PFAS restriction

# ACEA COMMENTS ON THE ANNEX XV DOSSIER OF THE UNIVERSAL PFAS RESTRICTION PROPOSAL

September 2023

Second submission

ACEA - European Automobile Manufacturers' Association

## WHO WE REPRESENT

ACEA MEMBERS

## ABOUT ACEA

The European Automobile Manufacturers' Association is a professional association uniting 14 major mobility actors on the European market.

- 13.0 million Europeans work in the auto industry (directly and indirectly), accounting for 7% of all EU jobs.
- 11.5% of EU manufacturing jobs – some 3.4 million – are in the automotive sector.
- Motor vehicles are responsible for €374.6 billion of tax revenue for governments across key European markets.
- The automobile industry generates a trade surplus of €79.5 billion for the European Union
- The turnover generated by the auto industry represents almost 8% of the EU's GDP
- Investing €58.8 billion in R&D per year, automotive is Europe's largest private contributor to innovation, accounting for 32% of the EU total.

Today, ACEA would like to extend the first submission to the public consultation on the universal PFAS restriction proposal that was submitted on May 24$^{th}$.

CONTENT

# I. INTRODUCTION AND CONTEXT

The PFAS REACH restriction is expected to have a major impact on the automotive industry. This document is the second response of ACEA to the public consultation and on the revised Annex XV dossier published on 22 March 2023.

PFAS are mainly used in the automotive industry for their unique properties:

- High stability
- Resistance to high temperatures and high pressures
- Electrical insulation
- Resistance to aggressive chemicals
- Resistance to friction
- Surfactants properties

As of today, the restriction proposal includes fluoropolymers and fluoroelastomers, which are fundamental to our industry. F-gases, also included in the restriction proposal, are also widely used as refrigerants and for testing methods.

As mentioned in our first contribution to the consultation (comment ID 4276) ACEA fully shares the desire to reduce the uses if PFAS in our industry. The current proposal by the dossier submitter is not appropriate as it would have critical impact on automotive industry; mainly the impossibility to produce, approve and place on the market vehicles, as well as strongly negate the possibility to shift to better and greener technologies and electromobility.

This submission is an addition to the first ACEA document submitted on the 24th of May 2023. We wish to explicit our position and give to the ECHA committees our proposal for relevant risk option management on PFAS. We also wish to give further details on the impact of the restriction proposal on the automotive industry, especially on the following subjects:

- Textiles in the automotive industry, as displayed in the answer to the ECHA online questionnaire – see online questionnaire.
- PFAS in air conditioning as an addition to our first submission.
- PFAS used in the production process of vehicles, part IV of this document, and in the production equipment.
- PFAS used in H2 technology in automotive industry, as annex I of this document.
- Electronics in the automotive industry, which can be found as the annex II in this document.
- Lubricants in the automotive industry, also to be found as the annex IV in this document.
- PFAS used in paints, lacquers, and coatings, as the annex VI of this document.

## II. PROPOSAL FOR ALTERNATIVE APPROACH ON PFAS DEROGATIONS AND EXEMPTIONS

We believe a reduced scope excluding non-hazardous PFAS such as fluoropolymers and fluoroelastomers would be beneficial. Some PFAS have proven to be non-mobile, non-bioaccumulative and non-toxic in their use phase. Furthermore, recycling obligations at the end of life are already applicable for some of their uses (for instance, as stipulated in the new Batteries Regulation).

A reduced scope would help industries and authorities to address every substance in a timely manner and identify priority issues for which urgent action is needed, thus bringing a rational, efficient and methodological approach to the discussions.

**As such, we would like to propose an exclusion of the fluoropolymers and fluoroelastomers of the scope of the proposal:**

- Concerning the manufacturing phase, the risks of PFAS emissions to the environment can be controlled with alternative Risk Management Options.
- Concerning the use phase, they are considered non-toxic, non-bioaccumulative, non-mobile and as such, are classed as polymers of low concern by OECD.
- Concerning the end-of-life phase, incineration of fluoropolymers does not contribute to environmental PFAS emissions and is a safe method of disposal.

Several other industrial associations have supported similar request in their submission to the public consultation, highlighting a growing concern across the industry.

ACEA also knows that changing the scope of the proposed restriction may be complex at this state of the process. Should the fluoropolymers and fluoroelastomers stay I the scope of the derogation, ACEA would request specific derogation concerning fluoropolymers and fluoroelastomers.

Currently, most fluoropolymers and fluoroelastomers uses fall under the proposed derogation 6.o about the safety of vehicles and passengers. As stated below and in our first submission, ACEA fully support the inclusion of this proposed derogation in the final text of the Annex XV dossier.

