMs), the construction equipment industry would need another 5 years once the new supply chain is operational to carry out verification, of newly developed components in their products to validate safety, performance, and reliability, especially for safety critical systems.

Regarding sealings and O-rings deployed in harsh conditions and hot temperatures, derogations of at least 13.5 years, after entry into force, are necessary to ensure that alternatives can be developed and verified by the supplier prior to OEM verification. For engines, transmissions, and hydraulic applications the cost for development and verification of those are estimated to be over €20M, upon development of alternatives conducted by the supplier. In that regard, CECE would like to highlight that the alternatives development will be solely dependent on the supply chain, and more specifically on the material formulators and compounders. OEMs cannot develop the alternatives which is why a PFAS prohibition, with no extensive transition period, would imperil our regular operations.

Regarding the substitution of the screws, we foresee a period of approximately 2 to 3 years with a cost exceeding €2,5M for a large enterprise. This will be detrimental to quality and durability bringing about the end-of-life earlier and intensifying the replacement frequency. Maintenance periods will shorten which will subsequently generate more waste.

In terms of O-rings, there are some parts designed for less harsh conditions (e.g., outside the engine bay) that may be substituted within 2-3 years after new materials have been developed by upstream supply chains. The estimated cost for these parts accounts for €70M, in the case of a large enterprise.

Recommendation:
In case of any fluoropolymers (including fluoroelastomers and polytetrafluoroethylene) restriction, CECE requests a general 13.5-year derogation after entry into force for all other essential PFAS uses on O-rings, seals, coatings, hoses, clutch plates alongside brake friction disks.

Insofar as OEMs define performance requirements and the supply chain selects the appropriate material solutions, CECE would like to emphasize that the use of, for instance, FKM in O-rings and sealings is not a preferred solution, in terms of material. It is a necessary solution to ensure safe and durable equipment. For engines, gearboxes, and transmissions as well as hydraulic applications, PFAS-containing parts are the only materials available today to minimize risks of safety critical failures, leakage (with major environmental consequences) and fires, among other issues. It needs to be ascertained that safe machines can be placed on the market with high durability. This policy direction should coincide

[12] Korzeniowski, S.H., Buck, R.C., Newkold, R.M., kassmi, A.E., Laganis, E., Matsuoka, Y., Dinelli, B., Beauchet, S., Adamsky, F., Weilandt, K., Soni, V.K., Kapoor, D., Gunasekar, P., Malvasi, M., Brinati, G. and Musio, S. (2023), A critical review of the application of polymer of low concern regulatory criteria to fluoropolymers II: Fluoroplastics and fluoroelastomers. Integr Environ Assess Manag, 19: 326-354.
[Accessible from: https://setac.onlinelibrary.wiley.com/doi/10.1002/ieam.4646]

with the ambitions of EU Green Deal to avoid excess waste and unnecessary use of rare materials and other resources where and when possible.

The below sub-sections delve into specifics and provide evidence-informed descriptions of essential applications and sub-uses.

Recommendation :
Having regard to the magnitude of this restriction proposal, CECE would like to invite the Commission to periodically exercise its implementing powers, conferred by Article 133 of Regulation (EC) No 1907/2006 ('REACH'), with the aim of reevaluating and redefining the duration as well as the scope of the derogations proposed or for reconsideration, following stakeholder consultations.

The development of alternatives will take years, adding to the legal uncertainty. An adequate use of implementing powers in the coming years would mitigate the legal uncertainty in addition to helping take the most proportionate decisions.

On that occasion, CECE would like to emphasize that the Revision of REACH will now fall under the next Commission in 2024, in view of the legislative calendar, and the debates surrounding the future provisions relating to Essential Use are at the beginning. WSP's report supporting the Commission in developing an essential use concept[13] proposed broad criteria for a use of a substance to be defined as 'essential' for society. Therefore, the Commission ought to clarify its intentions on the Essential Use concept and the regulatory implications that the WSP report may have.

Recommendation:
Considering that the revision of REACH is likely to take years, CECE calls upon the Commission to publish, at its earliest convenience, a Communication delineating the Essential Use concept and its methodology in future substance restrictions under REACH.

a. O-Rings

FKM is the preferred method for sealing wide range of fluids and gasses. O-Rings are relatively low cost, durable and serviceable and are therefore used in their thousands across our members' product lines. As the complexity of products has increased, O-Rings have also had to adapt particularly in their physical characteristics considering pressure and it has superior temperature and chemical resistance. As an example due to the addition of emissions reduction technologies, temperatures in and around engines and their ancillary components have significantly increased and, as a result, the requested target life for seals has increased accordingly. This has driven most manufacturers to transition to FKM for more seals over the years. If manufacturers were required to replace those seals with others made of materials inferior to FKM, there would be a drastic reduction in durability. Machines would have to be replaced and rebuilt at much lower hours, drastically increasing the workload for technicians and creating additional waste. There is no alternative polymer or elastomer available on the market that has equivalent performance and durability.

On average, a machine contains 300 – 3700 seals used in connection points and joints. Depending on the machine and its application, 17-62% of these seals contain PFAS (50-2300 seals per machine). The PFAS seals are strategically used in

[13] European Commission, Directorate-General for Environment, Bougas, K., Flexman, K., Keyte, I. et al., Supporting the Commission in developing an essential use concept – Final report, Publications Office of the European Union, 2023, [Accessible from: https://op.europa.eu/en/publication-detail/-/publication/69d5ea0d-d359-11ed-a05c-01aa75ed71a1/language-en/format-PDF/source-284023091]

systems that require performance at hot temperatures (>250°C), and/or require chemically inactive properties (e.g., low absorption).

Depending on the application and system conditions, an FKM-based O-ring could have a functional performance life from 10 to 100 times longer than an NBR- or EPDM-based O-ring, which are currently the best performing non-PFAS replacement material. With the average life of a machine being 10-60k hours, the lifecycle reduction has a significant impact on cost and waste produced.

In one machine model, it is currently recommended, for maintenance purposes, to replace the FKM-based O-Ring seals every 3000 machine hours, which is about every 6 months. Replacing the FKM-based seals with a lower temperature performing NBR-based seal will reduce the service life by approximately 97%. Using NBR-based seals will require replacement every 100 hours, which is about once per week.

Depending on the location of the seal, the required time to replace a seal varies significantly. At a minimum, 1 labor hour is needed. Engine removal and reconditioning equals about 24 hours.

b. Seals

1) Viton™ seals

The following chart (cf. below), taken from ASTM D2000, which is a standard classification system for rubber products that provides a way to describe their physical properties and suitability for specific environments. It was designed for automotive applications but is also used by other industries. The widely used Viton™ seals are made of Fluorine Latex ('Kautschuk') Material (FKM), which is a fluorocarbon-based fluoroelastomer. The closest material, in terms of temperature and chemical resistance, which is not a PFAS, is AEM/ACM, which has ~75°C less temperature resistance and a ~20% weaker oil resistance proving it to be not suitable for the harsh applications in construction equipment. It has become apparent that there are no viable alternatives available today.

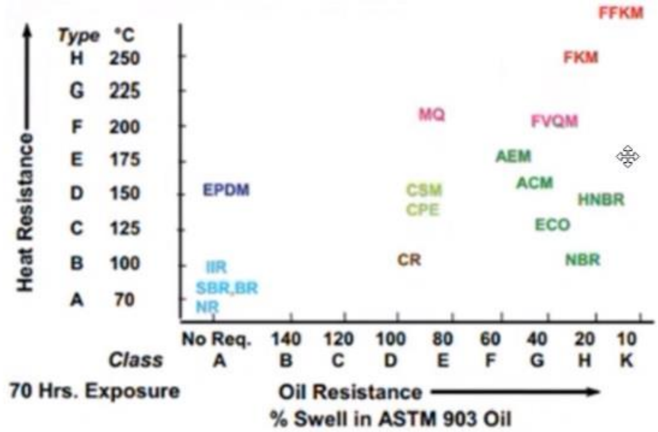


Figure 1: Performance by Heat and Oil Resistance
ASTM / IISRP / ISO Designation

Any restriction on the use of FKM as a material will result in significantly reduced seal lifetime and higher risk of leaks.

2) Press-in-Place Seals

Most of these seals are FKM on the same grounds as FKM use for O-rings.

3) Fuel Systems

FKM is a recommended seal material in diesel and biodiesel fuels. As well as the other properties duly noted, FKM is able to better withstand degradation from exposure to fuel and this is particularly true of the more recent biodiesel blends which are favored where decarbonization is being implemented. Other materials swell significantly and most, if not all, manufacturers switched exclusively to FKM in fuel systems over 20 years ago.

4) Clutch Disks

Friction disks for transmissions commonly use FKM compounds. FKM is preferred over other polymers, such as NBR, because of its superior temperature resistance.

5) Water Seals

Water seals are used to seal the coolant passages on engine blocks. These are typically coolant resistant FKM (CR-FKM). This material is the only available option because the application requires a coolant resistant material that can also withstand high ambient temperatures (from the cylinder).

6) Liner Seals

Manufacturers use FKM and CR-FKM on cylinder liner seals as well. The upper liner (or filler bands) are typically CR-FKM, because they are exposed to high temperatures and seal coolant from the bottom side of the seal.

7) Shaft Seals

Some rotating shaft seals are also made of FKM because of the need for high temperature resistance.

Comments on proposed restriction of Polytetrafluoroethylene

Polytetrafluoroethylene (PTFE) is an essential substance for the construction equipment industry which needs a derogation from the PFAS restriction proposal. In view of End of Life (EoL) risk-management practices, PTFE does not generate PFAS into the environment. A study released in Chemosphere review scrutinized PTFE combustion under regular waste incineration conditions at a pilot plant in Germany[14]. The researchers concluded that municipal incineration of PTFE, utilizing best available technologies (BAT), is not a significant source of PFAS under study and should be regarded as an appropriate method of waste treatment. As a result, a PTFE ban would be disproportionate in view of the available risk mitigation techniques.

a. Lithium-ion batteries

In the context of the electrification of our industrial machinery, including construction equipment and with the ever-growing demand for long-lasting batteries, it has become apparent that certain fluoropolymers will be instrumental in facilitating this cross-sector transition to zero-emission technology.

The automotive industry as well as the construction equipment industry need lithium-ion (Li-ion) batteries respectively for their electric vehicles and machines. This increased demand relies on gaskets for the electrodes of li-ion batteries. Certain corporate researchers surveyed the use of fluororesin made of PFA (Perfluoroalkoxy Copolymer), which is a co-

[14] Krasimir Aleksandrov, Hans-Joachim Gehrmann, Manuela Hauser, Hartmut Mätzing, Daniel Pigeon, Dieter Stapf, Manuela Wexler (2019), Waste incineration of Polytetrafluoroethylene (PTFE) to evaluate potential formation of per- and Poly-Fluorinated Alkyl Substances (PFAS) in flue gas. Chemosphere, Volume 226, 2019, Pages 898-906, ISSN 0045-6535, [Accessible from: https://www.sciencedirect.com/science/article/pii/S0045653519306435]

polymer of PTFE, due to its electrolyte resistance, electrical insulation properties, climate resistance and low moisture permeability[15]. They found that the PFA gaskets present a long-term reliability in the case of automotive Li-ion batteries.

Recommendation :
CECE stands for a cross-sector 13.5-year derogation after entry into force for uses of PFAS in Li-ion batteries.

b. Sealings and adhesives

1) Crankshaft Seals

These seals use a PTFE wafer as the main sealing lip on the crankshaft. To our knowledge, most if not all engine models use this type of sealing technology. There may be a few other types of crankshaft seals that do not use PTFE, but it would be a massive undertaking to design all new crank seals if PTFE would be banned.

2) Reciprocating Seal Rings

There is a family of PTFE rectangular shaped seal rings that are used with rubber energizers to seal reciprocating joints. PTFE is used because of its low friction properties.

3) Lip Seals

There is a family of machined lip seals made from PTFE billets that are used in brakes and transmissions as reciprocating seals again because of the low friction properties.

c. Coatings

A large percentage of highly durable O-rings (and most of the very high-volume STOR/ORFS O-rings) are coated with PTFE. This is done to reduce the friction when the O-ring is installed into the joint.

Comments on Essential applications with unspecified PFAS

Due to trade secret obligations, it was not possible to specify the PFAS used in multiple essential applications. In this case, we strived to submit, in lieu, data relating to the economic cost of a PFAS ban and the timespan needed to develop an alternative.

a. Hoses

Certain companies in the construction equipment industry offer over 100k variations of hoses with PFAS and produce millions of these hose assemblies per year. One of their most common hoses used on the engines of their machines has PFAS in it. These hose assemblies are primarily used on the engines due to their high temperature performance properties. If PFAS was restricted, exploring the possibility of replacing these hoses with a tube would cost approximately $2M per instance. If a tube is not a viable replacement, then a new hose material would need to be developed costing

[15] Liu J, Aoyama T, Tsuda H, Sukeagawa M. Long-term reliability evaluation of fluororesin gasket for electrode of automotive lithium-ion battery using simulation. COUPLED VIII : proceedings of the VIII International Conference on Computational Methods for Coupled Problems in Science and Engineering [Internet]. CIMNE; 2019. p. 269–79. [Accessible from: https://upcommons.upc.edu/handle/2117/190005]

roughly between $3M and $5M per hose type. Upon identification, development and validation of this new product would take 7 years and will likely be an iterative process due to the performance requirements and the dynamic nature of the machine cycles. After this time, an additional delay of 3 to 5 years and a sum of $500k - $1M would be needed for the new material to qualify for use in engine applications. The total time and value of replacing PFAS in our high temperature engine hoses could range from 7 to 13 years and $2M to $6M per instance.

b. Clutch plates and brake friction disks

PFAS is used in a proprietary compound in high energy transmission clutch plates, and brake friction disc packs (e.g., large mining equipment) due to the high temperature requirements and cycles these systems face. Any known substitute would decrease the current life of the friction discs by 75%. Switching to this material will cause a redesign of transmission controls, cooling systems and recertifying brake systems. Our current life of our high-performance compounded plates requires a change every 20.000 hours during a major maintenance session. The process of removal and reinstallation of the transmission takes 24 labour hours. In addition, rebuilding of the transmission takes about 65 labour hours and replacing the brake friction discs takes about 23 hours.

A new/replacement compound would reduce the life of the clutch, and friction disc plates by 75% which will require three additional replacements of the plates during the service life of the machines transmission and braking systems.

Comments on Essential uses of PFAS in Spare parts, remanufactured, refurbished, or second-hand products

a. Spare parts

CECE would also like to address spare parts. Our products often have extended lifecycles, regularly over 20 years for larger products. This circularity is key in the purchasing decisions of our customers, and we have extensive spare parts and service networks that have been developed over many years to foster repair of products. Spare parts constitute an important area of our industry and without a spare part derogation, this will adversely affect both our business in Europe, including loss of full-time equivalents (FTEs), and the possibility to simply and quickly repair machines already on the market. It would be impossible for manufacturers to develop and supply full component assemblies including alternative sealing technologies (even if they would be available) for these older machines that today would be repaired through the relatively simple replacement of a seal or O-ring. Our machines today work in many applications including civil construction, mining of essential minerals, infrastructure, waste treatment, and disaster relief. In case of breakdown of machines cleaning airports or building roads and with no opportunity to procure and install spare parts easily and at a reasonable cost, the impact on society will be severe. For instance, many roads may not be finished in time due to the lack of spare parts and the necessity to buy new machines instantly to finish the construction. Airports may not be cleaned from snow due to machines standing still and which cannot be repaired. Many roads may not be cleaned from waste or snow after a natural disaster hindering emergency vehicles to rescue people in need because there are no spare parts available to repair them in a time-sensitive manner. These examples of applications highlight the socio-economic consequences of a blanket ban on PFAS. Small and Medium-sized Enterprises (SMEs) should not be dealt with as an afterthought. In case they are deprived of spare parts to maintain their equipment, the impact on their business would be detrimental.

With an extensive prohibition of PFAS, and in the absence of drop-in alternatives without PFAS, the 'end-of-life' of construction equipment will be fast-tracked and its servicing, repair, and maintenance will be put in jeopardy.

Remanufacturing, refurbishing, servicing, maintenance, and repairs are instrumental in the EU Green Deal and circularity.

b. Remanufactured, refurbished, or second-hand products

In the context of the inter-institutional negotiations on the Proposal for Ecodesign for Sustainable Products Regulation (ESPR) and notably the negotiations between the European Union and India on a future trade agreement, the PFAS restriction proposal is at odds with the remanufacturing, refurbishment, and wider circularity incentives that the European Commission has been developing over the last few years. As an exemplification of this policy direction, the Commission tabled a Proposal for a Directive on common rules promoting the repair of goods earlier this year. If adopted, this directive would apply to the repair of goods purchased by consumers in the event of a defect of the goods that occurs or becomes apparent outside the liability of the seller.

The consequences of a PFAS prohibition on the aftermarket across industries should not be underestimated. Given that many engines would have to be withdrawn from the market, the supply of second-hand products would severely shrink and thereby incentivize the disposal of products. The coherence of the EU regulatory framework would thus be undermined. In addition, the socio-economic costs of engine and other products shortages should not be downplayed. The subsequent price increases of products, usually subject to remanufacturing and refurbishment and placed on the aftermarket, will further highlight the negative effects of this PFAS restriction proposal.

Recommendation :
Uses of PFAS in spare parts, remanufactured, refurbished, or second-hand products should benefit from a permanent derogation.

Summary table of main PFAS applications in the construction equipment industry

Substances / Applications	Fluoropolymers – Polytetrafluoroethylene (PTFE), Perfluoroalkoxyl polymer (PFA) & Polyvinylidene fluoride (PVDF) – PTFE and Teflon, PFA & PVDF	Fluorinated Gases - Refrigerants - Hydrofluorocarbons (HFCs) & Hydrofluoroolefins (HFOs)	Fluoropolymers - Family of Fluorocarbon-based Fluoroelastomer Materials - FKM, FPM & Viton™	1-Propene, 1,1,2,3,3,3-hexafluoro-, polymer with 1,1-difluoroethene	Ethene, tetrafluoro-, homopolymer
O-rings	PTFE		FKM, FPM		X
Seals (crankshaft, shaft, liner, lip, water seals; Press-in Place seals; piston; reciprocating rings)	PTFE		FKM, Viton™		X
PTFE tape					
Bushings					
Shims					
Teflon coated parts	PTFE				
Hoses	Teflon Seal Plug		Viton™		
Wires, cables or Looms					
Electrical equipment, including printed circuit boards, CPUs, LCD Screens, inverters etc.	Perfluorosulfonic Acid-PTFE Copolymer				
Lubricants and greases	PTFE			X	X
Hydraulic Oil					
Adhesive tape					
Bearings			FKM		

HVAC		R-134a & R-1234yf			

Substances / Applications	Fluoropolymers – Polytetrafluoroethylene (PTFE), Perfluoroalkoxyl polymer (PFA) & Polyvinylidene fluoride (PVDF) – PTFE and Teflon, PFA & PVDF	Fluorinated Gas - Refrigerants - Hydrofluorocarbons (HFCs) & Hydrofluoroolefins (HFOs)	Fluoropolymers - Family of Fluorocarbon-based Fluoroelastomer Materials - FKM, FPM & Viton™	1-Propene, 1,1,2,3,3,3-hexafluoro-, polymer with 1,1-difluoroethene	Ethene, tetrafluoro-, homopolymer
Fittings and fixtures	PTFE				
Precision Switch	PTFE				X
Cab seat	PTFE, PFA				X
Armrest kit LH & RH					X
High Water Temperature Switch			Viton™		
Oil Pressure Switch			Viton™		
Clutch			FKM		
Gear Motor	PTFE				
Gear Pump	PTFE		Viton™		
Oil Service Valve	PTFE			X	
Oil level capacitance switch	PTFE				
Water level capacitence switch	PTFE				
Liquid level sensor	PTFE				
Wear ring, Dust ring, Back-up ring	PTFE				

Powder coating	PTFE				
Fuel systems			FKM		
Brake friction disks (PFAS unspecified)					

Substances / Applications	Fluoropolymers – Polytetrafluoroethylene (PTFE), Perfluoroalkoxyl polymer (PFA) & Polyvinylidene fluoride (PVDF) – PTFE and Teflon, PFA & PVDF	Fluorinated Gas - Refrigerants - Hydrofluorocarbons (HFCs) & Hydrofluoroolefins (HFOs)	Fluoropolymers - Family of Fluorocarbon-based Fluoroelastomer Materials - FKM, FPM & Viton™	1-Propene, 1,1,2,3,3,3-hexafluoro-, polymer with 1,1-difluoroethene	Ethene, tetrafluoro-, homopolymer
Hydraulic control valve			Viton™		
Hose pipe rupture valve			Viton™		
Exhaust Blanket – Turbo Outlet	Teflon				
Exhaust Blanket – Doser Inlet	Teflon				
Exhaust Blanket – Doser Outlet	Teflon				
Exhaust Blanket – SCR Inlet	Teflon				
Mirror head	PTFE				
Bracket	PTFE				
Slipring seal kit	PTFE				
Stepseal kit	PTFE				
Li-ion batteries	PTFE, PVDF				

Gaskets for the electrodes of li-ion batteries	PFA				
Gasket	PTFE		FKM	X	
Filter			FKM	X	
Thermostat					X
Controller	PTFE				X

Annex II – European Agricultural Machinery (CEMA)[16]

Family (Subsistem of PFAS)	Sub "family"	Sub Category	Commercial Name	CAS Number (some EXAMPLES)	Common uses (some EXAMPLES)	Product type/Product group	Description of component/ subcomponent or process chemicals/formulations that contain PFAS
Polymeric PFAS (large molecules) Fluoropolymers	Fluoropolymers plastics	PTFE	Teflon	9002-84-0	[Sealing componentes (e.g. diaphragms, gaskets, hose lining, seals and O-rings), hydraulic fluid, alternative power technologies] [Chemical resistance Lubricants]	[TRACTOR] [COMBINE HARVESTER] [FORAGE HARVESTER] [BALER] [FORAGE HARVESTING MACHINERY] [Hydraulic system Rubber Vehicle automation] [Gardening, hydraulic, accident prevention] [back-up ring, TPU (thin wall tubing) and technical goods] [Automotive/mobility belt with fabric jacket] Hose lining sheet (TEFLON)	[STEERING SWITCH GASOLINE TANK RUBBER SEALS GREASE BELT MULTIFUNCTIONAL INSTRUMENT SWITCH] [Hydraulic valves O-rings and seals Sensors] [tapes, Teflon blades, bushing coating, anti-cut clothing] [back-up ring, TPU (thin wall tubing) and technical goods] [Automotive/mobility belt with fabric jacket] [This gasket is a ring made in PTFE. O-Ring is coupled with back up ring for avoid its extrusion and ensure the sealing.] It's a sheet in TEFLON used between internal parts of the tube of the electrical valve to guarantee the sliding of these into the tube and than the better working performance of the electrical valve
			Polyflon resins	9002-84-0	[Sealing componentes (e.g. diaphragms, gaskets, hose lining, seals and O-rings), hydraulic fluid, alternative power technologies] [Chemical resistance Lubricants]	[Hydraulic system Rubber Vehicle automation] [Automotive/mobility belt with fabric jacket]	[Hydraulic valves O-rings and seals Sensors] [Automotive/mobility belt with fabric jacket]
			Fluon	116-14-3	[Sealing componentes (e.g. diaphragms, gaskets, hose lining, seals and O-rings), hydraulic fluid, alternative power technologies] [Chemical resistance Lubricants]	[Hydraulic system Rubber Vehicle automation]	[Hydraulic valves O-rings and seals Sensors]
			Hyflon	161611-79-6	[Sealing componentes (e.g. diaphragms, gaskets, hose lining, seals and O-rings), hydraulic fluid, alternative power technologies] [Chemical resistance Lubricants]	[Hydraulic system Rubber Vehicle automation]	[Hydraulic valves O-rings and seals Sensors]
		PVDF	Kynar	24937-79-9	[Sealing componentes (e.g. diaphragms, gaskets, hose lining, seals and O-rings), hydraulic fluid, alternative power technologies] [Corrosion resistance]	TRACTOR [Chassy] [COMBINE HARVESTER] [FORAGE HARVESTER] [BALER] [FORAGE HARVESTING MACHINERY]	SENSOR [Welding]
			Hylar	24937-79-9	[Sealing componentes (e.g. diaphragms, gaskets, hose lining, seals and O-rings), hydraulic fluid, alternative power technologies] [Corrosion resistance]		
			Solef	24937-79-9	[Sealing componentes (e.g. diaphragms, gaskets, hose lining, seals and O-rings), hydraulic fluid, alternative power technologies] [Corrosion resistance]		
		PFA	Everflon	406-78-0	[Sealing componentes (e.g. diaphragms, gaskets, hose lining, seals and O-rings), hydraulic fluid, alternative power technologies] [Corrosion resistance]	TRACTOR, COMBINE HARVESTER, FORAGE HARVESTER [engine]	[TANK - AD BLUE] [Engine]
			Neoflon GP	80701-91-3	[Sealing componentes (e.g. diaphragms, gaskets, hose lining, seals and O-rings), hydraulic fluid, alternative power technologies] [Corrosion resistance]		
	Fluoropolymers elastomeric (i.e. rubbees)		FPM	1350768-28-3	[Sealing componentes (e.g. diaphragms, gaskets, hose lining, seals and O-rings), hydraulic fluid, alternative power technologies] [Chemical resistance Temperature resistance Wear resistance]	[Rubber Hydraulic system Engine] [o-ring, GAT and quadring made in FKM (called FPM)]	[Fuel pipes O-rings Hydraulic valves Hydraulic pumps] [o-ring, GAT and quadring]
			FVMQ	63394-02-5	[Sealing componentes (e.g. diaphragms, gaskets, hose lining, seals and O-rings), hydraulic fluid, alternative power technologies] [Chemical resistance Temperature resistance Wear resistance]	TRACTOR, COMBINE HARVESTER, FORAGE HARVESTER [Rubber Hydraulic system Engine, hoses]	[SEALINGS] [Fuel pipes O-rings Hydraulic valves Hydraulic pumps]
			FKM	9011-17-0 or 25190-89-0	[Sealing componentes (e.g. diaphragms, gaskets, hose lining, seals and O-rings), hydraulic fluid, alternative power technologies] [Chemical resistance Temperature resistance Wear resistance]	TRACTOR, COMBINE HARVESTER, FORAGE HARVESTER [Rubber Hydraulic system Engine]	[SEALINGS] [Fuel pipes O-rings Hydraulic valves Hydraulic pumps]
			FFKM	nd	[Sealing componentes (e.g. diaphragms, gaskets, hose lining, seals and O-rings), hydraulic fluid, alternative power technologies] [Chemical resistance Temperature resistance Wear resistance]	TRACTOR, COMBINE HARVESTER, FORAGE HARVESTER [Rubber Hydraulic system Engine]	Fuel pipes O-rings Hydraulic valves Hydraulic pumps
			Viton	9011-17-0	[Chemical resistance Temperature resistance Wear resistance]	[TRACTOR] [COMBINE HARVESTER] [FORAGE HARVESTER] [BALER] [FORAGE HARVESTING MACHINERY] [Hydraulic pumps and hydraulic components in general] [Rubber Hydraulic system Engine. hoses, o-ring]	[SEALINGS SWITCH] [gaskets, o-rings, membranes, hydraulic filters] [Fuel pipes O-rings Hydraulic valves Hydraulic pumps, hoses] [This material has better characteristics than the NBR with hight temperature and for the compatibility of some special working fluids used]
			AFLAS	27029-05-6	[Sealing componentes (e.g. diaphragms, gaskets, hose lining, seals and O-rings), hydraulic fluid, alternative power technologies] [Chemical resistance Temperature resistance Wear resistance]	[Rubber Hydraulic system Engine]	Fuel pipes O-rings Hydraulic valves Hydraulic pumps
	Fluoropolymers base oils		nd	69991-67-9	Grease, lubrificant	Manufacturing fluids likely contain PFAS. The Safety Material Data Sheets received until now do not show evidence of PFAS presence because they are not mandatory to declare. We'd need more time to investigate this materials.	Manufacturing fluids likely contain PFAS. The Safety Material Data Sheets received until now do not show evidence of PFAS presence because they are not mandatory to declare. We'd need more time to investigate this materials.
			PFPE	60164-51-4		Manufacturing fluids likely contain PFAS. The Safety Material Data Sheets received until now do not show evidence of PFAS presence because they are not mandatory to declare. We'd need more time to investigate this materials.	Manufacturing fluids likely contain PFAS. The Safety Material Data Sheets received until now do not show evidence of PFAS presence because they are not mandatory to declare. We'd need more time to investigate this materials.
Non-polymeric PFAS (small molecules)Perfluoroalkyl substances	F-gases		HFO-1234yf (or R1234yf)	754-12-1	Refrigerant	Air conditioning system	Filling gas
Other 1	-		trisodium hexafluoroaluminate (cryolite)	15096-52-3	-	TRACTOR, COMBINE HARVESTER, FORAGE HARVESTER	LAMPS BRAKE DISK
Other 2	-		1-Propene, 1-chloro-3,3,3-trifluorc	102687-65-0	-	TRACTOR, COMBINE HARVESTER,	PADDING (STEERING WHEEL)

[16] Non-exhaustive list of some examples of materials made with PFAS used for the Agricultural and Forestry Machineries

Annex III - Danfoss

Danfoss Climate Solutions

Danfoss Climate Solutions is a global supplier of components within the HVACR sector. Main sectors in which their products are used include:

1. Cold chain
2. Air conditioning
3. Heat pumps
4. Process cooling
5. Hydronic heating flows in buildings
6. District energy

In general, the sectors account for 60% of final energy use and serve basic demand within food supply and necessary wellbeing like heating.

Products in the vapour compression process

The bullets 1-4 above relate to the vapor compression process, where energy is moved from a cold volume to a warmer volume.

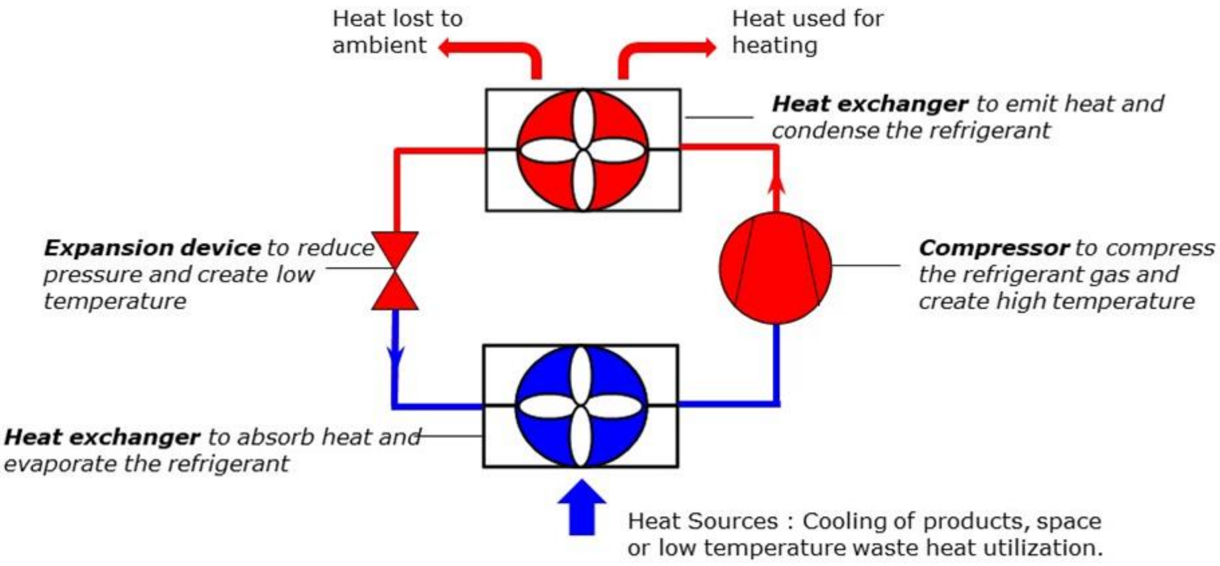


Figure 1: Basic principle of vapor compression system comprising the energy flows and the basic components.

The system relies on a 'refrigerant' fluid, which for some types – the F-gases called HFCs or HFOs – are classified as PFASs as well as their breakdown products known as TFA. Refrigerants can also be non-PFAS substances, e.g., naturally occurring gases like CO_2, ammonia, or propane. Danfoss delivers full product programs for natural refrigerants as well as for F-gases.

The main reason for using F-gases is safety. Safety is a concern if the gases are toxic or flammable and usage is regulated through complex safety standards. Not all F-gases are PFAS-classified as they break down to HF (no CF_3 part). Some of the PFAS-classified HFOs have very small TFA yields from breakdown, while others have 100 % TFA formation. Danfoss uses minor amounts of F-gases directly, but the components are designed to contain F-gases in the use phase.

It is important not to exclude all F-gases. The newly applied HFO gases like R1234ze and R1336zd have negligible amount of TFA formation [Environmental Effects of Stratospheric Ozone Depletion, UV Radiation, and Interactions with Climate Change ; UNEP 2022 Assessment Report of the Environmental Effects Assessment Panel], and, combined with the questionable negative impact, it is overdone and harmful to the green transition to exclude all F-gases in one basket.

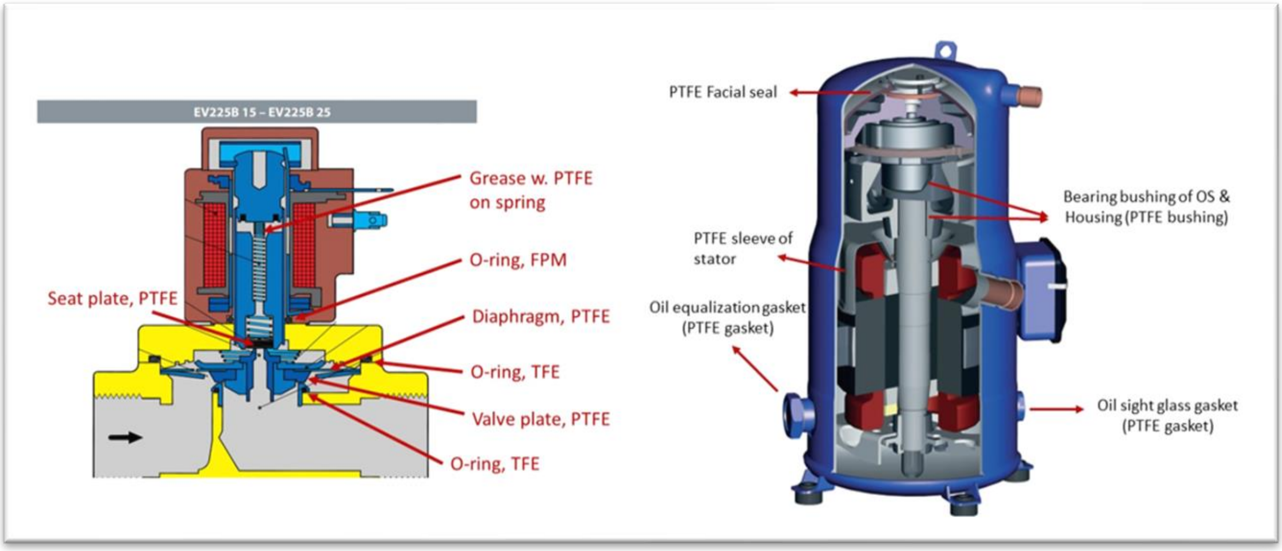


Figure 2: Compressor (left) and solenoid valve (right) exemplifying various critical fluoropolymer elements.

Fluoropolymers: The components comprising the vapor compression systems for refrigeration, air conditioning and heat pumps are based on at least 40 years of incremental design improvements, where the fluoropolymers are regarded as critical materials. The temperature demands inside the systems are dynamically varying from -50°C to 150°C, while pressures are ranging from 1 to 150 bar. The industrial usage of heat pumps has just started and will imply more extreme conditions on temperatures, which means the need for durable strong fluoropolymer materials.

The containment of refrigerants is a major factor, but accidents can happen. Safety is ensured by numerous standards constraining system location, human occupation and the charge size of specific refrigerants. Systems losing their refrigerant charge over time will underperform on energy efficiency. Leakage and tightness demands are all top priority issues in the industry. Reliable (long-term) gaskets and sealings are necessary as many systems are not 'hermetically sealed'. PFAS materials–fluoropolymers–are used for these applications (see table). Majority of valves are containing these sealings and gaskets.

The market using vapor compression systems is enormous. According to the IEA about 10% of the global electricity production is consumed by air conditioners and similar numbers can be estimated for food refrigeration. That percentage number will increase with the green transition towards heat pumps and the increasing food cold chain. The green transition will demand up to 60 million new heat pumps by 2030 ['Europe's Leap to Heat Pumps' ; European Climate Foundation]. A compressor uses bearings, sealings and gaskets based on fluoropolymers. Valves for controlling refrigerant flows are using the fluoropolymers for the same reasons. Besides the mechanical components, temperature sensors are necessary for avoiding burnouts of the compressor. Likely, the compressors will not last a week without those temperature-detecting components. To avoid usage of fluoropolymers in compressors and mechanical controls is a problem without solutions for the present state of materials if efficiencies and safety should be maintained at high levels.

Key components	**Key products**	**Key properties/requirements in relation to the materials used**	**PFAS materials**
Bearings Gaskets	Compressors Expansion valves	Lifetime / reliability	PTFE FEPM

Seals Seal rings Coatings Bushings	Heat exchangers Solenoid valves Ball valves Service valves Sight glasses Pressure regulating valves Non-return valves	High to low temperature performance Lubricant resistance Dimensional stability	PFA FEP FKM PVDF PFPE FEPM

Table 1: List of fluoropolymers used in Danfoss vapor compression components.

Hydronic heating flows in buildings and district energy

In hydronic heating systems, water is used to move heat from heat sources to where it is needed, e.g., from heat pumps or boilers to radiators, heating mats, etc., while district energy systems are networks of hot and cold-water pipes used to efficiently heat–e.g. using waste heat–and cool buildings and using less energy than if the individual buildings were to each have their own boilers and chillers. The safety of transport of water through pipes in such systems are highly dependent on the stability and tightness of components to be energy-efficient; hence, temperature and pressure are of utmost importance. Components containing PFAS in sealings and bearings are an essential part of securing this.

Heating and cooling of buildings represent 40% of global energy demand. Balancing and control valves ensure energy-efficient and reliable operation of such systems (district heating, HVAC, residential heating) by distributing energy from sources to consumers. The design life of such systems is 15-20 years. Danfoss cannot offer products enabling comparable system efficiency and lifetime without the use of PFAS materials.

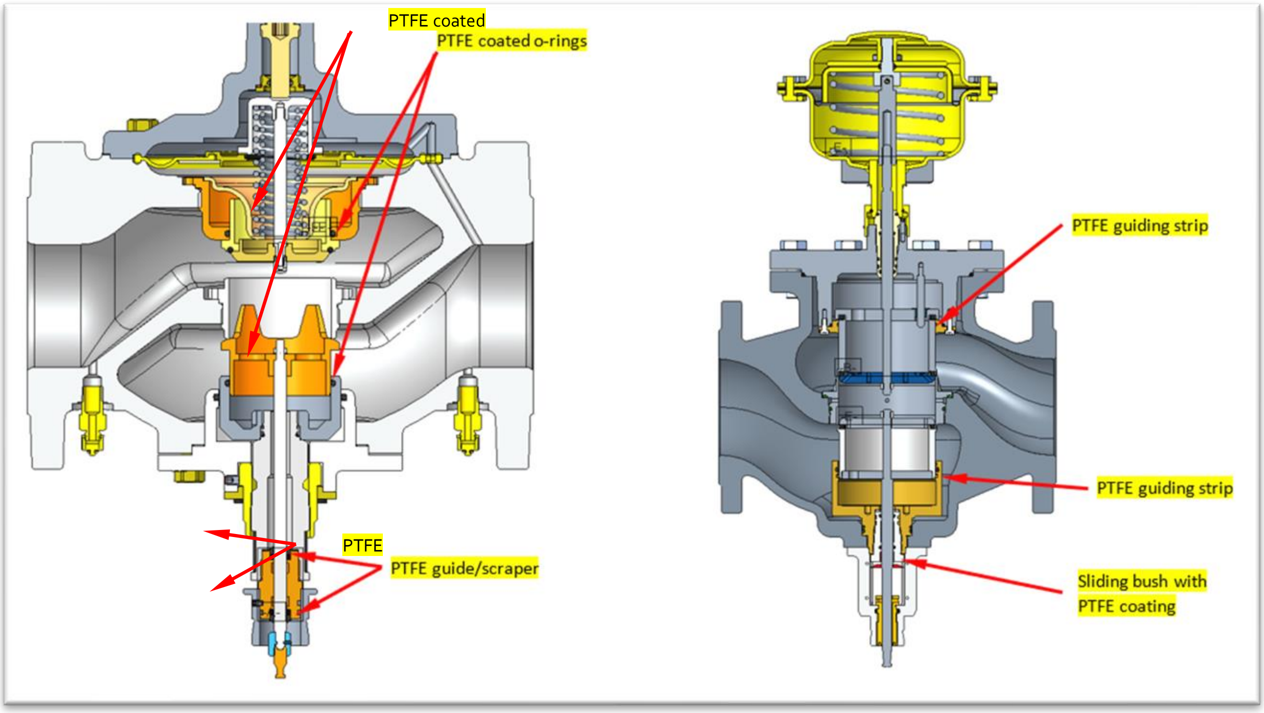


Figure 2: Pressure flow controllers ABQM (left) and AFQM (right) pressure-independent control valves exemplifying various critical fluoropolymer elements in hydronic heating and district energy system components.

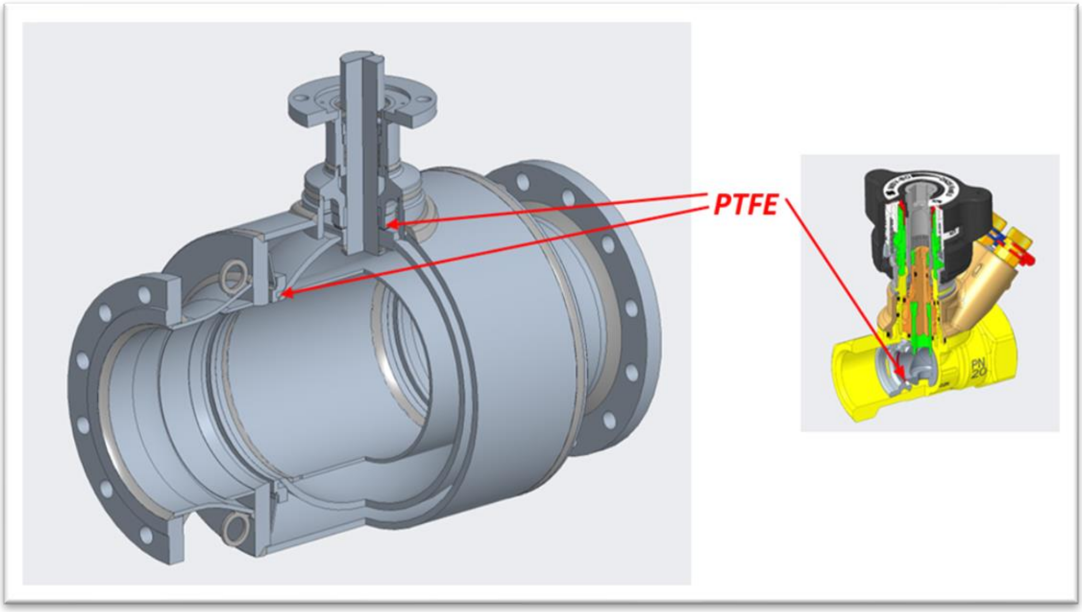


Figure 3: Ball valve for district heating and manual balancing ball valve (LENO) with critical fluoropolymer component.

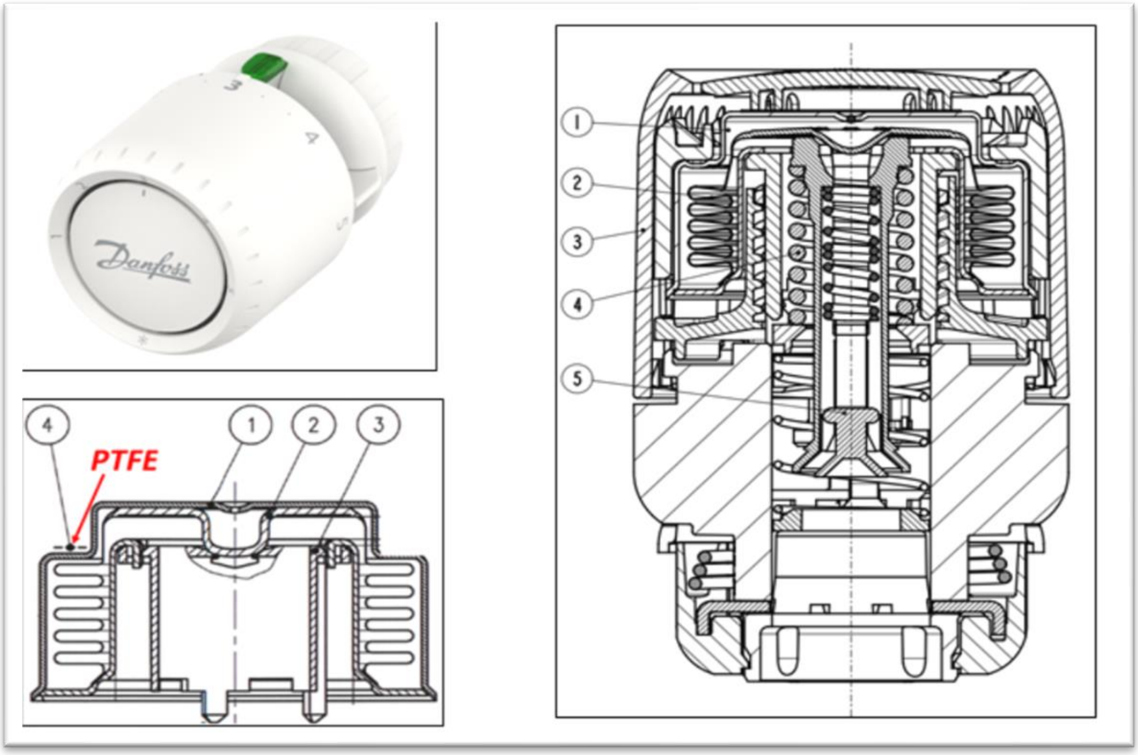


Figure 4: Radiator thermostat exemplifying critical fluoropolymer element.

Fluoropolymers: The components comprising the control valves and pressure regulators for heating and district heating are based on at least 40 years of incremental design improvements, where the fluoropolymers are regarded as critical materials due to high operating demands. The temperature demands inside the systems are dynamically varying from -50°C to 180°C, while pressures range from 1 to 40 bar and up. With the spreading of district heating there is an increasing need for more reliable control elements with lower hysteresis, i.e., increasing the need for durable, strong fluoropolymer materials.

1) Safety and 2) energy efficiency are major factors of the products with specific attention to properties of tightness, dimensional stability, wear resistance, and low friction. Re. 1), safety is directly related to unintended leakage of high-temperature liquid or gas to the surroundings as a potential danger. Reliable guide gaskets and sealings are necessary to prevent these risks. To ensure 2) energy-efficient systems, low friction is critical, as friction in valves, especially in pressure regulators, causes increasing hysteresis, meaning decreased regulation performance. PFAS materials–fluoropolymers–are used for these applications (see table). The majority of valves contain these guides and coated o-rings.

Key components	Key products	Key properties/requirements in relation to the materials used	PFAS materials
Bushings Guides/scrapers Coated o-rings Grease	Pressure regulators Pressure-independent control valves Control valves Pressure regulating valves	Lifetime/reliability High to low temperature performance Dimensional stability	PTFE
Lubricant	Gas filled self-acting radiator thermostats	Secure acceptable handle torque	PTFE-based dry-film lubricant
Seal rings Washer Greases	Ball valves	Lifetime/reliability High to low-temperature performance Lubricant resistance Dimensional stability	PTFE PTFE+C (compound)

Table 2: List of fluoropolymers used in Danfoss hydronic heating and district heating.

Compressors and intelligent controls of the systems all relate to PFAS-based electronics. This will be covered under the section from Danfoss Power Electronics and Drives below.

Danfoss Power Solutions

The product portfolio includes motors, pumps, valves, steering components and systems, electronic controls, electrical systems, PLUS+1 software, former Eaton Hydraulics products, and hydrostatic drive systems.