**However, some applications are reported to provide durability or to comply other regulations (example: emissions), which are non-safety related. As such, we would like to request a 6,5-year derogation for fluoropolymers and fluoroelastomers in such cases, with a review clause performed by the Commission to assess the state of the available alternatives.**

If fluoropolymers and fluoroelastomers are not excluded from the scope of the restriction proposal, we would need to have several new derogations to be able to transition and maintain a relevant industry. As of today, and considering the data we gathered on the uses of PFAS in the automotive industry, we identified the following derogations to be needed for our industry:

| Original Annex XV report text | Amendment |
|---|---|
| **Derogations with no time limitations** | |
| No Derogation<br>The following potential exemption are marked for reconsideration after the Annex XV report consultation:<br><br>6.o. [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 EiF]. | 6.o. applications affecting the proper functioning or safety of transport vehicles, or affecting the safety of operators, passengers, or goods. |
| No derogation<br><br>The following potential derogations are marked for reconsideration after the Annex XV report consultation:<br><br>5.ee [The semiconductor manufacturing process until 13.5 year after EiF] | **Use of PFAS in semiconductor Package**. |
| No derogation<br><br>The following potential derogations are marked for reconsideration after the Annex XV report consultation:<br><br>5.ee [The semiconductor manufacturing process until 13.5 year after EiF] | 5.ee The semiconductor **manufacturing process.** |
| 5.s lubricants where the use takes place under harsh conditions, or the use is needed for safe functioning and safety of equipment until 13.5 years after EIF | 5.s Lubricants (oils & greases) where the use takes place under harsh conditions, or the use is needed for safe functioning or for compliance to regulations (emissions, safety). |
| No derogation | 6.xx Low and high voltage Electrical and electronic components and control units |
| No derogation | **By way of derogation, paragraphs 1 and 2 shall not apply to:**<br>Vehicles already on the market and<br>- Spare parts to repair these vehicles<br>- Aged batteries for repurpose<br>- Maintenance of machinery<br>- PEM membrane for electrolysers<br>- machinery for tire production |

| | |
|---|---|
| **Derogation effective until 13,5 years after EiF** | |
| No derogation | 6.xx Rechargeable batteries cells until 13,5 years after EIF for automotive vehicles {*} |
| 6.e proton-exchange membrane (PEM) fuel cells until 6.5 years after EiF; | 6.e proton-exchange membrane (PEM), anode and cathode, gas diffusion layer, seals, humidifier membrane, Hydrogen sensor in fuel cells and electrolysers until 13,5 years after EIF. |
| No derogation | 5.xx Control cable lines, coatings for sliding elements (bearing, bushings, guides) and coating of tubes until 13,5 years after EIF. |
| No derogation | 5.xx Sealing applications until 13,5 years after EIF. |
| The following potential exemption are marked for reconsideration after the Annex XV report consultation:<br><br>5.v [hard chrome plating until 6.5 years after EiF] | 5.v Hard chrome plating until 13,5 years after EIF. |
| The following potential exemption are marked for reconsideration after the Annex XV report consultation:<br>5.u [textiles for the use in engine bays for noise and vibration insulation used in the automotive industry until 13.5 years after EiF] | 5.u textiles used in engine bays for ignition protection and noise and vibration insulation in automotive means of transport and non-road mobile machinery (NRMM) until 13,5 years after EIF. |
| No derogation | 5.xx Flame retardant additives until 13,5 years after EiF. |
| **Derogations effective until 6,5 years after EiF** | |
| No derogation | 5.xx Body applications until 6,5 years after EIF. |
| 5.e textiles for the use in filtration and separation media used in high performance air and liquid applications in industrial or professional settings that require a combination of water and oil repellence until 6.5 years after EiF. | 5.e filtration and separation media used in air and liquid applications in industrial or professional settings that require a combination of water and oil repellence until 6.5 years after EiF. |
| **Specific Derogation** | |
| No derogation | 5.xx Components of combustion engine systems in harsh conditions (high temperature, contact with Hydrocarbons) Examples: lines and hoses, sealing systems (static and dynamic) membranes (valves, |

| | |
|---|---|
| | sensors) until ICE ban, and for ICE and hybrid applications exported after. |
| No derogation | Any vehicles applications of fluoropolymers and fluoroelastomers not fulfilling any other derogations until 6,5 years after EiF |
| Only partial derogation<br>5.p Refrigerants in mobile air conditioning-systems in combustion engine vehicles with mechanical compressors until 6.5 years after EiF. | Refrigerants used in mobile air conditioning systems until:<br>- 7 years after EiF for new vehicle types for passenger cars.<br>- 17 years after EiF for new registrations for passenger cars.<br>- 10 years after EiF for new vehicle types for heavy-duty vehicles.<br>- 22 years after EiF for new registration for heavy-duty vehicles.<br><br>Unlimited derogation for systems in combustion engine vehicles with mechanical compressors. |
| No derogation | **“Request for distinction between vehicle New Type (NT*) and vehicle All Type (AT*) [**in case of derogation lower than 13.5 years after Entry In Force: +10 years between AT and NT<br>(*) according to (EU) 2018/858 type approval” |