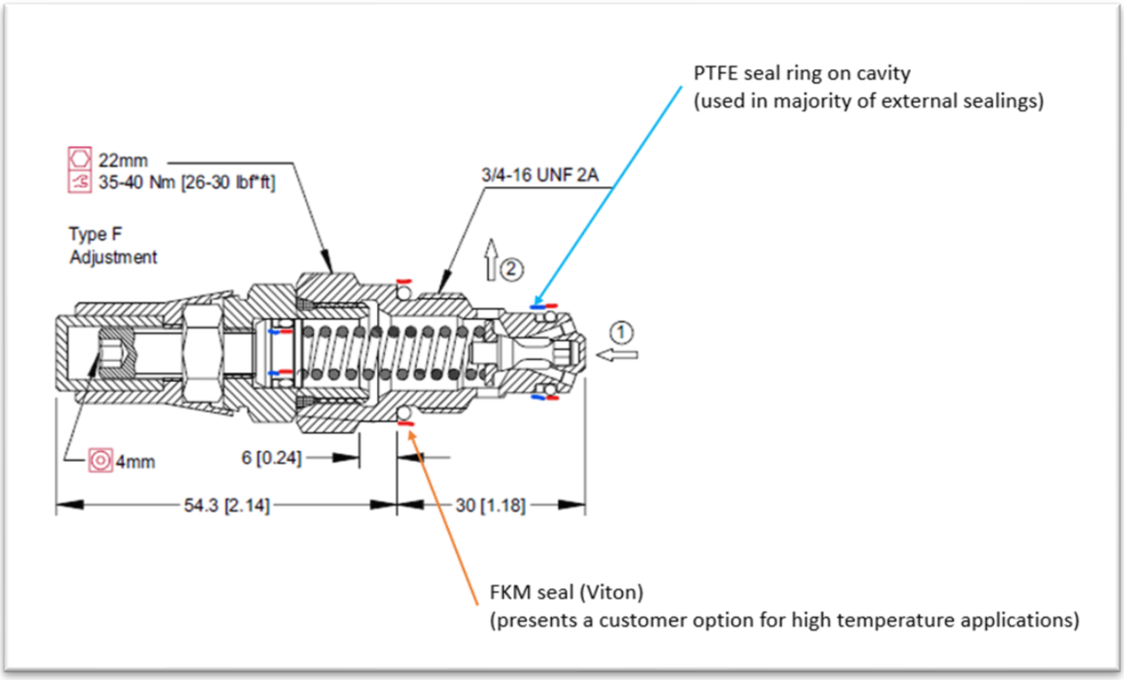


Figure 3: Example – Relief valve with PTFE and FKM

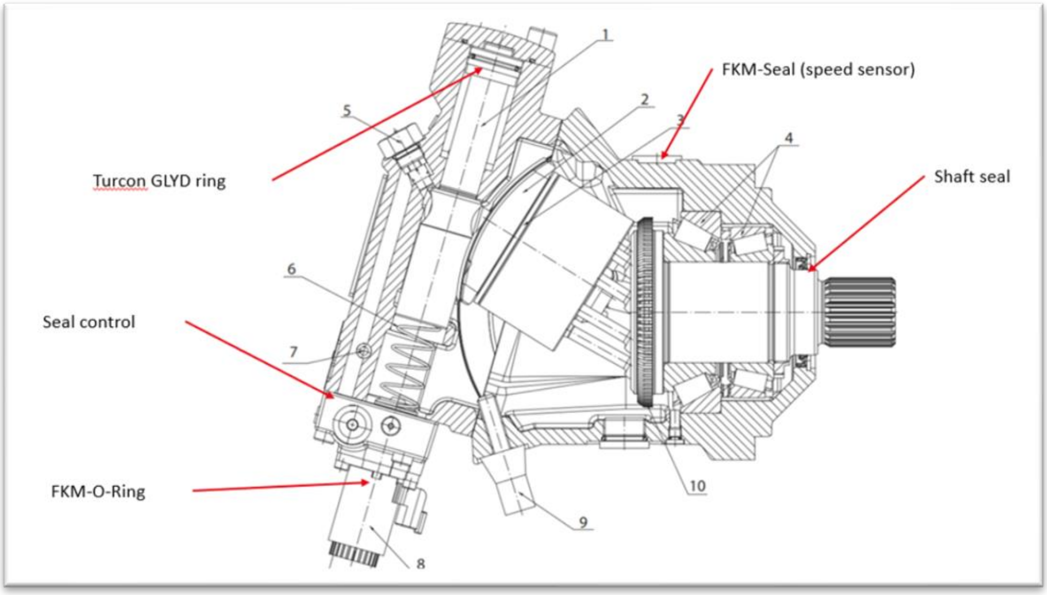


Figure 4: Example – Hydrostatic variable displacement axial piston motor with PTFE and FKM

Fluoropolymers: The use of PFAS substances in indispensable components such as seals is essential for the functionality of the products, especially in safety-related areas where resistance to high temperatures, pressure, abrasion, and to other extreme working conditions are required.

PFAS-containing seals and coatings play an important role in many product lines that convey hydraulic fluids (e.g. pumps, hoses, etc.). These components are supplied individually or as advance solutions for integration into final machine applications with no direct exposure to the environment.

The identified essential use of fluoropolymers in seals, coatings, and bushings is a stopgap situation in which replacements are actively sought. The essential use concept expects that PFAS uses considered essential today should be continually reviewed for potential removal or replacement by new technologies and be targeted by innovation toward alternatives. Unfortunately, fluoropolymers are the only comparable alternative to comply with a variety of official safety regulations applicable to Danfoss Power Solutions today.

Key components	**Key products**	**Key Properties/requirements in relation to the materials used**	**PFAS Materials**
Seals Seal rings Coatings Bushings	Axial piston pumps & motors Gear pumps & motors Steering Valves Electronic Controls Hoses	Resistance to physical effects (e.g. heat, pressure, resistance, abrasion, etc.) Safety in high-power and extreme work conditions	FKM PTFE

Table 2: List of fluoropolymers used in Danfoss Power Solutions

Danfoss Power Electronics and Drives

Danfoss offers a comprehensive range of semiconductor devices, power modules, stacks, and systems. As the world goes electric.

- Low-voltage single- and three-phase drives
- Medium-voltage drives
- Motion drives
- Low-harmonic drives
- Intelligent drives
- Decentral drives
- Semiconductor/chip production.

For the applications Danfoss are serving industries like HVAC (Heating, Ventilation, and Air Conditioning), Water - Wastewater treatments, Food & Beverage industries, Heavy industries, Textiles, Automotive, Electrification & Marine.

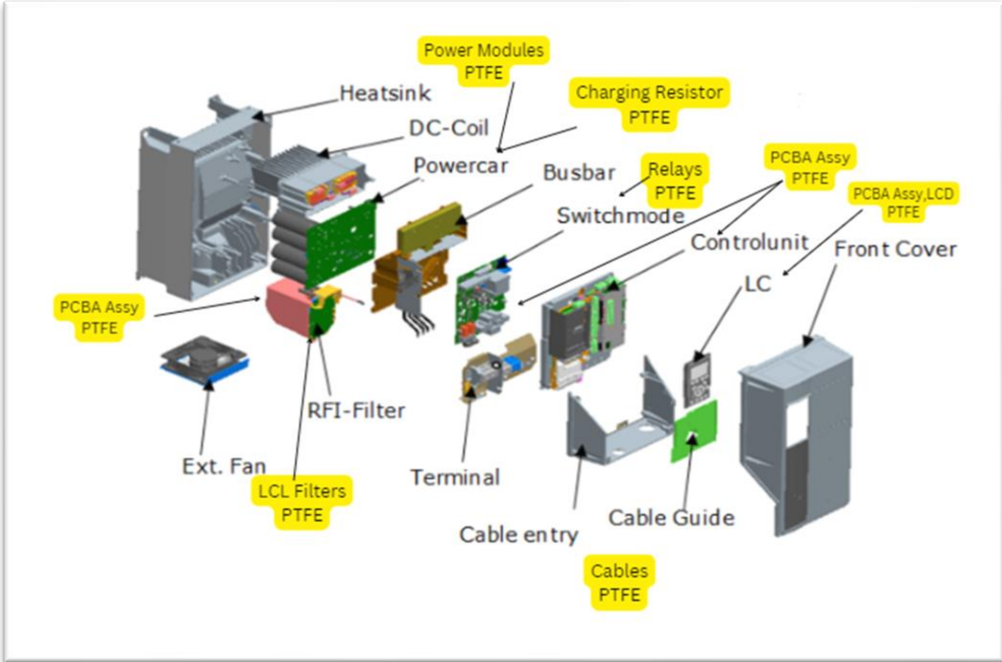


Figure 5: Example – Frequency Converter with PTFE-containing components

Fluoropolymers: The use of PFAS substances in components such as relays, soft starters, power modules, capacitors, LCL filters, conformal coating PCBAs (Printed Circuit Boards Assembly), cables, batteries, semiconductors, chip, and charging resistors is essential for the functionality of Danfoss Drives products. These components are essential for safety-related areas where resistance to elevated temperatures, pressure, abrasion, and other extreme conditions are required.

Semiconductor parts, cables, and coatings play a critical role in ensuring the reliability and performance of Danfoss Drives products - especially in heavy industry applications. While some of these components may contain PFAS, they are supplied individually or as advanced solutions for integration into final machine applications, with no direct exposure to the environment. These components are essential to the success of the European Green Deal, as they enable the creation of essential technologies like PV systems and wind turbines.

While fluoropolymers are currently the only comparable alternative for complying with official safety regulations applicable to Danfoss Drives, the company actively seeks replacements for identified essential uses of PFAS. The essential use concept expects that PFAS uses considered essential today should be continually reviewed for potential removal or replacement by innovative technologies and targeted by innovation towards alternatives.

Key components	Key products	Key Properties/requirements in relation to the materials used	PFAS Materials
Power module Relays Capacitors LCL filters Conformal coating in PCBAs Cables Batteries Charging resistor O-Rings Semiconductors Computer chips	Power modules Soft starter Variety range of drives Electric converters	Safety in high-power and extreme work conditions Resistance to physical effects (e.g. heat, pressure, resistance, abrasion, etc.)	PTFE ETFE Potassium nonafluoro-1-butanesulfonate Methyl perfluoroisobutyl ether Methyl nonafluorobutyl ether PFA (perfluoroalkoxy) PVDF (polyvinylidenfluorid) ECTFE (ethylenchlor-trifluorethylen) PFPE (perfluorpolyether)

Table 3: List of fluoropolymers used in Danfoss Power Electronics and Drives.

Annex IV - Europump

Europump
The Voice of the European Pump Industry

Sealing

In pumps, PFAS materials are used primarily in sealing applications, specifically in seals, O-rings, and gaskets. Because of their extreme cost, which varies from 2.5 times to nearly 100 times those of other natural or synthetic elastomers, the use of PFAS materials is limited a very small percentage of all pump applications. They are used only when absolutely necessary when there is no other suitable elastomeric substitute. The primary advantage of PFAS elastomers is that they have excellent chemical resistance to many highly aggressive liquids where standard elastomers will quickly fail. Furthermore, they can maintain their elasticity and sealing properties at temperatures where other standard elastomers will harden, often within a few hours or days of use, and become totally incapable of sealing.

PFAS seals are primarily, but not exclusively, used in the chemical and petrochemical industries where pump seal leakage can lead to exposure of operating personnel, equipment and environment to hazardous, corrosive, or toxic chemicals. They are also used in industries (such as pharmaceutical) where elastomeric seal residue contaminating the process liquid can lead to process upsets and final product safety issues. Moreover, in addition to leakage issues, attempting to use non PFAS materials when PFAS is needed will lead significantly increased service (disassembly and seal or component replacement) requirements. This will result in additional exposure of maintenance personnel to hazardous/corrosive/toxic process liquids.

Much more in depth technical information can be found in a position paper produced by the European Sealing Association (ESA) – "European Sealing Association (ESA) position statement relative to the European proposal for PFAS regulation in relation with the Sealing Industry."

Bearings

The majority of PFAS based bearings are made from PTFE and are used in applications where standard metal bearings cannot be employed due to high coefficients of friction and where other polymer bearings fail due to high loads or temperatures. Unlike other fluoropolymers, PTFE does not melt, has an exceptionally low coefficient of friction and high self-lubricating characteristics, resistance to attack by almost any chemical, and an ability to operate under a wide temperature range. These properties make PTFE an ideal material in applications with starved lubrication, aggressive chemicals, and high temperatures.

In many bearing applications, PTFE isn't used as a plain material, but is filled with glass fibre, graphite, or other inert materials to increase its application range. While unmodified PTFE can be used to a PV value of only 1,000, filled PTFE can be used at PV values up to 10,000 or more, exceeding the capabilities of most common bearing materials.

PTFE bushing type bearings offer dry-running capability for applications where limited lubrication-free behaviour is required. This makes them an ideal choice in areas where constant lubrication with oil-based lubricants is not possible, due to environmental or hygienic reasons, and when heat build-up due to friction is an issue. Examples are vertical pumps with product lubricated line shaft bearings in water and food processing, where the non-immersed bearings suffer from dry running upon start-up and shut down of the pump.

Due to the very low coefficient of friction of PTFE against all kind of metallic shaft material, the application of PTFE containing bearings contributes to the reduction of friction losses and thereby to saving of energy.

Due to their chemical inertness, PTFE based bearings are crucial in applications, where metal bearings may suffer from corrosion and non-PFAS polymers are prone to swell, leading to a derogation of their mechanical and tribological properties.

PTFE does not require processing aids such as stabilizers, which are generally used to protect against thermal degradation, or plasticizers used to improve overall elasticity. Its stability and lack of additives means that there is no leaching of foreign substance into the fluid that is flowing through the bearing. For these reasons PTFE based bearings are also chosen for applications in food and drink processing plants, where other materials will progressively break down and leach potentially harmful substances to the process.

Due to the very low coefficient of friction, which leads to a low wear rate and a high service life, the environmental impact of PFAS based bearings in pump applications can be rated as very low. A complete substitution based on the current state of the technology is not possible or may lead to other concerns related to environmental impact and public health.

Cable sheath

Some cables used within the pump industry are specially designed for use with heavy duty submersible products – one example being the HCR (Heat and Chemical Resistant) cable. HCR cables have an outer sheath and conductor insulation made of fluorinated ethylene propylene (FEP) and control wire insulation made of ethylenetetrafluorethylene (ETFE). The HCR cable is designed for use in severe conditions. It is resistant to chemicals and solvents (petrol, strong acids and bases), high temperature and mechanical stress, that often cause rapid deterioration of other cables. An HCR cable is used in hot liquid applications where temperatures exceed 70°C and at lower temperatures where superior chemical resistance is required.

Even though, they are used in demanding environment they can still retain mechanical and electrical properties over a long period of time. They also have excellent electrical insulation properties and are oil resistant for use in many types of liquids. If there is a need for a cable that can handle difficult temperatures > 70°C) and that also must be chemically resistant, there is today no alternative to these specialised cables with PFAS sheath, at least not if you want the cables to have a long life and assure stable processes and safe applications.

A silicone cable cannot replace the HCR cable since it does not have the tear strength and cannot handle the same mechanical stress as HCR. There are regular rubber cables often used for pumps and mixers, but these cannot replace the HCR because they neither handle the higher temperatures nor contaminated water (oil/acids/bases). Even though an HCR cable has many very good qualities, it is only used when needed due to high cost. In addition, it is hard to work with it due to its stiffness and smooth/slippery surface. In other words, pump manufacturers already apply use "restrictions".

To use of these cable makes the product more durable and, is in some cases, the only alternative for the products to even be used in certain environments. Longer lifetime of the product also gives less waste and less environmental risk as any cable failure may result in dangerous process consequences, such as a pump that does not pump anymore and results in a tank overflow. Since the HCR cable can be used in very contaminated water, it is a necessary application to pumps and mixers cleaning and preventing contaminated water reaching the environment.

Inserts for pumps

Certain pumps, for slurry and/or chemical applications, require elastomer inserts (liners) in the volute. The impeller may also be covered with elastomer in many applications.

Virtually all slurry pumps will be constructed with removable volute liners. This is due to the fact that they experience rapid wear and it is much more cost effective, as well as safer, to replace liners when they wear out, rather than to replace the whole volute. (Also, the first indication that the volute is worn may be catastrophic failure.) Depending on the application, an elastomer liner can be much more suitable for wear resistance than a metal liner.

Likewise, in certain chemical applications the use of a suitably resistant volute liner, either as an elastomer or as a polymer coating, can be a much better and more economical solution than to make the entire volute from a corrosion resistant metal. In most chemical applications the volute liner will be fixed to the volute with a suitable adhesive, rather than be removable.

As is the case with pump sealing applications, only a small minority of pump liners are required to be made from PFAS materials. In most situations standard (non PFAS) elastomers or polymer coatings work perfectly well. PFAS materials are never used where they are not required because of their high price. Depending on the composition involved, components produced from PFAS materials can cost between 2.5 and 100 times those produced using other technical elastomers.

The advantages of PFAS liners are their resistance to most chemicals as well as to higher temperatures than standard elastomers. Of particular importance is their resistance to swelling. For efficiency considerations it is important to have minimal clearance between the rotating impeller and stationary volute. When elastomer swelling is expected, this clearance must increase to allow free operation without rubbing, resulting in higher energy consumption.

One important point to note is that there is a fundamental difference with liners as compared to items used in sealing. In the case of seals, there is absolutely no way to practically replace PFAS materials, when they are required, with metals. In the case of liners, there can be, depending on the wear conditions, the possibility to eliminate the liner and use a suitably corrosion resistant metal casing. However, the disadvantages of doing this can be quite significant. Replacement of the whole casing due to corrosion and/or wear, instead of relatively thin liner or insert, will be required. Wear in the thick casing will mean greater degradation of performance and increase in energy consumption. Both of these circumstances are certainly contrary to the philosophy of a circular economy and will always require an increased carbon footprint over the life of the product.

Coatings for fasteners

Pumps require a multitude of fasteners with defined mechanical strength and corrosion resistance, to ensure tightness and safe operation. For high pressure pumps and axially split pumps, the cost of fasteners is a substantial part of the overall costs.

Usually, high strength fasteners are protected from corrosion by means of cathodic protection, either achieved by hot dip galvanizing or electrodeposition of zinc / zinc-nickel alloys. Further protection can be achieved by adding conversion layers based on chromium VI or chromium III. For applications in seawater and specific environments in the O&G industry this protection level is however frequently not sufficient. In this case the fasteners need to be made from costly stainless steel or even nickel base alloys, which are, with some exotic exceptions, limited by their mechanical strength.

Furthermore, the usage of stainless-steel fasteners bears the risk of galling / seizing, requiring the application of leachable lubricants, which may be detrimental to the environment. Risk of emissions from PFAS coated fasteners is lower than from using lubricants.

An appropriate method to overcome these problems is applying a PFAS based coating (Xylan) on high strength carbon steel fasteners. This provides a corrosion protection almost equal to stainless steel in aerated environment (seawater) and even superior in non-aerated environment like hot soil or aggressive chemicals. The wide range of operating temperature from cryogenic to + 290°C makes them applicable in a multitude of environments. Due to the low coefficient of friction, the application of lubricants is not required.

Further applications, where PFAS based fastener coatings provide a solution that is difficult to achieve with full metal fasteners, are in the assembly of dissimilar materials, where galvanic corrosion is a concern. Due to the insulating properties of the coating, a separation of the dissimilar components can be easily achieved. In comparison to zinc coated fasteners, where the zinc starts to corrode immediately when exposed to the environment, which makes it difficult to reuse them after a certain period, PFAS coated fasteners can be reused, as long as the coating is not mechanically damaged.

The ban of PFAS based fastener coatings would lead to a reduced lifetime of fasteners and in specific cases technical restrictions, which cannot be overcome with standard fasteners. In addition, costs would increase due to required replacement by high alloyed nickel containing materials, which require a lot of energy and resources to produce.

Membranes and PTFE diaphragms

In addition to static and dynamic seals, PFAS materials are widely used in positive displacement pumps as flexible pumping elements. The parts include vanes, tubes, stators, and diaphragms.

- Air operated diaphragm pumps and controlled volume metering pumps use a reciprocating diaphragm for pumping. The diaphragm materials used are PFAS elastomers.
- Progressing cavity pumps also use PFAS elastomers for their stators. Due to the eccentric rotation of the rotor, a flexible material with good friction behaviour is typically required for these pumps. These materials provide tightness guarantee and reduce energy consumption.
- In peristaltic (flexible tube) pumps, the tube material is often a PFAS elastomer.
- In flexible vane pumps, the vane material is often a PFAS elastomer.

In many cases the PFAS elastomers used are treated to increase their hardness (shore rating) for durability but require the flexible properties of an elastomer. Their low friction characteristics allow higher efficiency and resilience to wear. PFAS plastics and elastomers are required in these pumps for their broad chemical compatibility and temperature range. In particular fluoroplastics and fluoroelastomers are the types that combine both the broadest chemical resistance with the highest operating temperature range. No other plastic or elastomer type are a substitute at temperature above 200°C, and/or for aggressive chemicals.

In addition, low surface energy of these materials prevents fouling and the deposition of foreign materials on the surface. These pump types are used broadly across commercial, industrial and municipal pumping applications, and they would not be able to serve the application requirements without PFAS materials.

Illustration of PFAS used in the hydraulics of a complete pump

A metering pump is used as an example, however similar representation of PFAS would be found in other pump types. Figure 1 below represents an example of a metering pump assembly, highlighting the head assembly (liquid end).

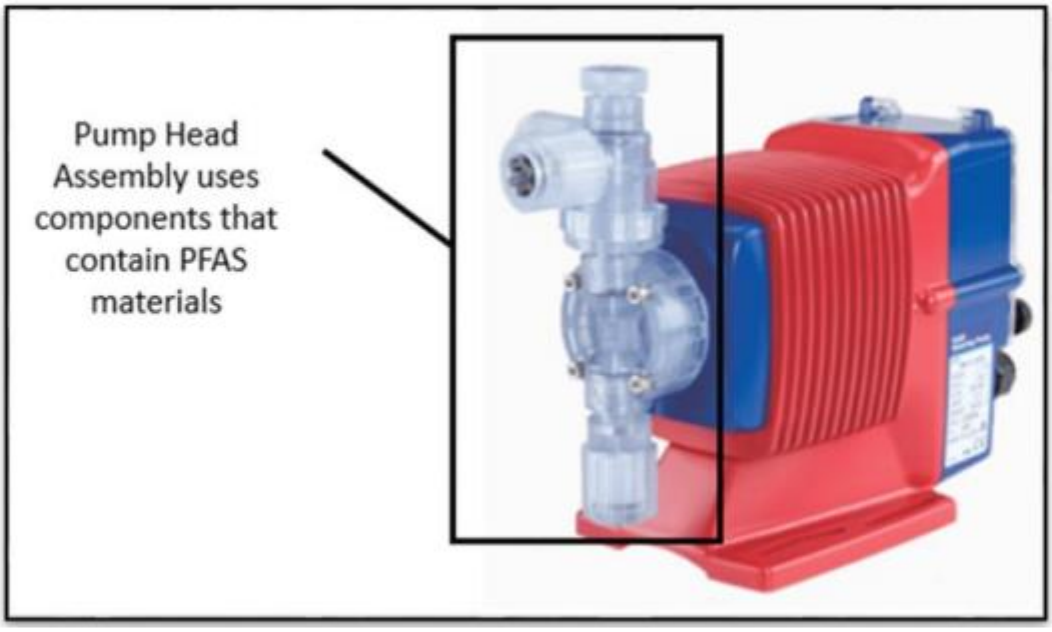
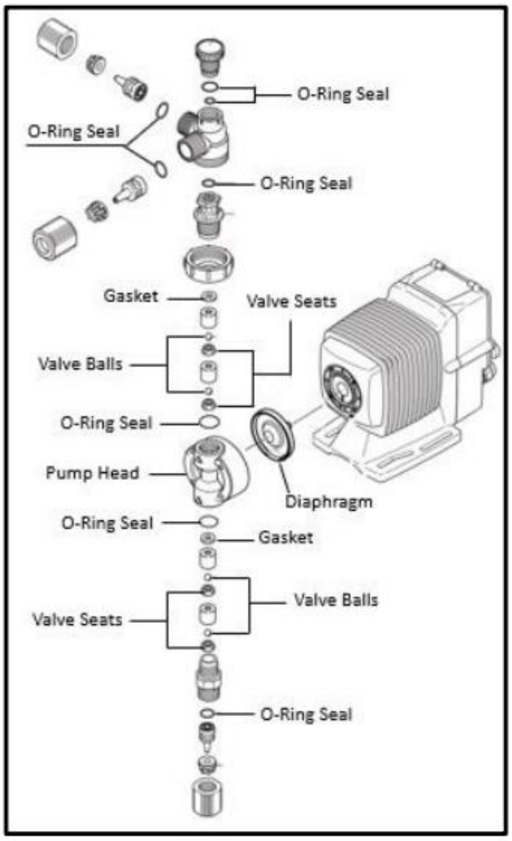


Figure 2 represents an exploded view of the above head assembly, in depth technical information can be found in a position paper produced by the European Sealing Association (ESA)1 – "European Sealing Association (ESA) position statement relative to the European proposal for PFAS regulation in relation with the Sealing Industry.", that highlights various PFAS materials used.



This metering pump example, along with several other models of similar construction, are used in a wide variety of applications – each with unique material requirements. These applications include chemical manufacturing, chemical toting + packaging, chemical blending, water treatment, plating, metal finishing, metal pickling, mining, bio-fuels, desalination, paper mill, ethanol – bulk metering, chlorination plants, refineries, fume scrubbers, semiconductors, bio-diesel generators, sodium hypochlorite generators, kidney dialysis, precision cleaning systems, circulation, chillers and battery manufacturing.

For some process fluids, there are "PFAS-free" metering pump versions available. However, there are many cases where non-PFAS materials (EPDM, GFRPP, PVC) are not chemically compatible with the process fluid and therefore have no substitutes (or "PFAS-free" versions) available. Some examples of such process fluid applications are discussed below.

The data from Table 1 below is taken from a compatibility chart, showing which non-PFAS materials are not compatible with certain chemicals and what applications use these chemicals.

Chemical (% Concentration)	Example of Application	Pump Head Materials				Gasket / Valve Ball Material	O-Ring / Seat Materials				Diaphragm Material
		PVC (2)	GFRPP	PVDF	316SS	PTFE	FKM	EPDM	AFLAS	PCTFE	EPDM
Chromic Acid (50)	Metal Finishing	N/R	N/R	A	N/R	A	A	N/R	A	A	N/R
Cyclohexylamine	Chemical Blending	N/R	N/R	NO DATA	A	A	N/R	N/R	NO DATA	NO DATA	N/R
Dibutyl Amine (Pure)	Chemical Blending	N/R	N/R	B	A	A	N/R	N/R	N/R	A	N/R
Nitric Acid (70)	Metal Pickling	N/R	N/R	A	B	A	B	N/R	B	A	N/R
Nitric Acid (98)	Chemical Blending	N/R	N/R	A	A	A	N/R	N/R	N/R	A	N/R
Sulfuric Acid (90)	Paper Mill	N/R	N/R	A	N/R	A	A	N/R	A	A	N/R
Sulfuric Acid (98)	Water Treatment	N/R	N/R	A	B	A	A	N/R	B	A	N/R

Table 1 shows that when metering pump components made from EPDM, PVC and GFRPP (non-PFAS) are not compatible with certain chemicals, the only options remaining are PVDF, PFTE, FKM, AFLAS or PCTFE (PFAS). In this table, "A" represents the best material suited for that chemical; "B" is the next best material, though swelling will occur sooner and require regular replacing of these materials when placed into these applications. "N/R" means "not recommended", or not compatible.

Some materials have "no data" accounted for in these applications. The purpose of this section is to help educate and give perspective on how components are used in metering pumps that contain both PFAS and non-PFAS materials. Through the study of a chemical compatibility chart, this section also elaborates on the reasons for selecting one over the other and emphasizes the importance of selecting the proper materials for certain applications. In summary, the absence of PFAS materials would make certain chemical process applications impossible in a variety of critical industries - especially the pump industry.

Annex V – Federation of Norwegian Industries

Norsk Industri

Hitachi Energy and GE Vernova

SF6 free solutions for insulating gases, fluoropolymers for bearings, gliding rings, lubricants and the essential arcing nozzle made from polytetrafluoroethylene in electrical high voltage equipment.

ABB

Medium voltage electrical equipment, primarily fluoropolymer materials as sealings etc.

GE Healthcare

Manufacture of pharmaceuticals and the use of fluoropolymer materials in (primary) packaging.

Elkem

Use of PTFE in membrane filters for filtration of silica fume in the Si/FeSi industry.

Borregaard

Use of fluoropolymer materials in membranes and equipment in the manufacture of chemicals.

Equinor

Use of fluoropolymer materials in different types of equipment in the petroleum sector: liners in flexible pipes, pump membranes, O-rings and seals in valves, subsea equipment, compressors, components of instrumentation, expansion bellows and others.

Annex VI – Fédération des Industries Électriques, Électroniques et de Communication (FIEEC)

FIEEC
FÉDÉRATION DES INDUSTRIES ÉLECTRIQUES, ÉLECTRONIQUES ET DE COMMUNICATION

Sectors and uses

The electrical and electronics sector relies on the use of articles and materials (solid, liquid and gaseous) containing substances falling within the definition of PFAS.

Our comments therefore relate to the following uses and sub-uses identified in Table 9 and 2 of Annex XV:
- Energy sector: Photovoltaic cells; Wind energy, nuclear power plant
- Construction products: Sealings and adhesives
- Lubricants: Low viscosity lubricants, Solid/dry-film lubrication, Release agents, Greases
- Applications of fluorinated gases: Refrigeration (E.2.8)Q, air conditioning and heat pumps
- Food contact materials and packaging:
- Medical advice
- Electronics and semiconductor
- Insulating gas in electrical equipment
- metal plating and manufacture of metal Products: Hard chrome plating
- Plastic packaging
- Polymeric PFASs used as processing aids for production of non-PFAS polymers/plastic Application Annexe E, 5.8, 131, 124, 2.11, 2.8

Proposed derogations

Photolithography in the semiconductor industry

PFAS-based technologies have played a crucial role in the semiconductor industry, enabling the development of smaller and more advanced products, particularly in photolithography. In this context, Photoacid Generators (PAGs) are vital components of Chemically Amplified Resists (CARs) used in advanced photolithography. These PAGs, which require sulfonium or iodonium salts with PFAS-type anions, generate strong acids upon exposure to ultraviolet (UV) light, leading to a solubility change in the photoresist. The presence of fluorine atoms in PFAS imparts strong electronegativity, resulting in the creation of super acids critical for this process. As a result, all successful PAGs demonstrated so far are fluorinated.

Additionally, top antireflective coatings (TARCs) in photolithography necessitate specific properties such as a very low refractive index, low surface energy, and exceptional barrier capabilities. Fluorinated acrylate/methacrylate/styrene-based copolymers are employed to achieve these properties. Furthermore, PFAS surfactants are utilized for various photolithographic materials due to their unique attributes, including very low surface tension and a combination of hydrophobic and oleophobic behavior. These properties make them valuable in forming immersion top coatings with the necessary low surface energy, outstanding barrier properties, and prevention of intermixing with the photoresist.

Dielectric Polymers, such as Polyimides (PI) and Polybenzoxazoles (PBO), provide crucial electrical, thermal, moisture, chemical, and mechanical protection for semiconductor devices. They are based on water-insoluble PFAS polymers, enabling water-based development processes.

The estimated PFAS consumption in Europe for the aforementioned photolithography activities is approximately 2248 kg per year, with projected emissions of around 1161 kg. As for PFAS discharge into wastewater, comprehensive industry-wide measurements have not yet been compiled. However, a peer-reviewed study featured in the "Environmental Science & Technology" journal in 2021 conducted an analysis on wastewater samples from three fabrication facilities in the United States. This analysis uncovered that the overall PFAS concentrations in downstream samples from these three facilities were recorded at 0.623 ± 0.024 µg/L, 0.394 ± 0.018 µg/L, and 0.376 ± 0.024 µg/L, respectively. To assess the significance of these values, they can be compared against the EU PFAS drinking water directive limit values for potable water, which is established at PFAS Total = 0.50 µg/L.

Missed uses

Food contact applications in the electric and electronic products

Fluropolymers are used in food contact applications because of their unique combination of properties: non-stick performance, mechanical resistance to abrasion, heat conductivity and resistance offering a high durability.

There is no substitute available with the same level of characteristics that need to be considered as a whole and not separately. Ceramic coating is presented in the restriction dossier as a potential alternative to fluropolymers but it has a lower non-stick performance and durability, requires more frequent replacement with an higher impact on environment. There is no evidence that acceptable substitute with the same level of performances and technical characteristics can be found even with R&D investment and sufficient associated time.

A universal ban of PFAS including fluropolymers for food contact application in electric and electronic products even with a 12-year transition, will heavily and negatively impact European manufacturers while fluoropolymers are not deemed to not have negative impact on human health and environment according to several scientific studies. A restriction of fluropolymers for food contact applications will not be proportionate.

Consequently, FIEEC requests the exemption of floropolymers for all food contact applications (professional and non-professional) in the electric and electronic products.

Fluoropolymer-insulated cables and wires

Key functionality: Fluoropolymer-insulated cables and wires are used when high temperatures and a long service life are required (over 20 years at 155°C à 260°C). They are also used when resistance to hydrolysis, thermo-oxidation, and stress cracking, flex-life et arc cracking is needed.

Fluoropolymers are also used in the following areas: aerospace & defense domain cables specificity

- Safety-critical applications bound by airworthiness standards
- High-performance level and strict technical requirements
- Harsh and extreme operational environments

The Fluoropolymers family is the one that demonstrates the highest range of operating temperature, along with excellent dielectric properties, low friction properties, and the highest existing chemical stability.

The alternative solutions proposed in the restriction dossier must be evaluated, considering that some properties, such as flexibility, do not align with our mission profiles. Silicone- insulated cables that could be used as a replacement solution encounter issues with electrical contacts due to oligomer migration and potential contamination of the electrical contact.

Until now, no alternatives to PFAS have been identified for cable and wire applications. The potential alternatives listed in point b (Electronics industry) of Table E.124, which includes available non-PFAS substances and techniques in the Electronics and Semiconductor industry in Annex E of the proposed restriction report (such as silicone materials, polyetheretherketone (PEEK), mica, EPDM, polyvinyl chloride, polyethylene, ceramic-based materials, and one confidential polymer as alternatives for wire insulation), are not considered qualified alternatives. Therefore, the ECHA should not base its decision on not granting a derogation for cables and wires insulation on insufficient evidence.

Microwaves

Key functionalities: PFAS, and fluoropolymers, show a unique combination of properties:

- stable dielectric constant over temperature and frequency (Low dielectric loss);
- Low moisture absorption.
- Excellent dimensional stability whatever the operating temperature. that make them the only choice for many electronic applications: cables and wire, but not only. Fluoropolymers are widely used in connectors, electronics components, and raw materials especially for microwave applications. Feasibility of alternatives: No alternative solution has yet been identified, with a similar set of properties, guaranteeing the same level of performance and reliability. Alternative solutions, if they existed, will require rigorous and in-depth qualification tests and will certainly require complete redesign of the equipment, which is not consistent with long life cycle of such electronic equipment and current European policies.

Surface treatments for metals due to their tribological properties: a request for 12 years

Key functionalities: PFAS (primarily fluorinated polymers) are used **as surface treatments for metals** due to their tribological properties. They help reduce friction between metal parts in numerous mechanisms that are crucial for electrical applications. In safety products like circuit breakers, for instance, the ability to open the circuit in the event of an electrical failure is essential for the safety of individuals and equipment. The speed of opening is the key factor, and PFAS surface treatment is a critical (key ou essential) element in the complex mechanical chain that ensures this speed and robustness.

The technical feasibility of alternatives: The electrical industry has years of experience with this solution and can guarantee that this type of mechanism will function properly and ensure safety even after 20 years without action. We have very little experience and feedback on possible alternative solutions to ensure the same level of long-term performance. The alternative solutions proposed in the restriction dossier do not target the same properties. Hardening treatment has been tested in a few minor cases, but the friction behavior is lower and requires external lubrication. It cannot be generalized. The amount of fluorinated polymer involved in this use case is relatively small (to be documented) but critical. Furthermore, in many cases, these metal parts can be recovered at the end of the product's life for specific treatment, thus avoiding any dissemination into the environment.

Our industry needs a derogation of **at least 12 years** to assess other solutions and gather sufficient feedback to ensure the same level of safety. In the event of safety issues and if no other validated solution is available, a permanent derogation should be granted.

Fluorinated mold release agents

Key functionality: Fluorinated mold release agents have an extremely low surface energy compared with silicon and wax. What's more, silicone release agents are banned in the automotive industry because they release oligomers. The French federation industries is currently assessing this draft restriction with its members. This contribution will be supplemented later with additional data.

Low friction: a request for 12 years

Apart from the applications already mentioned, fluorinated polymers are widely used when low friction is required. PEEK could potentially be considered as an alternative solution; however, its high rigidity (bending) makes it less suitable for tight structures like airplanes, for example. Similarly, PPS might appear as an alternative, but it is also more rigid and shows resistance issues with certain fluids required by the standards. **PTFE** parts are also used for their excellent thermal properties. Many applications in electrical devices, in proximity to an electrical arc, utilize PTFE parts due to their unique thermal resistance and ease of implementation. The low surface tension of PTFE is also essential for the dielectric behavior of products like circuit breakers, ensuring the safety of individuals and equipment.

In addition to its use in electrical products, PTFE is extensively employed in manufacturing machinery and automated production lines, enabling high production throughput. Having to replace PTFE parts in an industrial process could have an impact on production.

The restriction proposal on PFAS, including fluoropolymers, without considering any derogation for wires and cables, will have a major impact on various sectors that heavily rely on their usage for proper and safe applications, such as airplanes, cars, medical devices, and others.

As an aircraft component, the cable must meet the requirement for arc tracking (AT) resistance. This phenomenon involves the appearance of electric arcs, limiting the current in the circuit to an integrated value below the tripping threshold of the upstream circuit breaker. This electric arc causes cable deterioration due to thermal effects, ultimately leading to the risk of aircraft failure. The AT phenomenon cannot occur if the insulation is resistant to arc tracking. Compared to engineering polymers, fluorinated PM (especially PTFE) can provide the best AT resistance.

Besides than having Fluoropolymers listed in almost all of the design specifications for the above-mentioned applications, the qualification process for alternatives if identified will take time given the long-term tests necessary for approval on material which is part of critical applications.

A derogation of **12 years is required for the automotive** markets after the entry into force of the restriction proposal, given the short-term irreplaceability of PFAS and the current unavailability of replacements that guarantee the proper functioning of related applications.
A derogation of **6.5 years is needed for the construction market** after the entry into force of the restriction proposal, considering the ongoing PFAS replacement program. There **should be no time-limited derogations for the aerospace and medical markets**, as we consider the highest operational safety standards, and no substitute solution is available.

Batteries (PTFE/PVDF): A request for 12 years

Due to their unique properties, both Polytetrafluroethylene (PTFE) and Polyvinylidine difluoride (PVDF – both homopolymer and copolymer) are used as binder materials in the active material masses in electrodes in a wide range of battery technologies.

Key functionality: **PTFE** is used as the binder material for the positive electrode in Lithium primary batteries to provide three main functions:

1. Mechanical cohesion between the positive electrode particles to enable electrode integrity during cell assembly and throughout the lifecycle of the battery storage and use,
2. Lubricant to allow the electrode particles to slide over each other during electrode formation (compression) giving uniform electrode density that is important to consistent battery performance and longevity,
3. Lower water absorption during mixing (PTFE is a hydrophobic material) and more complete drying during electrode baking - low moisture content is critical in Lithium chemistry.

Key functionality: Although the PVDF binder comprises only a small portion of the composite electrode (typically 2–5% of the mass of the electrode), the binder plays four important roles in battery performance. The PVDF binder:

- Helps to disperse the active material and the conductive additive in the solvent during the fabrication process, enabling a homogeneous distribution of the slurry,
- Holds the active material and the conductive additive together and connects them to the current collector, ensuring the mechanical integrity of the solid electrode without significantly impacting electronic or ionic conductivity (see Figure 2),
- Acts as an interface between the composite electrode and the electrolyte. In this role, the PVDF binder protects the composite electrode from corrosion and the electrolyte from depletion while facilitating ion transport across this interface,
- Tailors the viscosity of the slurry to allow a smooth coating onto the current collector during electrode manufacturing.

The technical feasibility alternative: In view of the costs of PVDF and the health and safety concerns around the use of NMP solvent, many organizations have carried out research to try to find alternatives to PVDF as a binder material and NMP as the solvent. A peer reviewed academic article10 indicates that PVDF as a latex can be used as the binder for the positive electrode with water as the solvent instead of NMP. Next generation Lithium-ion battery developments are focused on producing positive electrodes using a dry process which avoids the need for NMP solvent. This dry process will significantly reduce energy consumption and lower the environmental footprint. However, the dry process still requires the use of PTFE or PVDF as the binder material for the positive electrode.

PFAS is also used in the electrolytes for Lithium-ion rechargeable, Lithium primary, Lithium metal rechargeable, and Sodium-ion rechargeable batteries.

To conclude, there is considerable uncertainty about the future of industry demand in Europe and therefore the timelines for these investments by the chemicals industry are not known. As a result, the battery industry requires derogation periods of **at least 12 years for each of the below applications**. If after the end of 12 years there are still no alternatives for specific applications, then the battery industry will need to apply to renew the derogation period for these specific applications.

Flame retardancy of plastics used in electrical : a request for 12 years

<u>Key functionality</u>**: Flame retardancy of plastics used in electrical products** is essential and critical because these materials must prevent the spread of fire in case of ignition due to electrical faults. 1/4 of fires originate from electrical faults. It is easy to understand that fire propagation immediately after ignition is crucial for safety. In recent years, the number of fireproofing solutions for plastics has decreased under regulatory pressure. A fireproofing system for plastic is specifically designed for the targeted standard test. In our field, the UL94-V standard is mandatory and very challenging to achieve. For certain plastics such as polycarbonate, the standard test can only be passed with a complex fireproofing system, one component of which is a PFAS (per- and polyfluoroalkyl substances). The amount of PFAS in the formulation is very low (a fraction of a percentage), but it is essential for test success.

Due to safety reasons, we cannot compromise the severity level of fluid resistance tests, and the plastics industry needs time to develop new fluid resistance systems, which is a lengthy process.

The extremely low level of fluorinated polymer in the formulation, combined with the difficulty of developing alternative solutions, means that we require a derogation of **<u>at least 12 years</u>** for this application.

The friction behavior of plastic parts in mechanical mechanisms : request for 5 years

<u>Key functionality</u>: Just like with metals, **the friction behavior of plastic parts in mechanical mechanisms is critical** for the safety of individuals and equipment.

<u>Feasibility of alternatives</u>: As explained in the case of PFAS surface treatment for metals, our experience with current solutions allows us to guarantee the safety of our products for at least 20 to 30 years. Finding an alternative solution takes time if we want to ensure the same level of reliability. Some plastics have intrinsic tribological properties, while others require additives to improve their friction behavior. Replacing additive plastics with polymers with good intrinsic friction is not feasible in all applications. The alternative solutions proposed in the restriction dossier (siloxanes) are not relevant for our applications. MoS2 can be used as an alternative to PFAS in certain plastics for better tribological performance, but this needs to be validated, and it takes time.

A derogation of **<u>at least 5 years</u>** is necessary to cover investigations with raw material suppliers, product-level evaluation, and long-term validation.

Fluorinated rubbers : request for 5 yeas /40 years

<u>Key functionality</u>: Fluorinated rubbers are used for difficult applications where high resistance to heat, and oxidation is required. For example, **FKMs** are used for seals in a high-temperature environment (close to metals at 115°C), in a high oxidative environment, with low permeation required and for a service life of 40 years in medium-voltage equipment. This equipment is recovered at the end of its life, and FKM parts can be recovered at the end of their life for specific treatment, thus avoiding any release into the environment.

<u>Feasibility alternatives</u>: Chloroprene rubber could potentially be tested, but compatibility with our mission profile needs to be ensured. Pending the evaluation of alternative solutions and long-term tests, we need a derogation of **<u>at least 5</u> years, if the tests are positive. If not, a longer derogation will be required**. Otherwise, a longer derogation will be needed, as these products will be developed for at least 40 years.

Capacitors and magnetics and coatings

Various type of PFAS are/can be used in capacitors as dielectric films. They are used for their high dielectric strength and heat resistance, as well as the as the ability to be produced into thin films. Due to their properties PFAS are currently excellent products for high-temperature application, and no direct alternate solution has been identified today.

Magnetic components such as inductors and transformers - Fluoropolymers are/can be used as additives in certain polymer resins to help with flow control for manufacturing and high-temperature thermo-mechanical performances.

The presence of PFAS on coatings for high-temperature electronics is also necessary, as they increase the thermal stability of the polymer structure and the reliability of the product.

Potential derogations marked for reconsideration

Semiconductors

The DIE ATTACH adhesive containing PTFE is seamlessly integrated within the semiconductor component and remains confined throughout its operational lifespan. PTFE plays a pivotal role in ensuring the processability and operational efficiency of semiconductor components when subjected to rigorous operational conditions. Both PTFE and PFPE lubricants are indispensable in facilitating the semiconductor manufacturing process by upholding stable temperatures and optimizing equipment performance. Manufacturing facilities rely on PFAScontaining polymers, such as PTFE and PVDF, across various applications including ultrapure water systems, chemical storage, transportation, liquid waste management, air emission treatment, and wafer cassettes. However, the use of R290 may not be universally applicable. As an alternative below the PRP 150, HFO remains the sole viable solution. Consequently, a 12-year derogation is imperative for fluorinated gases, exclusively pertaining to the maintenance and refilling of pre-existing heating, ventilation, and air conditioning systems. Newly installed heating, ventilation, and air conditioning systems remain unaffected by this derogation. Fluorinated gases find utility in plasma etching as deposition precursors and for post-processing cleaning of semiconductor manufacturing chambers. The utilization of specific fluorinated gases also falls under Gas F (with an accompanying derogation granted for their application in semiconductor manufacturing).

Manufacturers of electronic devices, in collaboration with their materials and equipment suppliers, typically must go through several stages of research, technological integration, prototyping, and manufacturing scaling up to achieve an effective process change. A technological development cycle usually takes around 10 years, from fundamental research to production scaling up.

Many materials are unique and have specific technical requirements, making it extremely challenging to find a viable alternative. For many of the uses of fluorocarbon-containing materials in the semiconductor manufacturing industry, there are no known alternatives. Additionally, alternative substances need to be invented before they can be qualified. The indicative timelines for developing, qualifying, and implementing alternatives fall into the following categories.

If there is a viable non-PFAS alternative that is accessible, and no changes to the existing infrastructure are required, with the demonstration of satisfactory performance for a specific application, the typical timeframe for conducting necessary manufacturing trials, obtaining recertification, and effectively integrating the alternative into high-volume manufacturing is generally 3 to 4 years.

In cases where a non-PFAS alternative is available but modifications to manufacturing tools, products, processes, or facilities are necessary before the alternative can be successfully introduced, the implementation process could extend to 3 to 10 years or possibly longer.

Photolithography: request for 25 years

The semiconductor industry has dedicated 25 years to researching alternatives free of PFAS. While there might be isolated cases where substitution is feasible, in most photolithography applications, the exploration of PFAS-free materials has yielded limited success or ineffectiveness. The task of finding viable PFAS-free alternatives for many applications would necessitate a process of reinvention. This journey of identification and implementation is a protracted one, encompassing academic research, material supplier exploration, development (validation), scaling up, and subsequent endeavors by semiconductor manufacturers for demonstration (verification), integration, implementation, and highvolume manufacturing scaling.

Although the challenges and development timelines for each PFAS application are distinct, the development of PFAS-free alternatives for most photolithography purposes is projected to take **between 15 to over 20 years**. For photoacid generators (PAGs), it is anticipated that this process will extend beyond 25 years.

Wet Chemistries : request for 3 to years

PFAS-free alternatives for wet chemistries vary a lot from application to application and are influenced by the technology and application in which they are used. Often, an alternative that is suitable for one application is not suitable for another. Therefore, the timeline for implementing alternatives for wet chemistries ranges broadly **from 3 to 15 years after a suitable alternative has been identified.**

Semiconductor Assembly, Test, and Packaging

The timeframe for implementing PFAS-free alternatives varies depending on the specific application and may span from 5 to 20 years or more. Simpler uses, like packaging fluxes, would likely require over 5 years for the qualification and successful integration of an alternative. For most adhesive applications related to packaging, the semiconductor industry has been in search of alternatives for 18 years without success, and it is anticipated that the identification and implementation process will exceed 20 years.

The modifications to assembly package materials, due to their interaction with the silicon die, the end customer product, and the environment, necessitate notifying customers of product changes and undergoing requalification and approval processes. This must be done while ensuring that the required specifications for thermal and chemical resistance are maintained. This additional step adds to the previously mentioned timelines. Initiating customer qualification activities at least 1-2 years prior to implementation of the change is mandatory; certain applications may even require more than 6 years. In some cases, the lack of viable alternatives is evident, resulting in compromised safety and functionality of the end customer product.

Pump Fluids and Lubricants request for 10 to 25 years

Despite the presence of PFAS-free lubricants, their failure to meet essential performance criteria such as resilience under challenging conditions, minimal off-gassing, and limited particle generation poses a challenge. These attributes are of paramount importance due to the stringent cleanliness requirements throughout the manufacturing process. Furthermore, these alternatives devoid of PFAS exhibit heightened failure rates and adverse effects on human health and safety. **Substituting PFAS lubricants in common applications is projected to necessitate over 10 years, while the replacement of lubricants used in photolithography, requiring ultraviolet stability, is estimated to span more than 25 years.**

For many applications, potential non-PFAS alternatives would demand a complete overhaul. If physically and chemically feasible, implementing a suitable alternative is anticipated to take more than 15 years, contingent on the material and its application. Given the intricate nature of the semiconductor supply chain, the adoption of PFAS-free alternatives demands coordinated efforts across the entire supply chain, which could potentially strain smaller partners within this chain.

Other identified uses

Polymères diélectriques [polyimides (PI) / polybenzoxazoles (PBO)] request for 5years derogations in the case of positive tests

Except already mentioned applications, fluorinated polymers are widely used when low friction is required. Alternative solutions exist such as POM but show also other problems. PTFE parts are also used for their extremely good thermal properties. Lots of applications in electrical devices, close to electrical arc are using PTFE parts because of unique thermal resistance and processability. The low surface tension property of PTFE is also key for the dielectric behaviour of products such as circuit breakers, ensuring people and equipements safety.

Apart from the use in electrical products, the usage of PTFE is massive in manufacturing machines and automatic lines allowing high production flow rates. Having to replace PTFE parts on industrial process could have an impact on production.

A minimum of 5 years derogation is required for clasical appliacations and a minimum 12 years derogation (if not permanent) for dielectric and high temperature purposes when safety is required.

Fluorinated rubbers are used for tighness applications where high thermal and oxidative resistance is required. For example, FKM are used for seals in a high temperature environment (close to metals at 115°C), under high oxidative ambiance, with low permeation required and for a 40 years lifetime in Medium Voltage equipments. Those equipments are retreived at end of life and thefkm parts can be recovered at the end of product life for specific treatment, avoiding any dissemination in the environment. Potentially chloroprene rubber could be tested but compatibility with our mission profile needs to be secured.