Considering the great number of uses of PFAS in the automotive industry, and in other industries, the research and qualification of alternatives will take an amount of time which is impossible to assess considering the current information. As such, we propose to add review clauses to all derogation proposals:

**UPDATE OF DEROGATION according to technical progress**: **Review clause after 3 years (for 6,5y derogation); Review clause after 10 years (for 13,5y derogation)”**

{*} We understand that the derogations are proposed for 6,5 and 13,5 years. However batteries applications would definitely need a specific revision clause, as the uncertainty around alternatives is too big to prevent us to have a clear view.

The review clause has already been acted for several restriction dossier, and it will enable the Commission to assess the state of the qualification of alternatives. This means that when required, extended derogation period could be granted to industrials if no PFAS-free substitutes have been found and proved to be efficient enough and commercially viable.

# III. MOBILE AIR CONDITIONING

In our first submission from May 2023, we pointed out that the PFAS ban on refrigerants as proposed has an impact on European vehicle production. As any vehicle must fulfil conformity of production when leaving the manufacturing plant any EU located vehicle plant has to produce vehicles with fully functional refrigerant systems. Therefore, manufacturers must consider PFAS free refrigerant in EU plants also for markets outside the EU, which we believe has been overlooked by the dossier submitters. Consequently, the restriction proposal would also indirectly affect non-EU market, where other refrigerants might be beneficial to meet customer expectations.

As a conservative estimate, R744 air conditioning systems would increase the production cost per vehicle by around 300€ (Report Summary F-gas use-July 2021) compared to the similar vehicle produced outside the EU with R1234yf Systems. This would mean a 1,7 billion Euro increases per year for the vehicle manufacturers in the EU and loss of competitiveness on worldwide market. This is expected to influence decisions to produce them outside the EU – with impact on employment. Overall, there are 3.5 million jobs on direct and indirect vehicle manufacturing in the EU today. Aftersales costs for dealers and workshops are significantly affected not only in the EU but also in target countries for vehicles “made in EU” – e.g., for servicing machines, workshop preparation, staff training.

Besides this direct effect for European vehicle production, we expect an impact and possible shortage of supplier capacities in Europe to meet this steep ramp up of supply parts.

# IV. PRODUCTION OF VEHICLES

## 1. Machinery and equipment are long-term capital goods.

Production facilities in the automotive industry are a very durable investment good that is handled very professionally over the entire life cycle of several decades.

A regulation that makes no distinction between new plants and existing plants endangers the continued operation of existing machines and plants. In some cases, this includes systems that have been in use for decades – and whose planned service life is far from being reached.

Regulation must therefore make a distinction between new systems and old systems; whereby old systems also include regular maintenance and repairs with the corresponding spare parts. Likewise, the affected chemicals needed can only be replaced if there are substitutes.

Individual components in these complex systems often cannot be replaced without a significant intervention in functionality, especially when elementary properties are changed. This would be expected in the event of a ban on PFAS in industrial components without replacement.

It is necessary to ensure that spare parts for these plants are available throughout the entire operating cycle in consistent quality with consistent properties to safeguard the investments made and not jeopardize competitiveness. A premature replacement of machines and systems jeopardizes investments made and must not be sought from the point of view of sustainability. Likewise, the usual further use must be possible until the end of the technical service life of used machines.

## 2. Use of PFAS in machinery and equipment.

PFAS are used as part of machine components in numerous applications. These include, for example, seals, valves, diaphragms, insulators, cables, semiconductors, and coatings.

Spare parts containing PFAS are also necessary for the long-term operation of the machines and systems, as long as no equivalent alternatives are available.

For purpose tailored and efficient implementation, the time horizon of capital goods must be considered. Even a derogation period of 13.5 years is often far too short. Accordingly, a much longer exception must apply to components and process equipment of capital goods for existing plants and their maintenance and spare parts.