Waiting for the evaluation of alternative solutions and long term tests, we need a minimum of 5 years derogation, in the case of positive tests. Otherwise a longer derogation will be necessary, those products being developed for at least 40 years.

Fluorocarbons Uses in Plasma Etch / Wafer Clean and Deposition

In the plasma, etch/wafer clean application, no viable alternatives for fluorocarbon chemistries are known, because of the basic chemistry and physics of etching silicon and its compounds, which are essential for fabricating semiconductors. For certain applications, PFAS-free alternatives have been identified, such as the use of nitrogen trifluoride in chamber cleans. However, these alternatives may produce emission by-products which contain PFAS, where carbon-containing films are present. However, these alternatives may not be suitable for all applications. In addition, some alternatives may give rise to further occupational health and safety concerns. Considering concerns regarding their global warming potential, the semiconductor industry has decreased the use of chamber clean gases that contain PFAS over the last 30 years. Even though fluorine-free alternatives meet the manufacturing needs, the industry has implemented best practices initiatives, reducing its air emissions of PFCs and hydrofluorocarbon compounds (HFCs) significantly.

To switch to fluorine-free alternatives, it would be necessary to fundamentally reinvent semiconductor devices, as it would require replacing silicon as the basis for semiconductor manufacturing.

Fluorinated Heat Transfer Fluids

To implement fluorine-free heat transfer fluids, it would be necessary to completely redesign semiconductor manufacturing-related equipment in the small number of applications in which these can be used. For the remaining applications, suitable alternatives offering the required technical performance have not been invented yet. For the small number of applications for which alternatives are available, implementation would **take 8 to 14 years**. Substituting refrigerants in process equipment chillers would take a similar amount of time.

For applications where no alternatives are currently known, these would have to be invented. Subsequently, it would take another **5 to 15 years** or more to implement these alternatives.

However, this timeline could be significantly longer depending on the number of cooling systems affected per manufacturing facility. Regarding PFAS-free thermal test methods, it would take **8 to 14 or more years**, after an alternative has been invested, to implement it.

Tribological properties : request for 12 years

PFAS (mainly fluorinated polymers) are used as metal surface treatment for tribological properties. It allows to lower frictions between metallic parts in lots of mechanisms which are critical for electrical applications. In circuit breakers eg, which are safety products, the capability to open the circuit on electrical defaults is critical for people and equipments safety. The opening speed is the main factor and PFAS surface treatment is a key element of the complex mechanical chain which ensures this speed and the robustness. The electrical industry have years of experience with this solution and can guaranty that this type of mechanism will work properly and ensure safety, even after 20 years without any action. We have very few experiences and feedback on possible alternative solutions to guaranty the same level of performance in time. The alternative solutions proposed by the restriction dossier are not targetting the same properties. Hardening treatment was tested in some minor cases but the friction behaviour is lower and need an external lubrification. It cannot be generalized. The amount of fluorinated polymer involved in that use case is quite small (to be documented) but critical. Moreover, in lots of cases, those metallic parts can be recovered at the end of product life for specific treatment, avoiding any dissemination in the environment.

FIEEC industry needs at least a minimum **of 12 years derogation** to evaluate other alternative solutions and have enough feedback to guaranty the same safety level. In case of safety issues and no alternative validated, a permanent derogation should be granted.

Plastics, tapes & liquid/ Cables inuslation and connectors PTFE/PVDF/ PFA/MFA

Fluorinated polymer insulated cables and wires are used when high temperatures and high lifetime is required (more than 20 years at 135°C). It is also used when hydrolysis, thermooxydation, stress cracking resistance is required. Alternative solutions proposed in the restriction dossier need to be evaluated, knowing that some properties such as flexibility are not in line with our mission profiles. Silicone insulated cables that could be used as alternative show issues with electrical contacts due to oligomers migration with a potential pollution of electrical contacts. Fluorinated polymers are also used in high frequency cables and connectors due to their unique stable dielectric properties in those conditions. No simple alternative solutions are available for this application today.

In general, fluorinated tapes are used for their essential and intricate characteristics, such as arc-cracking resistance, temperature resistance, fire resistance, mechanical strength including low abrasion, and compactness. This is why they are primarily found in the aerospace, aviation, and certain military applications.

A permanent derogation is necessary for fluorinated tapes, or one that extends beyond 40 years.

Fluoropolymers are considered crucial Strategic Raw Materials for aerospace cables, as they offer the best "technical performance/product weight" ratio compared to other engineering polymers. Currently, no precise alternative solutions have been identified on the market.

The implications of banning fluoropolymers for the Aerospace & Defence industry would include:

- Halting production and delivery of A&D products
- Inability to service and repair existing products
- Compromising the safety function of A&D vehicles
- Loss of reliability in operations
- Premature retirement of A&D equipment from service
- Potential risk of strategic dependency in Europe
- Job losse Considering these consequences, a time-unlimited derogation is necessary for the entire aerospace and defence domain.

Plastic additive: request for 12 years

Flame retardancy of plastics used in electrical products is key and critical as those materials must prevent fire propagation in case of ignition due to electrical defaults. 1/4 of fire have electrical defects root cause.One can easily understand that fire propagation just after ignition is key for safety. Those last years, the number of flame-retardant solutions for plastics decreased under regulatory pressure. A flame-retardant system for plastic is specifically designed for the standard test to target. In our domain, UL94-V is compulsory and is very difficult to achieve. For some plastics such as Polycarbonate, the standard test can only be achieved with a complex FR system in which one of the components (dripping agent) is a PFAS. The amount of PFAS in the formulation is very low (a fraction of percent) but key for a pass. For safety reasons, we cannot degrade the FR standard tests severity level and the plastic industry needs time to develop new FR systems which is a very long process. The very low level of fluorinated polymer in the formulation, combined to the difficulty to develop alternative solutions means that we need **<u>at least a 12 years</u> derogation for that application.**

As explained for PFAS metal surface treatment case, our experience with current solutions enable us to guaranty the safety of our products for at least 20-30 years. Finding an alternative solution takes time if we want to guaranty the same reliability level. Some plastics show intrinseque tribological properties when others need additives to improcve their friction behaviour. Replacing additived plastics by intrinseque good friction polymers is not feasible in all applications. Alternative solutions proposed in the restriction dossier (siloxanes) are not relevant for our applications. **MoS2** can be used as alternative of PFAS in some plastics for better tribological behaviour, but this must be validated and it takes time. **A minimum <u>5 years</u> derogation** is required to cover raw materail supplier investigations, evaluation at product level and long term validation.

Demolding agent or mould treatment(silicone) : request for 5 years

To validate alternative solutions Fluorinated mold release agents show extremely low surface energy compared with silicon and wax. Moreover, silicon mold release is prohibited in automotive industry due to oligomer release. FIEEC industry needs a derogation of **minimum <u>5 years</u>** to validate alternative solutions.

Annex VII – Fédération des Industries Mécaniques (FIM)

FIM

Sectors and uses

Please find below the sectors and (sub-)uses to which our comment applies according to the sectors and (sub-)uses identified in the Annex XV restriction report (Table 9 & 2).

- Food contact materials and packaging: Consumer cookware, Industrial food and feed production.
- Metal plating and manufacture of metal products: Hard chrome plating, Decorative plating with chrome, plating on plastics and plating with metals other than chrome (use as a surfactant for worker protection and emission reduction).
- Applications of fluorinated gases: Refrigeration and non-road mobile machinery.
- Medical devices.
- Transport (aeronautical, automotive, railway, space…): Body-, hull- and fuselage construction (blades, engine, nacelle, landing gear, braking, clutch, attachment) , Sealing and gaskets applications, Combustion engine systems, Coating and finishings.
- Energy sector: Photovoltaic cells, Wind energy, Nuclear power plant, Green Hydrogen use deployment: Membranes, equipment (pumps, valves, gaskets and sealing systems, bearings, etc.).
- Construction products: Sealings, taps and sanitary fittings, pumps, valves, etc.
- Lubricants: Low viscosity lubricants, Solid/dry-film lubrication, Release agents, Greases.
- Petroleum and mining: Lining of piping, machinery used by this sector.

Emissions in the End-of-life

FIM emphasises that supply chains of complex products include various operators and that the entire manufacturing process for products and components involves multiple stages. The use of PFAS, including their integration into components, takes place in a limited number of these stages. Adequate management of the risks posed by PFAS to human health and the environment could be achieved effectively through a combination of measures rather than a general ban of the use of PFAS. Such combination of measures would minimise the associated socio-economic impacts. The use of non-fluorinated polymerisation aid (NFPA) technologies to produce fluoropolymers without the use of fluorinated polymerisation aids have the potential to greatly reduce the use of non-polymeric PFAS in the production process, effectively addressing any concerns about the release of PFAS into the environment during the manufacturing stage. NFPA technology already exists, but to the best of our knowledge is not generally available on the market and would not enable all industrial sectors to switch to this technology within the timeframe set out in the restriction report. Releases from production sites could be minimized by regulating industrial emissions, for example under the Industrial Emissions Directive (IED), 2010/75/EU. Additional measures on waste treatment of waste containing PFAS could also address the possibility of PFAS emissions.

Missing uses

As a downstream sector, it is impossible for our companies to collect data on tonnage and emissions (at sub-sector level) of PFAS associated with the relevant use, the hazards and risks of alternatives. In addition, and due to the extreme complexity of identifying the presence of PFAS in products and processes for downstream users, it is not yet possible to provide data on the socio-economic impacts for each specific use. Thus, this contribution will be completed in the coming months with additional data.

Mechanical equipment and components

Mechanical engineering equipment (eg. Industrial machinery, non-road mobile machinery, pumps, valves, compressors, pressure gas equipment, etc.) and components (mechanical component used in other sectors as automotive, energy, aerospace, etc.) are not considered, or in very limited way, in this annex XV report and rely on the use of PFAS for several applications:

Sealing:

- PFAS used: Fluoroelastomers : FKM - FMVQ - FFKM ; Fluoroplastics : PTFE - PFA - PVDF - ECTFE – PCTFE
- Key functionalities: chemical inertness, friction properties and resistance to a wide range of temperatures
- Alternatives:
- PEEK, HDPE and PA have been identified for specific uses but are not suitable for every application, due to inferior performance. PEEK is significantly more expensive and is not a viable alternative for many applications.
- Substitution of PTFE and fluoroelastomers in static seals: Metal seals can be used in rare cases and are not suitable for many uses, notably for pressure equipment and performance duration when intensive use, because of inferior tightness performances that can conduct to leakages with risks of environmental pollutions.
- Substitution of fluoroelastomers: No substitution solution for applications requiring resistance to extreme temperatures has been identified.
- More generally, applications requiring a combination of several PFAS properties do not appear to be substitutable.
- Substitution of PTFE for friction bearings : PEEK and PA are not satisfactory (see above)

Friction applications:

- PFAS used: PTFE, PVDF, PCTFE, ETFE, FEP, THE-EFP, PVDF-HFP
- Key functionalities: Tribological properties (coefficient of friction, pressure-velocity limit, abrasion resistance and abrasion volume), extreme temperature and acids resistance, surfactants, improved resistance, antistatic agent, non-stick, resistance to aggressive chemical fluids and extreme temperatures fire resistance, anti-corrosion, insulation, non-wettability. In addition to their physico-chemical-tribological properties, PFAS are also used to guarantee compliance with regulations such as CE1935/2004 for use in food contact.
- Alternatives: No alternative solution has yet been identified. Most of the documents studied address the use of PFASs without focusing on the alternative materials that would meet the specifications of each sector. In particular, substituting nickel PTFE seems impossible at this time. More generally, applications requiring a combination of several PFAS properties do not appear to be substitutable. In addition, solutions based on brass (with lead content) can not be deployed or in a limited way because already regulated under the REACH and RoHS regulations.

Manufacture of metal products:

This sub-use is likely to cover various product categories in our sector, as products for installation in water networks, particularly drinking water networks, mechanical components and parts, fastening elements, etc.

General comment:

As a matter of fact, for the time being there is no feasible alternative to the use of PFAS for such applications. Moreover, PFAS have been privileged by national and international standards for their durability and reliability in terms of mechanical design aiming, therefore, at providing safe end products. Any future sound design alternative shall be validated through performance testing in the first place, and then by standardisation acknowledgement. Considering the normal standardisation timing, this process is bound to take at least 10 years.

Potential derogations

As a downstream sector, it is impossible for our companies to collect data on tonnage and emissions (at sub-sector level) of PFAS associated with the relevant use, the hazards, and risks of alternatives. In addition, and due to the extreme complexity of identifying the presence of PFAS in products and processes for downstream users, it is not yet possible to provide data on the socio-economic impacts for each specific use. Thus, this contribution will be completed in the coming months with additional data.

Hard chrome plating until 6.5 years after EiF

PFASs are primarily used in the manufacture of stainless steels and aluminium as a surface active additive for anti-fogging and anti-spattering purposes in surface treatment baths. They are mainly used for hard and decorative chromium plating with hexavalent chromium.

The ban on PFOS has led to a switch to other substances in the PFAS family, which do not appear to be substitutable today. Some applications appear to be substitutable but require to change completely the processes and technologies used. At this stage, we have no data on the operational feasibility of these changes or on their economic impact.

Refrigerants in mobile air conditioning-systems in combustion engine vehicles with mechanical compressors until 6.5 years after EiF

Refrigerants in mobile air conditioning-systems are also used in non-road machinery, including electric and hydrogen-powered vehicles. These products are not equipped with a combustion system and the refrigerant system is therefore driven by an electric motor. The compressor of these equipment contains notably refrigerant gas R134a or R1234yf.

The proposed restriction does not include electric and hydrogen-powered vehicles and must be extended to these products.

Other identified uses

Metal plating and manufacture of metal products

Fluorosurfactants are used in metal treatment processes to increase the flow rate and prevent cracking and crazing in the coating during the drying phase. Certain substances can also be used as corrosion inhibitors.

CTFE is used in particular for its anti-corrosive properties in valves and pumps.

Research is currently underway into substituting PFASs which are used for their surface-active properties.

Substituting nickel PTFE seems impossible at this time.

PTFE, FEP and PFA (particularly for slid/dry film applications) do not appear to be substitutable today. The alternatives are less durable, have coefficients of friction that are too high, and do not fulfil certain related characteristics (atmospheric and/or galvanic corrosion protection, electrical insulation, for example). Today, these coatings are widely used in the aerospace (flight parts, generally critical parts) and military (application on missiles and/or launchers in particular, including as part of our deterrence programme) sectors, requiring long qualification phases and tests. The alternatives presented in appendix A.3.15.1.4. Solid/Dry films, which accompanies the draft restriction, correspond to uses different from those currently used in industry. Several alternatives are in the research phase but none has demonstrated its equivalence.

Lubricants

PFAS used : Fluoropolymers (notably PFPE) , HFE, perfluoroalkyl ethers/alkanes, n:2 FTO, PTFE as additive, perfluoroether

Key functionalities of PFPE : resistance to extreme temperatures and harsh chemical conditions, very good oxidation stability, compatibility with oxidizing gases applications.

Alternatives: Substitution in perfluoropolyether-based lubricants: Research is underway into new types of lubricant, such as those based on vegetable oils or ionic liquids. Other lubricants on the market are based on mineral oils, silicones, polyol esters or polyalkylene glycol. However, the performance of these different solutions is inferior to that of PFPE. None of the existing alternatives is efficient as PFPE lubricants. Ionic solutions are still at an early stage of research at the moment.

Applications of fluorinated gases

Fluorinated gases are notably used in professional food refrigeration applications and non-road mobile machinery. The F-gas regulation provides for the phasing out of certain fluorinated gases with a high global warming potential (GWP) and the replacement by alternatives with a lower GWP. The definition of PFAS applies in particular to HFOs and HFCs, which are the alternatives to certain F-gases that are banned or about to be banned under the F-gas regulation. The only known alternatives are CO_2 and propane, whose use in installations is either technically impossible, or gives rise to significant risks for installations and users (higher pressure or flammability).

Examples of HFOs and HFCs meeting the definition of PFAS: R134a, R1234yf, R448A, R449A, R452A, R454C and R455A

In particular, R455A and R454C have a GWP of less than 150. The FGAS revision will allow the use of HFCs with GWP<2500 for appliances whose refrigerant circuit is not delivered assembled, as for example the following fluids R448a, R449a, R452a, R134A.

Cookware and bakeware

The Annex XV restriction proposal elaborates a list of alleged alternatives to fluoropolymer based non-stick coatings for use in consumer and professional cookware: ceramic, silicone based coatings and silicone bakeware, stainless steel, hard anodized aluminium, enamel, pre-seasoned iron/steel.

Except for ceramics, these technologies, have insufficient heat, corrosion and chemical resistance, non-stick and abrasion resistance properties, and durability. Ceramic has inferior properties in terms of non-stick performance, non-stick durability, and abrasion resistance, resulting in higher longevity, requiring more frequent replacement.

Any transition would take considerably longer than expected in the restriction proposal. Any shorter transition period than 12 years would impose a higher burden on European producers, which are able to handle R&D and transformation costs. Nevertheless, there is no guarantee that suitable innovation can be found without compromising crucial factors such as high performance, durability and functionality. These properties are essential for European producers to maintain their competitive advantage over non-EU counterparts.

Annex VIII – IPC[17]

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, epilame 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 telecommunication network

[17] Non-comprehensive table providing examples of PFAS critical uses in electronics

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
			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, etc.	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 characteristics, repellency, surface tension	Printed circuit boards (rigid, flexed, hybrid) - various uses especially in high speed/frequency applications	Various electronics, transportation/mobility, ICT equipment, base stations, aerospace
Printing materials	Low surface tension, electrical insulation, water repellency, oil repellency, chemical resistance,	Toner additives, Ink additives, Developer additives	Imaging equipment

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
	surface activity, high negative charge		
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

Annex IX – Swissmem

Sectors and uses

Sectors:

- Food contact materials and packaging (Cookware, industrial food & feed production)

- Energy sector (lithium-ion batteries, sealing, high purity applications, proton exchange membrane, isolation, gas industry applications, gas and steam turbine applications, photovoltaic energy, nuclear power plant applications, compressors for H2-mobility/energy transport&storage, insulating gases for T&D, fuel cells, wind energy)

- Transport sector (sealing, electrical engineering and information technology, safety equipement, coating)

- Electronics and semiconducturs (wires & cables, electronic components production, wafer production, coating, sealing, photolithography, solvents)

- Lubricants (grease, dry running friction application, granular solid lubricant, high performance lubricants, liner)

- Petroleum and mining (lining, seals, gaskets, sensors, cables,drilling fluids, application in compressors for refinery/gas gathering&processing, transport of aggressive chemicals)

- Medical devices (diagnostic equipment, inhalers, tubes)

- Construction products (sealing, gaskets)

Sectors not investigated in detail:

- Chemical industry (chemical plants installation, compressors)

- Defence industry (sealing and gaskets)

- Printing inks

- other niche applications (research, sealing and gaskets)

Missing sectors and uses:

- Machinery/mechanical engineering (valves, sealing, bearings, linings, tube seaming, flame retardent and other sub-uses)

- Building technology (HVAC, valves and sealing)

- Sealing in various sectors (see above)

Emissions in the End-of-life

Semiconductors & Lubricants

There are no emissions during manufacturing and when the substrate is cleaned, special filters are used. The filters are disposed professionally.

Consumables like cleaning wipes and gloves might be contaminated with a PFAS-solvent. They are disposed of as hazardous waste following a hazardeous waste incineration process.

All waste generated during the production processes at a semiconductor-producing company is sorted, collected and disposed according to its properties. Disposal is done by contractors at special industrial waste treatment facilities.

The incineration of the waste in municipal waste using best available technologies is done at ca 870 to 1000°C with resident times of 4,0s or 2,7s respectively, depending on the charge, and these conditions have been demonstrated to destroy PTFE polymers without releasing PFAS to the environment, therefore, as the PFAS containing waste generated by the company is incinerated in hazardous waste facilities that operate with temperatures of 1200°C. no PFAS should be released as a result of the production of liquid tunable lenses and other optical instruments at this company.

The company is committed to avoiding any release of PFAS to the environment during production of its products and managing all associated risks. At the moment, wastewater content of PFAS is being analyzed to verify that the filters installed are retaining all PFAS. Depending on these results, adjustments might be made to ensure that no PFAS are being released to the wastewater.

Concerning all sectors

Disposal in the environment in Switzerland and most EU-countries is highly unlikely for most mentioned products.

The Interstate Technology Regulatory Council (ITRC, a USA State led coalition) has been cited for their information that fluoropolymers are not degrading under environmental conditions. RIVM (Dutch National Institute for Public Health and the Environment) incineration review states that PTFE is stable at 260 °C and therefore would not degrade in a landfill. Further reports. A SETAC working group has been cited for their finding of the stability of fluoropolymers under environmental conditions.

The numbers for the indications of emissions in different life stages are not available to our industry, being a part of a complex value chain. During the use phase in manufacturing industries and their product lifetime, emissions are extremely low for fluoropolymers. They are also low for the sub-uses where gases (insulating gas in switchgear) are used (0.1% per year according to information from switchgear producers).

Proposed derogations

Foreseen derogations necessary to ensure manufacturing and sustainable technology for the future in Europe: 5.g, 5.h, 5.k, 5.n, 5.o, 5.r, 5.s, 5.t, 6.a, 6.b, 6.c, 6.d, 6.e, 6.f

Energy sector: 6.f fluoropolymer applications in petroleum and mining industries, 5.r insulating gases in high-voltage switchgear (above 145 kV)

Semiconductors: 5.k industrial precision cleaning fluids

Lubricants: 5.s lubricants where the use takes place under harsh conditions or the use is needed for safe functioning and safety of equipment

Food contact materials: 6.a food contact material for the purpose of industrial and professional food and feed production

Medical devices: 6.b implantable medical devices (not including meshes, wound treatment products, tubes and catheters)

Medical devices: 6.c tubes and catheters in medical devices

Petroleum & mining: 6.f fluoropolymer applications in petroleum and mining industries (lining of piping, seals, gaskets, sensors, cables mentioned by companies)

Missing uses

Energy sector

- sealing in compressors (PTFE, PEEK/PTFE-mixtures as solid lubricants)

- other sealing applications e.g. use of gaskets to seal capacitors (preventing the leakage of synthetic oil), sealing applications (FKM, PTFE) for wind energy, nuclear power plant, proton exchance membrane

- piping: Transport of high-purity water or aggressive chemicals in the "new energies" sector (Fluorpolymers/-elastomers such as PVDF, ECTFE, PTFE, FKM, FFKM)

- High voltage applications: Fluoropolymers for bearings, gliding rings and lubricants and the essential arcing nozzle

- insulating gases (assessment in the existing restriction proposal is incomplete, e.g. for Heptafluorobutyronitrile (C4-FN, CAS No. 42532-60-5))

- vacuum valves for PV modules and nuclear power plants (FKM, FEPM, FFKM, FVQM, PTFE, PFA)

- PTFE, PFA, FEP in coatings, peripherial supplies, insulation, flow system, structural and leakage control in gas and steam turbine applications

- compressors: PTFE-based materials are used for dynamic sealing systems because of their extremely favorable tribological properties, their excellent chemical resistancy, their large temperature application range and very good shape adaptability.

- Piping: Purity, chemical resistance in general plus combination of other properties (e.g. flame retardancy, dielectricity)

- valves for PV modules and nuclear power plants: Sealing materials for vacuum valves that must be extremely resistant to chemical and thermal stress.

- FP are used when other polymers cannot reach the required performances in terms of safety and lifetime, due to usage conditions. In some of the applications where FP are used, other polymers can be used as soon as the boundary conditions allows (temperature, pressure, chemical environment), but a much shorter replacement time needed for other materials. As they are used in critical conditions, where other materials were proved to fail, there is no real chance for replacement that could be considered.

<u>Status of R&D</u>

- **compressors**: various substitute materials were tested (plastics, graphite, ceramics), but they either showed very high wear, were abrasive against the metallic mating partner, or were too brittle to be used as a sealing material. In general, plastics either show too low temperature stability, poor tribological behavior or are too brittle if filled with inorganic solid lubricants. Graphite materials show quite high wear in dry running, especially with very dry gases, and are too brittle for a good sealing effect. Some of the ceramic materials tested showed high wear themselves and caused high wear of the mating partner. Costs so far for search for alternatives: 1 Mio Euros. Estimated time needed for finding and implementing an alternativ(s): 15-20 years. If materials with worse tribological properties are used, ring wear of the sealing elements and wear of the mating partner will increase. As a result, the maintenance intervals are much shorter and damaged mating surfaces must be replaced. Operation of the compressor is then no longer economically feasible, especially for dry-running systems. Furthermor, the energy consumption of the compressor will increase, if materials with higher friction coefficients are used. For the compression of very reactive gases such as HCl, H_2S, O_2 or Cl_2 no alternativ materials with the same chemical resistance are availabe. These compressors must be taken out of service.

- other sealing applications: Compatibility between materials in contact with oil plays a crucial role in the energy sector. Unfortunately, the alternatives proposed for other sectors (such as the electronics sector) are not suited to the needs of this application, as they do not take into account the specific problems linked to oil and its compatibility. When non-compatible materials come into contact with the oil in place, its resistivity increases, making these alternatives incompatible for use in the high-voltage sector. Complex qualification of products is very costly, high costs of validation testing, once an alternative is found. Safety is the main concern. If oil leaks from the capacitors, it can lead to overheating and even fire. In addition, extreme temperature conditions are present when transporting energy, ranging from -60°C to +80°C. It is therefore essential that the seals used are capable of withstanding these temperature fluctuations without compromising the integrity of the system. There are also sustainability issues, with environmental risks in the event of oil leaks and the contribution of the products to carbon neutrality objectives. Products for the energy infrastructure contribute to the stability and protection of electricity grids, and needs in these areas are growing with the production of renewable electricity.

- **valves for PV modules and nuclear power plants**: in literature no alternative could be found, measures have already been implemented (improvement of the yield in the vulcanisation process, reduction of the amount of elastomer used per component, collection of used sealing materials for controlled disposal and possibly recycling). FFKM and FKM are expensive materials and the company would immediately use alternatives if technically and economically possible. Time estimated to implement an alternative: >15 years

<u>Feasibility</u>

- **Compressors are needed for LNG transport** (LNG terminals, LNG tanker ships) and H_2 infrastructure (H_2 refueling station, trailer filling, power-to-gas, storage, pipeline injection). Hydrogen as energy carrier plays a key role for reaching the goals of the European Green Deal. Within the hydrogen infrastructure fluoropolymers are used not only for PEM electrolyseurs/fuel cells, which are listed as sub-use, but also for hydrogen transportation and storage equipment, for example in (compressor) seals, gaskets, and bearings. For dry-running compressor applications, no alternative sealing materials are available and therefore we suggest a derogation for fluorpolymers in sealings application for the energy sector equal to the derogation for fluoropolymers in the "petroleum and mining" sector. Socio-economic impact: Major loss of sales in CH and EU for one company (300 Mio Euro), loss of jobs around 350 plus around 3000 at suppliers

- sealing applications in energy sector: There are sustainability issues, with environmental risks in the event of oil leaks and the contribution of the products to carbon neutrality objectives. Products for the energy infrastructure contribute to the stability and protection of electricity grids, and needs in these areas are growing with the production of renewable electricity.

- sealing applications in energy sector 2: 0.65 Mio Euros loss, manufacturing in EU at risk, technological drawback of 10-20 years

- **piping**: EU Green Deal target are at risk (e.g. High Voltage Direct Current Transmission, hydrogen production with cooling and critical chemicals)

- **valves for PV modules and nuclear power plants**: loss of 100 Mio Euros and appr. 200 jobs, major drawback for manufacturing and digitisation in Europe, jeopardize EU Green Deal and European Chips Act

Lubricants

- specific use missing: PTFE based materials for dry running friction application and PTFE (granular, not micro-powder!) as solid lubricant in plastic materials for friction application, used for dynamic seals or actuators for HVAC (building technology)

PFAS as flame retardents

- In some specific cases, PFAS might be used as flame retardents, however, this is very difficult to be known by downstream users, as their presence is usually confidential business information of upstream actors.

Building technology

- ball valve sealing for HVAC (PTFE)

- applications for energy-related installations such as elevators, escalators and moving walks

- tribological properties, temperature resistance, high sealing properties

State of R&D

Various potentially interesting alternative materials are being developed by the suppliers and will be tested if available (close exchange with the suppliers), invested 25'000 Euros so far, estimated time for implementation: 2 years from point of technically and economically viable alternative which is not foreseeable at the moment.

Mechanical Engineering: (PTFE, FKM, FFKM, PVDF, ECTFE)

- general mechanical engineering

- hydraulic applications

- sealing, sliding rings, sliding foil, shaft seals, valves, linings, bearings

-high temperature resistance, chemical resistance, tribological properties, non-stick properties

State of R&D

companies fear for their existance.

Sealing in various sectors

Spare parts in various sectors

- Much equipment used in the industrial sectors, including e.g. motors, generators and power electronic equipment in energy and heavy industry has a very long service life, often 30 years or more. Where spare parts are supplied for such equipment and the original part contained PFAS, it may not be possible to make a spare part without PFAS without having to change other parameters of the larger equipment at the same time. In such cases, the spare parts without PFAS would not be suitable for use in the original equipment. This would lead to the environmental and social cost of the equipment having an end of life many years earlier than would otherwise be necessary. It is contradicting with the original spirit of the legislation. Therefore, there should be an exemption of at least 30 years for PFAS in spare parts for equipment that was legally allowed to contain PFAS in that application when it was placed on the market.

Transport sector

- FFKM and FKM are the state-of-the-art sealing materials for ammonia fueled engines due the high resistance against oil and ammonia. Ammonia-fuelled engines have the potential to allow zero carbon shipping operations.

Potential derogations marked for reconsideration

Semiconductors 5.ee semiconductor manufacturing process, where the following sub-uses have been mentioned:

- electronic components, wires and cables
- coatings, solvents and cleaning
- sealing
- sealing for vacuum valves
- pumping systems
- flowmeters
- photolithography
- handling of wafers, wafer cleaning, wafer edging, wafer plating, wafer polishing
- reactive gas in the process
- optical applications and photonics

-> The list of sub-uses in the documents has been regarded as very incomplete by the respective industry. (Examples: Piezoelectric and piezoresistive sensors, the additionally required electronics and manufacturing aids)

-> Substances used: PVDF, ECTFE, PTFE, FKM, FFKM, Fluoroelastomers, PFA, FEPM, FVQM

Food contact materials: 6.g non-stick coatings in industrial and professional bakeware

Medical devices: 5.bb, 5.cc, 6.j, 6.n

Other identified uses

Energy sector:

- Heat pump, H2 technology, carbon capture use and storage (CCUS)

Transport:

- sealing applications (FKM, PTFE)
- FP are used when other polymers cannot reach the required performances in terms of safety and lifetime, due to usage conditions. In some of the applications where FP are used, other polymers can be used as soon as the boundary conditions allows (temperature, pressure, chemical environment), but a much shorter replacement time needed for other materials. As they are used in critical conditions, where other materials were proven to fail, there is no real chance for replacement that could be considered.

Food contact materials:

- consumer cookware

- industrial food and feed production

Medical devices:

- diagnostic equipment
- inhalers
- tubes & catheters
- implantable medical devices

Construction sector:

- sealings & adhesive, processing aid, coating

Petroleum & mining industries:

- drilling fluids

Chemical industry:

- Compressors for various applications
- transport of aggressive chemicals

Printing inks

Defence industry:

- sealing & gaskets

Annex X – ZVEI

zvei electrifying ideas

Semiconductors

The semiconductor industry is highly dependent on many applications of materials that fall under the definition of PFAS as set out in the EU REACH proposal to restrict PFAS.

These applications are very specific to the sector and are determined by the particular physico-chemical properties of PFAS. which provide stability, low surface tension, inertness, purity and chemical compatibility, chemical and permeation resistance, a wide range of temperature stability, a low coefficient of friction, electrical properties, resistance to bacterial growth, non-flammability, and a long service life (over 25 years).

Sectors and uses

We refer to the following sectors and (sub-) uses identified in table 9:

- Electronics and semiconductors (Annex E.2.11.) Semiconductors Wires and cables / Coating,
- Solvents, and cleaning / Electronic components / Heat transfer fluids / Advanced
- Semiconductor packaging / Photolithography
- Applications of fluorinated gases (Annex E.2.8.) Refrigeration / Insulating gas in electrical equipment

Emissions in the End-of-life

End-of-life phase of equipment and articles in semiconductor manufacturing

The semiconductor manufacturing sites have a long lifetime of more than 25 years (ESIA, 2023). The inherent necessity for clean-room fabrication and ultra-pure, but aggressive chemicals results in the need to use fluoropolymers. As a result, a fab may contain several tonnes of fluoropolymers in tubes, valves, O-rings etc. (PFAS-Consortium - Articles Working Group, 2023). Due to the long lifetime of fluoropolymers and the long use of semiconductor equipment, emissions at the end-of-life phase of the PFAS-containing equipment are small compared to the amount found in a fab and are collected according to the European harmonized waste key-numbers for mixed plastics (European Commission, 2002).

End-of-life phase of PFAS-containing semiconductor products

Some semiconductor products, such as MEMS, may contain PFAS to provide a safe connection to the environment, e.g. pressure sensors may contain PFAS-containing gels as a sealing to provide a safe and pressure-sensitive interface to the sensor. This is important to ensure a long lifetime in aggressive environment such as combustion gases in vehicles or everyday chemicals such as sea water, nail polish, cosmetics, or acidic or caustic cleaning agents. Furthermore, inertial sensors such as accelerometers and gyroscopes may be coated with an PFAS-containing film to reduce the stiction in case of a shock (drop of smartphone or wearables) (PFAS Consortium, Plasma Etch and Deposition Working Group, 2023), (PFAS-Consortium Assembly, Test, Packaging and Substrates Working Group, 2023). Consumer electronics are subject to the WEEE Directive (European Parliament and Council, 2012) and for vehicles the ELV directive (European Parliament and Council, 2000) is valid, both of which should lead to the recycling of semiconductor products and minimise emissions to the environment.

The use of PFC (Perfluorinated Compounds) gases, some of which fall under the definition of PFAS in the Annex XV report, remains critical to semiconductor manufacturing. During these high thermal processes or chamber cleaning, a certain amount of the gases is absorbed in the process and has already been degraded to less harmful components (Table 6.11, https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/3_Volume3/19R_V3_Ch06_Electronics.pdf).

For many years, SC industry already has set itself ambitious targets to reduce remaining PFC emissions. For example, abatement tools have been installed on a voluntary basis. These abatement tools typically operate with a specific destruction removal efficiency (DRE), depending on the PFC used (e.g. PFAS C_2F_6 with a default DRE of 0.95 – Table 6.17, https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/3_Volume3/19R_V3_Ch06_Electronics.pdf).

Within these abatement tools the remaining PFC gases are further destroyed using high temperature (e.g., natural gas burners or electric plasma systems) in combination with washer systems. The PFC gases are destroyed in the burner system by a chemical reaction (incineration) and remaining particles are washed out and neutralised in subsequent washing processes.

Even under state-of-the-art municipal waste incineration conditions, PFAS are converted to inorganic fluoride at a minimum incineration temperature of 850°C (Aleksandrov K. et al. 2019).

This meets the legal requirement of the 17th German Federal Immission Control Ordinance (17. BImSchV) (https://www.gesetze-im-internet.de/bimschv_17_2013/BJNR104400013.html). It prescribes a minimum combustion temperature for waste of 850 °C. (Paragraph 6, (1)).

The incineration temperature must be 1,100 °C if the halogen content in the waste is more than 1%.

However, in many products containing PFAS and in municipal waste, the fluorine content is much lower than 1% (https://www.sciencedirect.com/science/article/pii/S2095809917300796).

Incineration plants typically cover the temperature range between 600-1600 °C (https://www.sciencedirect.com/science/article/pii/S2095809917300796).

A minimum of 1,100°C for 2 seconds results in complete decomposition of most PFAS (Yamada T. et al. 2005) (https://www.sciencedirect.com/science/article/abs/pii/S004565350500425X).

Studies on the incineration of PFOA, PFHxA, PFOS at different temperatures (800 °C, 900 °C, 1000 °C) showed that no fluorinated by-products were formed at higher temperatures (1000 °C) (Residual organic fluorinated compounds from thermal treatment of PFOA, PFHxA and PFOS adsorbed onto granular activated carbon (GAC) | https://link.springer.com/article/10.1007/s10163-016-0532-x).

Impacts on the recycling industry

Most PFAS emissions we get through photolithography emissions and emissions from uses of gaseous perfluorocarbons. Overall, it is estimated that the total PFAS used for photolithography described above in Europe amounts to 2248 kg per year. The estimated emissions amount to 1161 kg.

Gaseous PFCs are used for plasma etching, reactive ion etching and CVD chamber cleaning. The amount of gaseous PFCs air emissions covered by the proposed REACH restriction definition for PFASs was estimated to be 12,892 kg in 2022.

There are no industry wide measurements yet for PFAS emissions into wastewater. There are a peer-reviewed study published in "Environmental Science & Technology" in 2021 collected and analysed wastewater samples from three fabs in the United States (Paige Jacob, Krista A. Barzen-Hanson, and Damian E. Helbling Environmental Science & Technology 2021 55 (4), 2346-2356 DOI: 10.1021/acs.est.0c06690). The sum totals of the PFAS concentrations in the downstream samples from the three fabs are 0.623 ± 0.024, 0.394 ± 0.018, and 0.376 ± 0.024 µg/L, respectively. These are the concentrations in the wastewater measure prior to dilution in a receiving water system or with municipal wastewater and are relatively low compared to other known sources of PFAS emissions to the environment.

The production of semiconductors mostly takes place under clean room conditions and in closed systems. To prevent the release of chemicals during all process stages, the industry implemented strict risk management systems and safety measures, cause any kind of impurity would negatively affect the quality and functionality of the product. Under normal production condition, there is no measurable emission to the workplace.

The semiconductor industry has reduced its PFC emissions through commitments and financial investments in abatement systems from 2010 to 2022 by 42% (https://www.eusemiconductors.eu/sites/default/files/20230713_ESIASummaryPaper-PFAS.pdf).

According to Table E.130 in the Annex XV Report, an immediate ban of PFAS in the electronics and semiconductor sector would only have a very small impact on the resulting total emission reduction of PFAS compared to the maximum proposed time derogation (2025-2055: ~2.4%; 2025-2070: ~0.7%).

Proposed derogations

The majority of PFAS emissions come from photolithography emissions and emissions from the use of gaseous perfluorocarbons. Overall, the total mass of PFAS used for photolithography as described above in Europe is estimated to be 2248 kg per year. The estimated emissions amount to 1161 kg.

Gaseous PFCs are used for plasma etching, reactive ion etching and CVD chamber cleaning. The amount of gaseous PFCs air emissions covered by the proposed REACH restriction definition for PFASs was estimated to be 12,892 kg in 2022.

Industry-wide measurements of PFAS emissions into wastewater are not yet available. A peer-reviewed study published in "Environmental Science & Technology" in 2021 collected and analysed wastewater samples from three fabs in the United States (Paige Jacob, Krista A. Barzen-Hanson, and Damian E. Helbling Environmental Science & Technology 2021 55 (4), 2346-2356 DOI: 10.1021/acs.est.0c06690). The summed PFAS concentrations in the downstream samples from the three fabs are 0.623 ± 0.024, 0.394 ± 0.018, and 0.376 ± 0.024 µg/L, respectively. These are the concentrations measured in the wastewater measure prior to dilution in a receiving water system or with municipal wastewater and are relatively low compared to other known sources of PFAS emissions to the environment.

The production of semiconductors is mostly carried out under clean room conditions and in closed systems. To prevent the release of chemicals at all stages of the process, the industry has implemented strict risk management systems and safety measures, as any kind of impurity would negatively affect the quality and functionality of the product. Under normal production conditions, there are no measurable emissions into the workplace.

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According to Table E.130 in the Annex XV report, an immediate ban of PFAS in the electronics and semiconductor sector would only have a very small impact on the resulting overall emission reduction of PFAS compared to the proposed maximum time derogation (2025-2055: ~2.4%; 2025-2070: ~0.7%).

Missing uses

Semiconductors and their manufacturing processes are highly complex, so it can take several years before a significant innovation can be developed to market level. Materials from the PFAS substance group are used in these processes due to their unique properties. The uniqueness of PFAS and the proposal to restrict the entire substance group in the EU would result in an extremely great challenge of adequate substitution with regard to the necessary technical properties and their effects on human health and environment ("Regrettable Substitution"). With current state of knowledge, it can be stated that for a large part of the applications in the semiconductor industry, no alternatives exist or are known. In many cases, fundamental research is first required to make potential alternatives available at all, which can then be tested for their substitution potential in the individual processes and then, if applicable, also qualified, which will also require 3-10 years or more. In addition, there is also the possibility that the test result of a potential alternative will be negative and the process will have to start again.

The 13.5 years proposed in the Annex XV report for the semiconductor manufacturing process is not sufficient because substitution timelines are assumed for the following applications in the semiconductors industry:

Photolithography:

Research over the last years and decades has not shows any substitution possibilities for PFAS in most applications of photolithography, so that it is necessary to reinvent possible PFAS-free alternatives here. A time horizon of 15-20 years or more is assumed, depending on the application.

Wet chemistries:

Possible substitutes for PFAS in wet chemistry vary greatly, as the technology used and the respective application are the deciding criteria here. Once a potential alternative has been identified, this does not necessarily mean that it can be used for all applications in wet chemistry, so that a time horizon of 3-15 years is assumed with regard to possible substitution in the application areas.

Fluorocarbons Uses in Plasma Etch / Wafer Clean and Deposition:

There are no known potential alternatives for this application area of fluorocarbon chemistry, and a switch to non-fluorine materials would require the fundamental redesign of semiconductors, as silicon would have to be replaced as a fundamental element in the manufacture of semiconductors.

Fluorinated Heat Transfer Fluids:

Alternatives exist only alternatives for a small number of applications, because it is not so easy to find alternatives that meet the same technical requirements. However, even the small number of alternatives take 8-14 years to implement.

Similarly, replacing refrigerants in process equipment chillers would take a similar amount of time. For applications where no alternatives currently exist, a suitable alternative would first have to be developed. This means that it would take another 5 to 15 years or more to implement these alternatives. It could also take even longer depending on the number of cooling systems affected per production facility. For PFAS-free thermal test methods, it would take 8 to 14 or longer to implement an alternative after investment.

Semiconductor Assembly, Test and Packaging:

The introduction of PFAS-free alternatives can take 5 to 20 years or more, depending on the intended use. For packaging fluxes, qualification and introduction of an alternative is likely to take more than 5 years. For most packaging-related uses of adhesives, the semiconductor industry has been unsuccessfully searching for alternatives for 18 years, and it is expected to take more than 20 years to find and implement alternatives.

Another fact that is added, additional time is required to notify the customer of the product change and to re-qualify and approve the product.

It is necessary to start customer qualification activities at least 1-2 years before the change is implemented; in some applications, even more than 6 years are required. In certain cases, the lack of viable alternatives is evident, resulting in compromised Safety and functionality of the end-user product.

Pump Fluids and Lubricants:

Lubricants must meet certain performance requirements, such as inertness under harsh conditions. The possible substitution timeline for the replacement by PFAS-free substances is estimated to be more than 10 years in general fields of application. For the replacement of the lubricants used in photolithography, even more than 25 years are assumed, since UV resistance is also required.

Articles:

Switching to PFAS-free alternatives would mean a reinvention in many applications in this area. If at all possible, a time horizon of 15 years and more is assumed, depending on the field of application and material.

Other identified uses

PFAS are essential for semiconductor manufacturing and semiconductor products. Therefore, it is not currently possible to demonstrate that a non-PFAS alternative can meet the application-specific performance requirements for semiconductor products such as ASICS, CMOS, data storage or MEMS. In such cases, it may be necessary to discover novel chemicals and/or different ways to create sensors that deliver the required performance. Invention is a never-ending process with no set deadline or guarantee of success. It is therefore necessary to (i) outline specific applications that rely on PFAS materials for specific performance requirements, and (ii) highlight the need for derogations for specific uses of PFAS materials in the semiconductor industry. Many specific applications in the semiconductor industry have not been mentioned from the ECHA PFAS restriction proposal dossier submitters, such as: adhesives, coatings, lubricants, encapsulation of semiconductor products with PFAS-containing passivation gels, vapor phase soldering, anti-stiction coatings for MEMS and sintering of semiconductor products on heatsinks. There are many other applications which have been added to the 'updated' list to table A.49 in the consultation feedback of the ESIA (ESIA, 2023).

Analytical methods

Currently, analytical methods do not exist for all individual PFAS compounds; there are too many PFAS compounds to do so.

Industry has tested some analytical methods that can detect some PFAS species in semiconductor wastewater. However, there are limitations to analysis by LC-MS/MS, since comparative standards are not available for all substances in use. To finding an analytical method that can detect all PFASs in a comprehensive manner has not been possible.

It is therefore important that further research be conducted to find and improve suitable analytical methods so that a more comprehensive set of analytical methods is available to the semiconductor industry.

1. US EPA 537.1 (modified)

The detectable PFAS was C4-C13 species. In semiconductor wastewater, the limit of detection was found to be ~1ppt. The primary gap highlighted with this method related to almost all the species included in the analytical library are not used in semiconductor manufacturing, with perfluorobutanesulfonic acid (PFBS) commonly being the only exception. The applicability of this method is limited mainly to the detection of PFAS by-products.

2. US EPA Draft 1633 (EPA method in development)

The detectable PFAS was C4-C13 species. The limit of detection was ~ 1 ppt. This method is not yet commercially available.

3. US EPA Draft 1621 AOF (EPA method in development)

The detectable PFAS for this method was the total organic fluoride content. The limit of detection was unknown but was assumed to be in the ~100-900 ppb range. The gap identified with this method for semiconductor wastewater was the fact that most short and ultrashort PFAS species will not be detected, as they must first adsorb to the GAC column, and most C1-C5 species adsorb in an inadequate manner, if at all.

4. DIN 38407-42 (F42): 2011-0 (Analytics for waste water)

This method is for determination of 27 individual PFAS compounds and sum PFT (PFAS 27). The determination limit is 0.010-0.015 µg/l for the single compound.

5. ISO 21675:2019

Water quality: Determination of perfluoroalkyl and polyfluoroalkyl substances (PFAS) in water — Method using solid phase extraction and liquid chromatography-tandem mass spectrometry (LC-MS/MS) Detection limit is 10 ng/L (for drinking water), 20 ng/L (for wastewater).

6. AOF - Adsorbable organically bound fluorine, DIN 38409-59:2022 DE

In combustion ion chromatography, a high temperature combustion furnace with absorption module is coupled with an ion chromatograph (IC). In CIC analysis of AOF in aqueous matrices, the organic fluorine compounds are adsorbed on activated carbon. The enriched activated carbon is combusted at 1000 °C in an oxygen/argon stream. The fluoride formed is quantitatively determined by ion chromatography with conductivity detection.

The determination limit is 3 µg/l in waste water or 1 µg/l in clean water.

The method was developed on the basis of the standardized procedure DIN EN ISO 9562 for adsorbable organically bound halogens (AOX).

As expected, the determination of the parameter AOF leads in most cases to higher results than the analysis of the individual substances.

PAMCo

The semiconductor industry is highly dependent on many applications of materials that fall under the definition of PFAS as set out in the EU REACH proposal to restrict PFAS.

These applications are very specific to the sector and are determined by the particular physico-chemical properties of PFAS. which provide stability, low surface tension, inertness, purity and chemical compatibility, chemical and permeation resistance, a wide range of temperature stability, a low coefficient of friction, electrical properties, resistance to bacterial growth, non-flammability, and a long service life (over 25 years).

Sectors and uses

Electronics & Semiconductors, Energy & Power, Lubricants, Petroleum & Mining, Food Contact & Packaging, Industrial Food & Feed are important consumer sectors for the PAMCo sector.

PAMCo applications are not sector specific. Therefore, PAMCo needs to be considered as a separate application sector in the dossier.

Alternatively, the following markets, among others, should be added as application sectors:

Power and energy, district heating and building automation, industrial gases, food and beverages, chemicals and petrochemicals, oil and gas, pharmaceuticals and biotechnology, marine equipment, water and wastewater, pulp and paper.

No emissions are expected during the lifetime of the products.

PAMCo products are B2B products and don't end up in household waste. Controlled recycling is likely. Professional recycling is standard or could be easily implemented.

Missing uses

a) PAMCo applications are not sector specific and therefore PAMCo has to be treated as a separate use sector (see 1).

Annual tonnage in EU: 2363t/year

b) Typical reasons for FP applications: temperature resistance, chemical resistance, low friction, long life, excellent sealing, low emissions, flame retardant, low dielectric constant. (see attached fact sheet for details)

c) Estimated 1000 companies

d) No available alternatives to replace fluoropolymers as state of the art

e) Due to the long and complex supply chains, PAMCo companies generally don't have direct commercial contact with raw chemical suppliers /producers of PFAS

Although we are in close contact with our suppliers and even if alternatives were available, we would still need more than 12 years for implementation, product (re-)qualification and (re-)testing/(re-)certification after finding alternatives for substitution, due to the highly regulated market in the PAMCo sector and the required external approvals and testing.

f) n.a.

g) The EUR 56 billion market for PAMCo in Europe would be directly endangered; in addition, special attention must be paid to spare parts used in public infrastructure and industrial plants. Otherwise, future functionality and safety cannot be guaranteed.

Potential derogations

Inclusion of PAMCo equipment as a missing use,

2. Spare parts and refurbished products must in principle be excluded from the restriction.

The "repair-as-produced" principle must be applied to the placing on the market of spare parts, wear parts and used parts.

Especially in the process industry, a product life of 30 years is typical and therefore spare parts must be available in approved/certified equipment must be available.

3. Fluoropolymers should be considered as “Polymers of Low Concern” (PLC) and therefore

- be excluded from the restriction scope or
- should have a 12-year derogation (plus transition period) for use in PAMCo equipment with review option for extension if no suitable substitutes are found.

Other identified uses

State of the art: There are no alternatives.

It is important to enable EU companies to meet their obligations under the Green Deal.

This requires a risk-based approach in the PFAS Regulation.

Analytical methods

For the majority of the more than 10,000 PFAS, no specific analytical methods are available today.

The extremely low thresholds of 25 ppb and 50 ppm for a large number of regulated PFAS cannot be safely enforced in global, branched supply chains.

Electric welding equipment

Sectors and uses

In our sector, PFAS, mainly FLUOROPOLYMERS, are used to obtain the following properties

- Resistance to high temperatures
- Resistance to aggressive chemicals
- UV resistance
- low friction
- long term stability

To the best of our knowledge and based on what has been reported to us by member companies and their suppliers, PFAS used in electric welding equipment would be irreplaceable at this time.

We understand that fluoropolymers are generally considered to be chemically inert, non-soluble and non-bioaccumulative. They wouldn't have the environmental and toxicological profiles associated with other PFAS of concern.

Missing uses

c)

• Market environment: information from EWA (European Welding Association)

- market of arc welding equipment in Europe: 1,2 billion EURO
- employees of welding industry in Europe 25.000

• torches: approx. 30 - 40 %, power sources significantly more Affected approx. 50 % of sales

• Globally networked supply chains

• Welding and cutting technology as core competence in almost all industrial applications d)

• No substitution for temperature-loaded electrical insulations

• Silicone for O-rings: not useful

Potential Derogations

• Conflicting goals with Ecodesign directive - mandatory spare part delivery over 10 years

• Mandatory compliance with Ecodesign directive in terms of energy efficiency

Electric Drive Systems

Sectors and uses

Electrical drive systems in industrial applications and processes drive machines (e.g. Conveyor belts, pumps, compressors, fans, robots, etc.). Optimized drive systems are the key to efficient drive solutions in process and production automation.

Electrical drive systems mainly consist of the following components:

- An electric motor that converts electrical energy into mechanical energy
- A device for controlling the motor and connecting it to the grid; usually a frequency inverter, soft starter or contactor
- A gear unit that adapts the mechanical power of the motor to the operating point of the machine, i.e. increases the torque by reducing the speed (or vice versa)

The requirements mentioned by ZVEI do not always apply at the same time. For example, the temperature resistance can only be achieved at a significantly smaller interval than the specified interval if the mechanical or chemical stress is very high.

Potential Derogations

The use of PFAS in drive systems has been identified, among other things, in the sealing, cabling, insulation, sliding elements and greases, mainly to ensure the required sliding properties of the moving parts and to protect the components from heat, aggressive atmospheres and sea water. No technically and economically suitable alternatives are known for these applications.

We therefore call for an unlimited exclusion of fluoropolymers and perfluoropolymers from the scope of the restriction for use in drive systems and their components, as well as in production machines and systems.

As it is uncertain whether drop-in alternatives will exist for existing HVACR systems 13.5 years after the entry into force, the exception for the maintenance and refilling of such systems should not be limited in time. Instead, we propose that the EU Commission reviews this exception by this time in the light of new scientific findings and, if necessary, amend the exception accordingly

Electric Equipment for Transmission and Distribution

The following description of the situation for electrical equipment for transmission and distribution (T&D) has been created and discussed by the leading equipment manufacturers organised in ZVEI covering transmission (above 52 kV) and distribution (below 52 kV) and gives a common understanding on the situation.

Electrical equipment for transmission and distribution are very complex products consisting of thousands of parts with extreme durability, a long lifetime of 40 years or more and high technical requirements as wide temperature range, resistance against wear, resistance against electrical arcs or others. To allow this, in combination with long maintenance periods or even maintenance free design, high grade materials are used. For some of the technical functions PFAS materials are used intentionally or might be used as components of 3rd-party materials without any further specifications on chemical consistency. The materials used in electrical equipment are divided in the following groups:

1. Articles or components containing PFAS, which have been selected intentionally by the equipment manufacturer, following the design as material or as ingredient of a material mixture for a specifically defined function
2. Material in articles or components, that has been selected based on technical parameters by the equipment manufacturer, but where PFAS material is contained as ingredient of a material mixture based on the definition of the material manufacturer.
3. Components, articles or assemblies, which are designed and supplied from 3rd party suppliers. PFAS has not been specified by the equipment manufacturer nor direct supplier but might contain PFAS as an intentionally added ingredient of a material mixture or as material based on the definition of the component- or the material manufacturer.
4. PFAS contained as contaminant based on the production process, e.g., as release agent used in a cast moulding process to allow easy demoulding, surface treatment using PFAS or PFAS containing substances, in the production machine or due to manufacturing of PFAS containing products next to the production line.

Add to 1) Articles or components containing PFAS are selected when reliable operation is required in harsh conditions, such as extreme temperatures, an aggressive environment, and mechanical endurance. Our electricity sector uses PFAS because of their capacity to resist these harsh conditions, in addition to other applications such as electrical insulation and sealing. Manufacturer of the electrical equipment are already active to identify and search for alternatives for some components. This process is actually ongoing.

Add to 2) It is already more complex, as materials are used in many applications and changes of a material recipe might have impact on the technical parameters. A change in material might result in a requalification of the alternative material. Alternatively, the supplier might decide to stop the production of the material. Then a new supplier for a similar material with acceptable risk profile must be identified and the substitute quantified.

Add to 3) An example for this group could be electronic equipment as control and protection relays, which are a mandatory component for most products used in electrical equipment. They contain semiconductors or other electronics, where it has been announced from the industry that it is almost impossible to offer PFAS free solutions.

Add to 4.) Due to limited availability of analytical methods that can reliably quantify substances falling under the wide-ranging definition as PFAS, it is effectively impossible to control and ensure the low threshold of 25 ppb. Even more so, if the manufacturing processes uses materials, parts or components manufactured and imported from outside the EU.

It should be stated that the replacement of PFAS substances can potentially worsen safety properties of electrical equipment for transmission and distribution, such as fire resistance, as alternative materials may have less favourable characteristics in this regard. Furthermore, PFAS substances are partially used in core components of power electronics and control systems (for example, thyristors and optical fibres). The use of an alternative material requires the utilization of different types of these components, which necessitates significant hardware and software adjustments. The required development work may take 5-10 years after alternatives have been made available by our partners and suppliers. The non-availability of products during that time frame would cause shortage of electrical equipment with huge financial impact and direct negative impact on the energy transition plans and the required extension of the electrical networks. Type tests for grid components are mandatory for most markets, including EU. Any function determining material change has an impact on the results and thus does consequently lead to a repetition of type tests. As these tests are very time consuming and some specific tests are extremely expensive it is mandatory to complete all replacement of PFAS in a specific product prior to re-testing and/or re-certification. For many T&D applications, there is neither guarantee that current performances will be reached, nor overall carbon footprint limited to acceptable levels. This brings high uncertainties in the achievement of EU's 2030 and 2050 decarbonisation targets.

The proposed blanket restriction of all PFAS, regardless of toxicity, risk profile, and respective use, is not consistent with the risk-based approach according to Article 68(1) REACH and substance-based approach according to Article 69 REACH.

A more differentiated regulatory approach has been proposed by the UK's Health and Safety Executive, adopting a pragmatic approach to limit the use of PFAS and control exposures to human health and the environment. The thousands of PFAS substances have very different physical, chemical, and biological properties, and not all PFAS remain in the environment with a practical degradation at the end of their lifecycle. We support a similar approach to restrict PFAS substances, with a differentiated consideration of the risk for each substance in its specific use, while considering critical use for society, such as electricity security and supply.

When PFAS substances are identified as posing an unacceptable risk to human health or the environment, a differentiated regulatory PFAS restriction should consider:

- The risks associated with individual substances, and their application within T&D equipment, including the consideration of vastly different risks of release during manufacturing, operation and maintenance compared to consumer uses.
- The most appropriate measures to manage the risks posed by PFAS used in T&D equipment, such as requirements for recycling and effective waste treatment from manufacturing to decommissioning after its lifetime, which usually is over 40 years.
- The potential for PFAS replacement, including consideration on whether the alternative already exists at a significant scale and has an appropriate technological readiness level while being cost-effective. This is in line with Article 68 of REACH regulation, which states that any new restriction must consider the socio-economic impact, including the availability of alternative solutions. The lifetime of products with the alternatives shall also be compared with the lifetime of current products to avoid uncontrolled refurbishment or replacement rates.
- For any substances or applications where the only available means to manage the posed risk require actual phase-out and substitution, the timeframe for development and certification of substitutes shall be considered appropriately. For those PFAS uses where restriction is the only available option, we recommend including a requirement to assess the availability of a suitable PFAS-free alternative before the end of any relevant transition period. This requirement is in line with what ECHA's Socio-Economic Analysis Committee (SEAC) proposed for the EU-wide PFAS ban in firefighting foams for substances covered by the Seveso Directive and for offshore installation in the oil and gas industry.
- The criticality of PFAS use for society, in the context of the energy transition, climate impacts, and environment & human health protection. This means a differentiation between PFAS used in essential closed-loop long-life products which are indispensable for society (e.g., critical infrastructure) and uses with obviously lower performance requirements.
- Appropriate transition periods for PFAS substances used in T&D equipment, where an unacceptable risk to human health and the environment has been identified, with no sufficient control measures available, and available existing alternatives. For PFAS-applications with no available alternative, specific and adequate derogations must be considered.

Electric Power Tools

Sectors and uses

Electronics; Energy Sector

- High performance and rate capability in both the charging and discharging directions
- Thermal operating conditions between -20 and 60°C
- Resistance against mechanical impact to ensure integrity and safety of the battery cells
- Good energy to weight ratio as hand-held power tools must be able to be handled in an ergonomic and safe way over prolonged periods of time
- PVDF and PTFE in binders in the active material mass are necessary to ensure the integrity of the electrode and enable a homogenous distribution of the slurry.
- In next generation batteries, several kinds of fluoropolymers are used to manufacture very thin high - performance gaskets with sufficient thermal stability and high permeation resistance to provide stability in high temperature and high power cells, withstanding up to 280 amps.

Emissions in the End-of-life

b. For waste batteries, it is ensured that they are recycled wherever possible and not simply discarded into the waste stream due to the valuable materials contained in them. The EU Batteries Regulation (Regulation (EU) 2023/1542) sets recycling and collection targets and in that way already contributes heavily to these goals.

Impacts on the recycling industry

For waste batteries, it is ensured that they are recycled wherever possible and not simply discarded into the waste stream due to the valuable materials contained in them. The EU Batteries Regulation (Regulation (EU) 2023/1542) sets recycling and collection targets and in that way already contributes heavily to these goals. However, as the ZVEI Section Electric Power Tools represents manufacturers of electric power tools, we cannot give more information on the necessary efforts for recyclers to comply with the proposed concentration limits.

Potential derogations

We call upon the European Commission, ECHA, its committees and the competent authorities of Member States to consider a general exemption for fluoropolymers of low concern, due to the low risk to the environment and human health they pose, as stated in the cited OECD guidelines (OECD, Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance, 2021).

For the typical use cases within the power tools sector, such as housing, high performance plastics and rubber materials, sealings, adhesives and lubricants, electronic components, cables and wires and bolts and screws, no currently known alternative materials are available on the market. Therefore, we call upon the European Commission, ECHA, its committees and the competent authorities of Member States to consider a derogation for these applications of fluoropolymers of 13,5 years.

For the reasons outlined above, fluoropolymers, specifically FKM, cannot be substituted in components in combustion engines, and we call upon the European Commission, ECHA, its committees and the competent authorities of Member States to consider a derogation for these applications of fluoropolymers, specifically FKM, of 13,5 years. This time is needed to be able to identify parts and subcomponents, validate the components with a new material, should it once become available on the market, validate the product with the new components, implement assembly pre-development, and in the worst-case re-design and develop a product, start-up production, implement it in the machinery fleet, turn the existing inventory and lastly recertify the product.

As outlined above, fluoropolymers are necessary for several uses in rechargeable lithium-ion batteries and cannot be substituted today, which is why we would ask ECHA, the European Commission and the competent authorities of Member States to **consider granting derogations of 13,5 years** for the following uses of PFAS in power tool batteries:

PFAS Type	Where used in the battery	Type of battery	Derogation / transition period
PVDF	In binder in active material mass	Li-ion wet process (except for the graphite anode)	13,5 years because no alternative is available
PTFE	In binder in active material mass	Li-ion dry process and semi-dry process	13,5 years because no alternative is available
Various PFAS including LiTFSI, $LICF_3SO_3$ (triflate)	In electrolytes	Li-ion rechargeable	13,5 years because no alternative is available
PFA, VDF, HFP, FKM	In gaskets	High energy density batteries which require very thin high-performance gaskets such as Lithium-ion rechargeable batteries	13,5 years because no alternative is available
PTFE, PVDF	In coatings on separators	Li-ion rechargeable	Transition time of 6,5 years because substitution takes more time
PTFE, FEP, PFA, VDF, HFP, FKM	In valves, gaskets, washers	Li-ion rechargeable	Transition time of 6,5 years because substitution takes more time

Electronic conectors

Sectors and uses

The restriction dossier summarizes the whole E&E industry in a short paragraph without respecting the complexity of the E&E industry or applications. Nearly every complex technical article is somehow related to E&E from a small bicycle lamp to complex industrial tools. Hence only individual examples can be provided as representatives for a lot of other applications.

Lubrication and contact wetting

Since no contact surface is perfectly smooth, thinly applied contact lubricants fill in existing irregularities, not only improving contact and electrical performance, but also extending service life by reducing hot spots during current transfer and abrasion. By filling the air gaps between contacts, contact lubricants provide a critical increase in actual surface area, which in turn prevents local current leakage and the associated temperature rise and resulting oxide formation. Contact lubricants form a barrier to airborne contaminants and reduce frictional effects by providing fluidity of motion. Only by using contact lubricants can multipole connectors be reliably mated or unmated by hand. If the surface contact is insufficient, the current is only transported over a small part of the surface, resulting in strong heating at the contact points where the surface oxidizes and increases the contact resistance.

Regardless of whether they are static or dynamic, mechanical wear occurs on metal interfaces. With static contacts, abrasion occurs due to minimal movement of the contacts caused by vibration, temperature changes. When the surfaces rub against each other, metal particles brake off from the tips and bore through the coated surfaces. This exposes the surface itself and the underlying metal to oxidation and wear. In addition, the detached metal particles can cause interference with current transmission and switch failure. Industrial contacts are used at temperatures up to approx. 120°C, so local temperatures at the contact points are increased again due to contact resistance. For reliable lubrication of the contacts at temperatures >130°C, only PFPE-based contact lubricants are currently available. In addition, industrial connectors are frequently used in harsh ambient conditions in corrosive atmospheres, so that the contact lubricants must additionally be resistant to corrosive media, which likewise only synthetic lubricants have so far ensured.

The lubrication of different friction partners in electrical applications fulfils various functions. Basically, it serves to optimise friction between different material pairings. These can be plastics, metals or both combined. On the one hand, plugging forces are reduced, the frequency of plugging and unplugging cycles is increased, fretting corrosion is avoided or, in general, the stucking of moving elements is prevented.

Lubricants containing PFAS are used to guarantee the above-mentioned properties under the various temperature conditions (actuation temperatures with high minus and plus degrees; actuations after reflow soldering process 260 C) that prevail in the applications and also after several years of ageing. Another reason is the material compatibility in relation to the various metals and plastics used in connectors.

Fluor elastomeric sealing

Connectors for non-office applications need in many cases high IP protection for error-free operation. For this requirement O-Rings or custom designed sealings are used to keep the electrical contacts from being contaminated with liquids, chemicals, dust and protect the connector against short circuits and therefore ensures secured electrical operation.

In case of IP protected connectors in environments with an extended temperature range and aggressive chemicals fluor elastomeric polymers like FKM, FFKM, FEPM, FEP, PFA and PTFE offer superior material properties. The fluor elastomeric sealings also provide excellent performance over the lifetime of the entire connector. The design of the sealing and therefore the entire connection is in many cases directly related to the material properties which are used for those sealings.

Electronic connectors are used in various applications, therefore they must withstand different external influences. Fluor elastomeric sealing materials like FKM, FFKM, FEPM, FEP, PFA und PTFE provide excellent material properties like

- wide temperature range (-30 to +200 °C)
- resistance to different organic solvents, acids and bases
- UV and Ozon resistance
- Durability and Longevity over lifetime

PFAS containing Membranes for Pressure Release in Connector Housing

The following described application is a specific application of technical fibres for the use in EEE – but also on part level e.g. sensor or connector. The membranes are typically used for sealed applications within EEE applications. In a connector the membrane design elements are typically based on fluoropolymers (e.g., PTFE, ePTFE, etc.) and are used to prevent the penetration of humidity into the product and at the same time to allow some gaseous media to escape to the environment to avoid under- or overpressure inside the product or to enable gas exchange into defined areas of Electronic Equipment for measuring of gas concentrations.

In case of harsh temperature change between ambient and ECU the thereon related vacuum can lead to suction of wetting water on the ECU-housing. The water based liquid film inside the ECU or electronic application may then lead over lifetime to an electric failure of the EEE-application based on electrochemical migration.

Beside this quality related function of the membranes, they are also required in e.g. motor engine ECU's as they need to measure continuously the current ambient pressure to ensure a correct functioning of the engine. As the sensor is an internal element of the ECU, a sufficient pressure equalization of ECU- and ambient-pressure must be ensured. This is particularly important to comply with the high requirements for exhaust gas control.

The over years developed state-of-the-art technical solution that yields acceptable device sizes and function is an application of a porous membrane that compensates the pressure of the ambient and inside the control unit while blocking harmful media. The only known membrane materials that overall fulfil the requirements of media robustness, sufficient air flow rate and high-temperature stability are expanded Polytetrafluoroethylenes (ePTFE) which are a subset of the PFAS-group. We note that all membranes used in our applications are mainly based on fluoropolymers that fulfil the OECD criteria of "polymers of low concern".

PFAS containing Potting Materials

The primary purpose of using Fluor elastomer potting materials is to provide a protective barrier around sensitive connection components, circuits, and devices. This encapsulation shields the internal components from environmental factors such as moisture, dust, chemicals, and mechanical stress in industrial environments. PFAS containing potting materials are realising an extension of life of connections and connectors in harsh environments. Further most of potential substitutes are based on containing silicon materials which are exhale silicon particles. These particles are creating problems in many different applications such as automatic painting and color coating. Automobile production can be mentioned here, especially painting with the hart requirement of "silicon freeness" (Keyword: substances that interfere with paint wetting).

Increasing the resistance against high temperature, Mineral oils; increasing aging resistance. PFAS-containing potting materials act as a chemical barrier, preventing corrosive substances, solvents, and other chemicals from reaching and damaging the enclosed contacts, connections and electronics. The offer of good thermal stability and heat resistance, helping to dissipate heat generated by electronic components and maintain optimum operating temperatures.

PFAS containing Anti-Driping additives

Polytetrafluorethylen (PTFE) finds widespread use as flame retardant synergist for polycarbonates (PC), acrylic butadiene styrene copolymer (ABS) and polybutylene terephthalate (PBT) to prevent a melt-drip of polymers in fire, as burning drips can spread the fire. PTFE acts as anti-dripping additive and is necessary for the material to attain UL 94 V-0 classification. Due to their good mechanical and insulating properties, polycarbonates and PBTs find frequent application in electrical connectors, for example as strain relief. They operate in close proximity to currents and as such are subject to rigorous safety standards concerning flammability. European technical standards for fire safety requirements are for example IEC 60898 for circuit breakers, IEC 60947 for industrial control equipment or IEC 60335 for the area of domestic appliances determined from the International Electrotechnical Commission (IEC). Furthermore, technical standards of the American Underwriters Laboratories (UL) have been adopted in Europe and Asia as well. Therefore, the American UL 94 V-ratings are also internationally known and used flammability requirement.

PTFE usually makes up a small amount of the material (≤0.9% of total composition) and complements the flame retarding system. The mode of action is described as a "physical effect of microfibrils formed during processing which shrink back under fire, preventing dripping release" in case of polyamides.(1) For polycarbonate and ABS, rheological effects of reduced viscosity and induction of a flow limit ("solid-like behaviour at low shear stresses below a yield point") are discussed in literature.(2)(3) Since the main (flame retarding) component BDP functions as a plasticizer for PC/ABS, the benefits of flame retardation are negated by the decreased viscosity which promotes dripping. The addition of PTFE as synergist is necessary to compensate for this effect, allowing the material to fulfil the flammability standard according to UL94 V-0. The anti-dripping flame retardance provides a higher amount of safety and security to end-users, greatly reducing the likelihood of a thermal event and PTFE provides a critical anti-dripping property to flame retarded grade polymer resins, this prevents meltdripping in fire event in finished goods.

Emissions in the End-of-life

The PFAS based substances are used in a controlled industrial environment. Management processes like ISO 9001 and ISO14001 ensure the proper and safe handling of these substances.

Connectors are typically collected and treated/milled in the waste stream. Metal components are recycled by melting and reused for creation of new metal alloys. Melting on brass happens at temperature over 1000°C that PFAS lubricants will be decomposed. In any case the PFAS content adhering to connector pins is negligible and impossible to be measured in the exhaust gas during the melting process.

The literature offers different sources on investigations on the incineration of PFAS. In summary PFAS decompose in municipal incineration facilities at BAT level.

Impacts on the recycling industry

From today's point of view the recycling industry isn't impacted because the PFAS adhering to the metal parts decompose during metal recycling. The plastic components of electrical connectors are typically incinerated in case of waste coming from end-of-life goods. Production waste is treated single graded with technically and economically reasonable processes.

Potential derogations

We are requesting an exemption for electrical connectors for a period of **12 years** plus a reasonable transition period of **at least 4 years** for all types of electrical connectors.

In addition, it must be possible to apply for a further derogation in case no suitable alternative is available on the market. The exemption methodology should be in line with the current RoHS Directive.

Passive electronic components

Passive Components are used in the market segments of Telecommunication, Consumer & Home Appliances, Micromobility, Medical & Healthcare, Industrial & Energy and Automotive.

Passive components, such as capacitors, resistors, inductors or filters, are crucial to make the (electronics) world "go round". There is no semiconductor component and no electronic circuitry which can work properly without passive components.

PFAS are essential in a wide range of applications at the present time and for the foreseeable future. PFAS are used due to their unique combination of properties and their important characteristics for the wide range of our products and technologies.

- Environment-independent lifetime
- High temperature performance
- Electrical insulation; dielectric strength
- Chemical resistance against aggressive media

- Heat resistance at extreme temperatures and non-flammability

- Resistance against climatic influences (e. g. moisture, wetness, dust)

- Good mechanical properties (e.g. abrasion, surface tension, friction)

Sectors and uses

ZVEI input mainly covers "Electronics and semiconductor (Annex E.2.11.)".

However, since other sectors also depend on the passive electric components, some of ZVEI contributions refers to e.g. Applications of fluorinated gases (Annex E.2.8.), Lubricants (Annex E.2.14), and "Plastics (other than packaging) and rubber/elastomer production (including flame retardant) [These are not listed in Table 9, but shown as "uses not researched in detail" in Table A1 of Annex A.].

Almost all industrial sectors are affected by regulation of electrical and electronic equipment because they use electrical and electronic parts as components. Therefore, some of our contributions also refer to e.g. Medical devices (Annex E.2.9.) and (ii) Transport (Annex E.2.10.).

POLYMERS OF LOW CONCERN

The vast majority of PFAS remaining in products belong to the polymeric PFAS group that is considered thermally, biologically, and chemically stable, negligibly soluble in water, nonmobile, nonbioavailable, nonbioaccumulative, and nontoxic.

In general, the commercially available and used fluoropolymers, which account for about 96% of the overall global fluoropolymer market, are deemed polymers of low concern, e. g. by OECD.

USAGE AND ALTERNATIVES (respectively the lack of thereof)

While some chemistries might offer a similar performance to PFAS for a particular parameter or property, it is the unique combination of properties that sets fluoropolymers apart and makes them vital for the electric components industry.

Alternative solutions are only partially available for some specific applications, for some no alternative is known at all.

- PTFE, FEP, ETFE, PVDF or PFA:

Exemplary use cases: electrical insulation on electronic components (cable sheath, shrink tubes, insulators for HF applications, insulating films in capacitors, etc.)

Required characteristics: unique combination of heat resistance, electrical insulation, resistance to chemicals and mechanical properties (abrasion, flexibility, ...),

Alternatives: PVC or PP are already in use as wire insulation for low temperature applications, but they cannot be used if high operating temperatures (**above** 105°C) are required. Polymers like PEEK or Polyimide are suitable for high operating temperature but have different mechanical and/or electrical properties compared with fluorinated polymers.

- FKM or FVMQ

Exemplary use cases: O-rings and sealings

Required characteristics: unique combination of heat resistance, resistance to chemicals and mechanical properties (flexibility)

Alternatives: EPDM rubber, Nitrile rubber (NBR) or Hydrogenated NBR as sealings are not suitable in most applications due to their insufficient media resistance.

- PFPE (example 1):

Exemplary use cases: glue for attaching sensitive MEMS to pressure ports

Required characteristics: unique combination of wide application temperature range, resistance to chemicals and mechanical properties (stability)

Alternatives: Substitution only partially possible by glass solders with lead (Pb) content. Also the substance lead (Pb) is affected by several regulations (RoHS, ELV, REACH) and should be avoided as PFAS-replacement for environmental reasons.

- PFPE (example 2):

Exemplary use cases: process aid in the manufacturing of film capacitors to define unmetallized area

Required characteristics: unique combination of electrical parameter and heat resistance

Alternatives: Not known.

- PFPE (example 3):

Exemplary use cases: heat transfer fluid for resistance measurement at NTC thermistors

Required characteristics: unique combination wide application temperature range, resistance to chemicals, dielectric properties

Alternatives: Not known for a general replacement. Only in some specific cases, silicone oil can be used. But silicone oil is a banned substance for certain applications (e.g., automotive) and by customers.

- PTFE tools

Exemplary use cases: jigs and tools in the production of electronic components (e.g. wafer carriers, sealing rings and handling tools).

Required characteristics: unique combination of heat resistance, resistance to chemicals (process aids) and mechanical properties (flexibility and stability) to prevent scratches on e.g. sensitive silicone-wafers

Alternatives: Not known.

- PFAS coatings

Exemplary use cases: coating/encapsulation of sensors in harsh environments

Required characteristics: unique combination of heat resistance up to 260°C, resistance to chemicals, resistance to moisture and wetness (hydrophobic properties), mechanical properties (stability), dielectric strength at high temperature.

Alternatives: It is very likely that alternatives do not exist at all (based on experience from extensive R&D efforts).

- C_3F_8, C_4F_8 (and CF_4):

Exemplary use cases: used for MEMS Reactive Ion Etching (RIE) and Deep Reactive Ion Etching (DRIE) in order to passivate the silicon surface

Required characteristics: Achievable aspect ratio (defined as the total depth etched divided by the total elapsed time)

Alternatives: Not known at all. A sufficient aspect ratio is only known to be commercially achievable with fluorinated process gases.

Emissions in the End-of-life

The amount of PFAS, which can theoretically be emitted in the End-of-Life treatment, is also very limited. PFAS containing articles in electrical and electronic equipment are collected and dealt with in accordance with applicable regulations, e.g. Waste Framework Directive (WFD) 2008/98/EC, ELV Directive 2000/53/EC and WEEE Directive

2012/19/EU. If the components cannot be repaired or directly reused, they are sent for material or thermal recycling (a recent study by Conversio has shown that at its end-of-life approximately 85% of all fluoropolymers end up in waste-to-energy recovery incinerators). In these processes, the polymeric PFAS contained in our articles are either broken down into their original components or mineralized so that the PFAS properties are lost. Latest studies confirm that fluoropolymers at their end of life when incinerated under representative European municipal incinerators conditions do not generate any measurable levels of PFAS emissions and therefore pose no risk to human health and the environment.

Most of the technically used PFAS are stable for a long time and very resistant to chemicals. PFAS waste treatment technologies are mostly investigated and technically evaluated by energy assisted technologies. In the case of polymeric PFAS, incineration technologies were investigated with PTFE waste.

Under test conditions in a waste incineration chamber, with a setup in compliance to the requirements of the 17th BImSchV, it was demonstrated that polytetrafluoroethylene (PTFE) can be almost fully transformed into fluoride (F-) (as hydrofluoric acid (HF)). Samples of the flue gas were analysed for the presence of 31 PFAS and found to be without significant measurable PFAS content.

At temperatures above 750°C PTFE decomposed to C_2F_4 and C_3F_6 in a pyrolysis process. During further combustion CF_4 will be generated. At combustion temperatures above 1000°C CF_4 formation is much reduced.

Based on this result a municipal incineration system according to the requirements according to §8 of the 17.th BImSchV was sufficient to not detect any PFAS in the flue gas with exception of greenhouse gases like CF_4 or C_2F_6 but with low evidence due to weak database. Technologies for CF_4 decompositions are in operation and development with a focus on semiconductor processes. A system for incineration of hazardous waste operates at about 200°C higher combustion temperature.

A test facility for incineration of production PFAS waste was setup in Cooperation with the "Deutsche Bundesstiftung Umwelt" and company Dyneon. This facility is able to decompose more than 90% into its monomers.

Other test facilities investigated the incineration of PFOA treated fibers and observed decomposition at 1000°C without chromatographically detectable PFAS in the flue gas.

In a literature study PFOA and PFOS decomposition was successfully investigated at 350°C in supercritical water.

Incineration of Perfluoropolyether (PFPE) are less investigated but during development of PFPE fluids was observed that these fluids become instable at temperature above 290°C

Other incineration systems for PFPE operate at 330°C with metallic iron reactants like aluminum powder for binding decomposed PFPE.

For treatment of radioactive PFPE lubricants an incineration system with MnO_2-catalyst and $N_{12}CO_3$ immobilizer was successfully tested.

Impacts on the recycling industry

PFAS-containing products already placed on the EU market can no longer be supplied after the compliance enforcement date and have to be disposed of as hazardous waste. Also, existing stocks of PFAS-containing components and equipment already placed on the market for the first time have to be disposed of as hazardous waste, incl. almost all electric and electronic devices for second-hand use.

Recycling industry is working with high volume processing, such as shredding, of different types of products with different compositions on a ton scale and not on a single piece scale. Given the extremely low threshold of 25 ppb, even a few components containing PFAS would degrade extremely large quantities of recycled materials into hazardous waste.

High amounts of high-quality material as well as still fully functional devices must be treated as hazardous waste instead of being recycled, reused and conserving resources. Instead, high amounts of virgin materials are required to cover the needs with the related environmental impact and the dependance on the sources, which are often outside of the EEA.

Proposed derogations

German manufacturers of electrical components are calling on the regulatory authorities to preserve the European production, labor and sales market. Restrict PFAS only in areas where there is a real risk from PFAS and establish exemptions and derogations where PFAS are safe to be used and crucial in critical-to-the-world applications:

1. Introduce a reporting requirement to ensure sufficient data on use along the supply chain.

2. Fully exclude polymeric PFAS from the scope of the upcoming restriction; at least fluoropolymers/-elastomers and perfluoropolyether.

3. Establish a **13,5-year exemption** for the use of PFASs in electronic components and their manufacturing, to be reviewed for renewal at least two years prior to expiration. In this context it is very important to choose a wording that allows PFAS as ingredient within the components as well as the use of PFAS as process aids in the production of electronic components.

4. Establishing a reasonable and practicable threshold for intentionally added levels of 0.1 percent by weight.

For no. 2 and 3 above we propose the following wording:

"By way of derogation, paragraphs 1 and 2 do not apply to:

- Polymeric PFAS such as fluoropolymers/elastomers and perfluoropolyether for use in for use in and manufacturing of electrical and electronic equipment (EEE) or associated electronics and components such as control units, sensors, capacitors, resistors, inductors, filters and electrical and electromechanical components such as connectors.

- Non polymeric PFAS for use in and manufacturing of electrical and electronic equipment (EEE) or associated electronics and components such as control units, sensors, capacitors, resistors, inductors, filters and electrical and electromechanical components such as connectors until 13,5 years after EiF. This derogation shall be reviewed and assessed by the commission no later than 11,5 years after EiF"

Batteries

ZVEI Battery Section supports the objective of avoiding emissions of hazardous substances into the environment. In our view mobility and energy supply must become climate-neutral within a few decades. The German industry offers a wide range of solutions in the area of batteries to reach this goal. Batteries are essential for the success of the EU Green Deal and to meet the goals of the EU Fit For 55 program. All state-of-the-art batteries of today – irrespective of the electrochemical systems – benefit from or even cannot be produced without the use of PFAS. No non-PFAS alternative materials that meet the standards of efficiency, durability and safety are currently known. PFAS used in the battery industry are crucial as their chemical resistance and tolerance to a high range of working temperatures are necessary properties for the safe and proper functioning of the batteries. PFAS are used in key components and/or production of most high-performance battery technologies such as lead-, nickel-, alkaline metal-air- and especially lithium-based systems as needed for future electromobility and energy storage applications. Even if alternative solutions exist or can be developed, they are expected to lower the efficiency and durability of batteries in most cases, which would also mean that much more batteries need to be produced to achieve the planned energy transition, leading to higher consumption of energy and material and more waste at the end of life. Restricting substances for batteries should therefore not be done without a differentiated consideration of the uses and the consequences for them. Moreover, a more differentiated regulatory approach that is risk-based according to Article 68(1) REACH and substance-based according to Article 69 REACH should be applied. The proposed use-ban of PFAS in the battery industry regardless of their toxicity and their potential to emit into the environment does not meet these criteria. Most PFAS substances that are relevant for batteries (such as PVDF and PTFE as electrode binders) are fluoropolymers, which are not toxic and have a much more benign environmental profile than monomolecular PFAS regarding their bioaccumulative properties and mobility in the environment as defined by OECD and shown in numerous studies (e.g.: A critical review of the application of polymer of low concern regulatory criteria to fluoropolymers II: Fluoroplastics and Fluorelastomers, Stephen H. Korzeniowski et al, 2022. A critical review of the application of polymers of low concern and regulatory criteria to fluoropolymers, Barbara Henry et al, 2018). Fluoropolymers should therefore not be in the scope of the planned regulation. For all PFAS substance used in batteries that will eventually be restricted, the German battery industry requests derogation periods of 13.5 years due to the fact that suitable non-PFAS alternatives are not known so far. On top of that, downstream industries such as manufacturers of equipment powered by batteries will need further 2-3 years (and even much longer in case of some especially safety-sensitive applications such as explosive atmospheres) for testing and adapting of PFAS-free batteries in their products.

Finally, we would like to stress the need for timely and frequent reviews during the derogation periods and the possibility to extend them in case that potential alternatives still have not been found after a certain time.

Sectors and uses

The comments apply for the following sectors:

- energy and here as sub sector batteries, specifically downstream user industries (e.g., manufacturers of equipment, vehicles and products powered by batteries).

Emissions in the End-of-life

2a) Emissions during battery manufacturing: No unintended and uncontrolled PFAS emissions are foreseen during manufacturing of batteries or battery components (see section 4.2.1 of the attached RECHARGE paper).

Emissions during battery use: Batteries are defined in the REACH regulation as "an article with no intended release" meaning that, under normal and reasonably foreseeable conditions of use, no end-user of the Batteries will be exposed to any chemical substances. No PFAS emissions are foreseen during battery use (see section 4.2.2 of the attached RECHARGE paper).

Emissions during battery recycling: In general, the new battery regulation and the existing battery directive stipulates that no batteries should end up in the environment at the end of their life cycle.

b) No adequate information available.

Impacts on the recycling industry

No adequate information available. Battery recycling is mandatory in Europe since 2006 according to the Battery Directive and will remain mandatory with higher recycling targets in the upcoming Battery Regulation.

Missing uses

a) There are no national sector figures for the German battery industry available. Therefore, we refer to section 4.1 of the Recharge paper for the PFAS consumption in tons in the EU.

Emissions during manufacturing – we refer to sections 4.2 and 5 of the paper submitted by REACHARGE to this consultation.

b) PFAS (in particular PTEF and PVDF) are used in batteries as binder materials in active material mass of electrodes. Even if a battery system does not benefit from PFAS in active material, PFAS are used in electrolytes, valves, gaskets, washers, permeable membranes (more details in section 2 of the Recharge paper).

In addition to the PFAS contained in the batteries, we would also like to point out the importance of using PFAS, especially fluoropolymers like PTFE, in manufacturing equipment for batteries. Depending on the kind of battery, parts like mixers, pipes and coaters used in related processes are often exposed to extreme conditions like high temperatures and corrosive chemicals, for which no other suitable materials are available. In this respect, we support the contribution of VDMA (Verband Deutscher Maschinen- und Anlagenbau) to this consultation.

Proposed derogations

No adequate information available for our industry

Proccess-supporting-substances

Sectors and uses

Because of the unique characteristics PFAS are required as processing agents for dedicated advanced processes in industrial applications. The respective tools are developed for very particular processes with high investment requirements. Usually these machines are depreciated over 10 years and longer (AFA-list) and need double the lifetime to make the high investments reasonable. As common characteristic the PFAS are kept in close industrial processes without uncontrolled release into the environment. The PFAS containing liquids are used in closed loops and are internally circulated and refurbished by the manufacturers.

The restriction dossier summarises the entire E&E industry in one short paragraph, without taking into account the complexity of the E&E industry or applications. Nearly every complex technical article is somehow related to E&E, from a small bicycle lamp to complex industrial tools. Therefore, only a few examples can be given as representative of many other applications.

Emissions in the End-of-life

The PFAS-based substances are used in a controlled industrial environment. Management processes such as ISO 9001 and ISO14001 ensure that these substances are handled properly and safely. In general, the liquids containing PFAS are extracted from the tools and returned to the manufactures for cleaning and reuse or are sent to qualified waste stream operators.
In applications where PFAS-based liquids are used as process fluids (i.e., vapor phase soldering or fluid heating processes) the PFAS-based liquids do not have an end of life through contamination or chemical destabilisation. At the end of the life of the process equipment, these PFAS-containing process fluids are drained, filtered and then 100% reused in new production equipment. The PFAS containing process fluids are NOT disposed of or destroyed.

Gaseous PFAS emissions, e.g., from etching processes, are treated in qualified abatement systems using thermal incineration.

There are different sources in the literature for studies on the incineration of PFAS. In summary, PFAS decompose in municipal incineration facilities at BAT level. See attached PDF for more details

Impacts on the recycling industry

There are different sources in the literature for studies on the incineration of PFAS. In summary, PFAS decompose in municipal incineration facilities at BAT level. See attached PDF for more details

Missing uses

The physical and chemical properties of the PFAS heat transfer liquid are essential for the process of vapor phase soldering and fluid heating. Only these properties make this process possible and applicable for production. The properties are immanent to PFAS, they are based on this chemical structure and are conditioned by it.

The properties of the heat transfer liquid required for vapor phase soldering and fluid heating can only be guaranteed by PFAS. No other material offers the properties required for this process. If the production or composition of this heat transfer fluid is changed, this process no longer works. The PFAS cannot be substituted by any other material as a heat transfer liquid.

There has been permanent searching for alternative substances that are not based on PFAS and have the properties of PFAS as a heat transfer liquid. Regular and repeated contacts with the chemical industry, research and development and universities brought the only result: there are no alternatives and they are not even imaginable.

A ban on PFAS for use in vapor phase soldering systems and heat transfer liquids therefore inevitably leads to the "end" for the technology.

Many existing products in the E&E industry can no longer be processed without these processes and the machines that run these processes. If these processes and the respective production machines are not derogated, Europe will not only lose all this E&E production but also experience a significant step backwards related to the use of products of important sectors such as electronics for the energy sector (production of energy, storage, power electronics), automotive (electromobility, charging infrastructure), medical, aerospace and communication technology (5G, networks, data storage) - just to name a few examples. The significant impact on daily life is self-explanatory.

Proposed derogations

The use of PFAS-containing lubricants is suggested by the entry "s" for a derogation, but this only refers to specific applications where they are used as lubricants.

However, there are applications, where PFAS-containing "lubricants" are used for purposes other than lubrication.

In vapour phase soldering systems, the substances are used for the process itself - heat transfer to heat various products for electronics or other applications. There are no PFAS-free alternatives for the vapour phase soldering process.

The same is true for the etching process and the liquid heating process.

We see a need for these substances to be made available for an **unlimited period of time** due to their wide range of uses. A time limit on the exemption should only be imposed in individual cases where substitutes are already known and under further development.

Consumer Electronics

Consumer electronics (CE) products are used in every household and in many cases also in companies. PFAS, especially fluoropolymers, are relevant for the production of various products in the consumer electronics industry and affect the following product groups, among others:

- TV sets (including displays, housings, cables)
- Projectors
- Sound systems / loudspeakers

- Microphones

Accordingly, consumers and commercial users would be particularly affected by a PFAS ban.

Sectors and uses

- Lifetime: Consumer electronics (CE) products must withstand the everyday stress of frequent daily use. PFAS are therefore used, for example, in housings and other components to extend durability.
- Required availability period of spare parts: For displays, for example, this is regulated in the corresponding Ecodesign Regulation. This stipulates that spare parts must be available for at least seven years after the last product in a product series has been placed on the market. According to the present restriction proposal, a PFAS ban would also apply to spare parts and make repairs impossible.
- Temperature resistance: Consumer electronics (CE) products usually have cables whose coating almost without exception contains PFAS to ensure heat resistance.
- Standards: UL 94 is important for PFAS e.g. PTFE as anti-drip agent. PTFE is used to improve flame retardancy. It has an extremely high melt viscosity and is elementary for the safety of electrical and electronic equipment.

Impacts on the recycling industry

The environmental impact of PFAS in electrical and electronic equipment (EEE) is foreseeably extremely low, as EEEs are to be disposed of properly according to the WEEE Directive.

Proposed derogations

- A transition period of at least 6.5 years is generally required.
- We request a general derogation period of 12 years (plus transition period) for PFAS in Li-ion batteries (see the submission of ZVEI battery section).
- For semiconductors, a transition period of at least 12 years (plus transition period) is necessary (see the corresponding consultation contribution or the factsheet on semiconductors).
- Polymeric PFAS meeting the OECD criteria for "polymers of low concern" should be excluded from the scope of the restriction or should be granted a long-term derogation.
- All exemptions should include a review option for further prolongation if no substitutes are available.

Electric Household Appliances

The supply chain of household appliances is long and complex. A lot of information is passed along the supply chain - but not all of it. Many manufacturers of household electrical appliances do not have comprehensive information on PFAS processed in their products, as there is no obligation to provide information along the supply chain. Due to the complex supply chain and the variety of individual substances to be checked, which are grouped under PFAS, it is therefore not possible at the present time to carry out a conclusive assessment on the use of PFAS in household electrical appliances. The present assessment can therefore be continuously supplemented.

Sectors and uses

Household appliances are indispensable in every household, which is why a universal PFAS ban would primarily affect consumers. PFASs, especially fluoropolymers, are relevant to produce a wide variety of products in the household appliance industry and affect the following product groups (list not exhaustive):

- Refrigerators: refrigerators, freezers, ice-cream makers;
- Cooling, heating and/or dehumidifying appliances: air conditioners, water heaters, air purifiers and dehumidifiers;
- Washing and/or drying appliances: dishwashers, washing machines, tumble dryers, washer-dryers (all with/without heat pump technology);
- Cleaning appliances: hoovers, washing vacuums, window vacuums, floor cleaners, wet/dry/ash vacuums, high-pressure cleaners, steam cleaners, air purifiers;
- Cooking appliances: sandwich toasters, waffle irons, electric grills, hot air fryers, coffee makers, ovens, blenders, food processors, cookers, slow cookers, rice cookers.

PFASs are used in many different components and parts of the household appliance industry. Due to the wide range of applications, it is not possible to make a concrete estimate of the proportion of jobs and turnover accounted for by products containing PFASs.

As products used by the consumer in everyday life, good performance and reliability, for example through consistently reliable heat and water resistance, sensible seals as well as well running grinders (e.g. in coffee machines), are particularly important for household appliances. Doing without the polymers used could reduce these two particularly important properties and lead to higher resource and energy consumption through the increased use of replacement and wear parts, which is contrary to the goals of the EU Green Deal.

Household electrical appliances have to withstand many stresses in everyday life. Consumers use the appliances every day to facilitate many activities. Household electrical appliances must be built accordingly. Here, PFASs help, for example, to make surfaces scratch-resistant and appliances particularly heatresistant, or to make rubber seals more flexible.

For large electrical household appliances, the corresponding ecodesign regulations provide for the stocking of spare parts for several years after the last appliance was placed on the market. In this way, consumers should have reliable access to spare parts. These spare parts contain the same substances as the appliance produced. A ban on PFAS in spare parts would thus artificially reduce the lifetime of large electrical household appliances, as even minor repairs would no longer be possible.

Many household electrical appliances have a cable for the power supply. Cable sheaths must be resistant to flying sparks so that they are not set on fire. PFASs are used in the cable sheathing for this purpose.

The use of PFAS enables long-lasting components and products because they are resistant and robust. This leads to low spare parts consumption and service requirements.

Impacts on the recycling industry

- Electrical appliances are usually recycled properly after use.
- Sorting residues containing PFAS are disposed of properly and in accordance with defined standards of the German WEEE legislation (ElektroG).
- In the production of household electrical appliances, attention is paid to the appropriate legal protection for workers in the workplace.

Proposed derogations

As the current data situation on PFAS within the sector of household electrical appliances is insufficient or hardly available, longer transition periods and differentiated consideration of PFAS are necessary. The reason for this is that manufacturers do not yet have complete transparency of the supply chain.

We also propose an exemption for b2c products for fluoropolymers and fluoroelastomers and a longer transition period of several years. This would give the household electrical appliances sector sufficient time to change.

Cables

PFAS are used in the form of fluoropolymers in cables. Cables and conductors with these PFAS are indispensable for the implementation of the energy transition, expansion of sustainable energies, electromobility, production areas including food production, pharmaceutical and chemical industries, medical technology and plastics processing, as well as plant safety.

Sectors and uses

Cables have to be insulated to meet the requirements of a technically safe product (e.g. compliance with the Low Voltage Directive). In particularly aggressive environments and critical applications, material components out of the group of fluoropolymers are used. According to the OECD, fluoropolymers are considered as "polymers of low concern"/PLC.

Other components of a cable, such as fillers and tapes, are also made of fluoropolymers in order to achieve certain required properties in the overall product.

The required properties result from the area of application of the respective cable type. For cables, containing Fluoropolymers such areas of application are:

- Automotive industry
- Aerospace industry
- Pharmaceutical and chemical industry
- Food production
- Plastics processing
- Wind power plants
- Medical technology others

Fluoropolymers are selected for their particular combination of properties when no other alternatives are possible. These requirements are:

- Flexibility
- Wide temperature range (-30 to +200 °C)
- Resistance to different organic solvents, acids and bases
- UV and Ozon resistance
- Non-flammable property
- Low permittivity value (electric parameter for data communication)
- Very low friction (bending performance)
- Very thin wall thicknesses (processing - extrusion)

- Durability and Longevity over lifetime

End of life phase

The PFAS based substances are used in a controlled industrial environment. Management processes such as ISO 9001 and ISO14001 ensure that these substances are handled properly and safely.

Cables are typically collected and treated/milled in the waste stream. Metal components are recycled by melting and reused for the creation of new metal alloys. The polymer fraction is incinerated.

Impacts on the recycling industry

From today's point of view the recycling industry isn't impacted because the PFAS adhering to the metal parts decompose during metal recycling. The plastic components of cables are typically incinerated in case of waste coming from end of life goods. Production waste is treated single graded with technically and economically reasonable processes.

Proposed derogations

We therefore request long-term and unlimited exemptions for fluoropolymer applications in the cable industry. This also implies the raw materials used for our products, such as granules, powders, suspensions. Alternatively, an indefinite exemption for this group of PFAS is essential for cable applications.

Electrical Installation Systems

Electrical installation systems with products made of:

- Polycarbonate with partly safety-relevant flame-retardant properties or as an additive in polymer production and chemical synthesis
- Abrasion-resistant, permanently slippery or chemically resistant surfaces to maintain the technical properties (e.g. safety
-Relevant components for protection against electric shock) and service life of equipment components e.g. switching elements, sliding pairs
- Printed circuit boards with flame retardant and durable surface protection (protective lacquer)
- Insulation in electronic components and circuits to achieve the dielectric strength and tracking resistance required by safety and standards in combination with higher temperature resistance.
- Durable, weather-resistant seals and surfaces - Electrical installation tubes for high-temperature protection in plant and machine construction
- Various currently unknown PFAS applications in all stages of the manufacturing process
- Based on current knowledge, almost all EIS products may be affected
- Greases and lubricants in safety-relevant components for protection against electric shock.

Sectors and uses

Electrotechnical products are indispensable for building technology (switches, sockets, protective switchgear), for energy-efficient building automation (actuators, sensors, smart home), for decentralized power generation, for storage systems, for energy management systems, and in plant and mechanical engineering for protecting cables and electrical connections at high temperatures. Protection devices make an important contribution to the security of supply of electrical systems.

Proposed derogations

Qualification and approval of alternative materials require a very large amount of time:
- Development of the alternative material at the material manufacturers.
- Approval / listing of these materials - Equipment development for conversion to alternative materials
- Approval of the corresponding devices

These steps can essentially only be processed sequentially. Depending on the extent to which even completely new material compositions must be researched, time periods in the order of 10 years may well come into play for this.

a) approx. 3 years for known substitutes

b) For substitutes not yet ready for industrial use, approx. **5-10 years**

c) For drop-in substitutes with market maturity approx. **5 years**

Conclusion

In light of the extensive technical and scientific data gathered from our members, Orgalim believes to have given clear evidence of the harm a universal ban for PFAS will mean. A blanket ban will severely impact Europe's technology industries, whose production will face serious challenges given the current unavailability of viable PFAS-free alternatives.

Furthermore, the specific derogation proposals of each industry make visible the impracticality of imposing a one-size-fits-all approach for such a broad restriction. Therefore, a long-term general derogation for fluoropolymers without relevant risk to be reviewed before expiration is crucial.

The relevance of PFAS in production can not be underestimated. Orgalim calls upon the relevant legislators to reconsider the blanket ban approach as it will endanger the fulfilment of the climate and industrial policy objectives of the Green Deal, innovation, and competitiveness of EU's industry as our members have substantially evidenced it.