Currently, the use of PFAS in existing machines and systems is not fully known due to a previously non-existent PFAS declaration obligation throughout the supply chain. To efficiently assess impact and substitutes, such a declaration obligation would be required. It however needs to be understood that there is time required for the supply chain to comply with such "new" obligation.

## 3. Use of PFAS as process chemicals in production

PFAS used in the process chemicals may not be fully declared in the safety data sheet as most of them are not classified as hazardous and there are no legal obligations to disclose the full composition of mixtures in the safety data sheet. Considering the thresholds proposed in the Annex XV, we support an extended PFAS reporting obligation for the suppliers to make sure we would be able to comply with the restriction proposal.

Process chemicals include lubricants and release agents, heat transfer fluids, test gases, electroplating additives, adhesives, cleaning agents, solvents, and auxiliary materials in the painting process. An obligation to declare PFAS in the safety data sheets of these excipients is also a prerequisite for being able to estimate which industrial machines, plants and processes would be affected.

For some applications, there are currently no suitable alternatives, which would lead to significant production restrictions, if banned. Essential coating processes for example are currently not feasible without PFAS.

A possible ban on PFAS in all areas of application of the production plants would have to be preceded by a precise declaration obligation to be able to subsequently develop the possible substitutes or process changes. A ban on fluoropolymers, which are classified as polymers of low concern, must be exempted.

## 4. Summary

**In summary our demands are:**

- ✓ a phase-out roadmap for polymeric and non-polymeric PFAS with risks to humans and the environment and substitution options,
- ✓ a review process for polymeric and non-polymeric PFAS with risks to humans and the environment and a lack of substitution options,
- ✓ a general exemption for fluoropolymers due to their low risk (OECD classification "polymers of low concern"),
- ✓ a general exemption for spare parts based on the "repair as produced" principle,
- ✓ an obligation to declare PFAS,
- ✓ a differentiation of the possible prohibitions according to the use and substitutability of the PFAS components of machine components and process chemicals,
- ✓ the openness to innovation to enable the use of polymers of low concern (PLC) in new technologies and applications that are not yet known, and
- ✓ Research funding for the replacement of essential use PFAS in production, recycling, and waste treatment.

# ANNEXES

# I. USES OF PFAS IN $H_2$ TANK STORAGE SYSTEM

| Identification | | | | | Function of PFAS in the material | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Product / Technology | Short description of product | Affected components / mixtures | PFAS | CAS number | Low friction | Heat resistance / Temperature retention | Chemical / fuel stability | Durability | Pressure equalization (membrane) | Others |
| Hydrogen tank storage systems | O-ring sealing in the tank | Tank liner-boss | FVMQ | | | X | X | | | |
| | Back-up sealing in the tank | Tank liner-boss | PTFE | 9002-84-0 | X | | | | X | |
| | O-ring sealing in the valve | Valve | FKM | 25190-89-0 | | X | X | | | |
| | Gasket in the valve | Valve | PTFE | 9002-84-0 | X | | | X | | |
| | Back-up ring sealing in the valve | Valve | PTFE | 9002-84-0 | X | | | | X | |
| | Anti-wear ring sealing in the valve | Valve | PTFE | 9002-84-0 | X | | | | | |
| | Rotula bearing | Rotula (neck mounting) | PTFE | 9002-84-0 | X | | | | | |
| | Lubricant grease | Valve-boss mounting | PTFE | 9002-84-0 | X | | | | | |
| | Gasket for cryogenic valve | Valve | PTFE | 9002-84-0 | X | X | | X | | Sealing |
| | Fluometal bearing for shaft guidance | Valve | PTFE | 9002-84-0 | X | | | X | | |
| | O-ring sealing in vacuum plug | Vacuum plug | FKM | 25190-89-0 | | | | | | Sealing + Vacuum compatibility |
| | Fluometal bearing for sliding suspension | Bracket | PTFE | 9002-84-0 | X | | | | | |

# II. ELECTRONICS IN AUTOMOTIVE INDUSTRY

## SUMMARY


- Non-polymeric PFAS monomers are used during the semiconductor manufacturing.
- Polymeric PFAS are contained in many electrical and electronic components.
- The dossier submitters have identified “Transport” and “Electronics and semiconductors” as independent main applications (sectors). But, in fact, there are many connections between these two sectors. This was visible during the semiconductor shortage which led to global production stop by many OEMs in 2021 and 2022.
- The dossier submitters did not propose a derogation for PFAS in electronics. Therefore, we propose to add a derogation for electrical and electronic components for 13.5 years.
- In the case of semiconductor manufacturing there is a time-unlimited derogation required due to lack of alternatives and complexity of the production processes.


## AUTOMOTIVE USES

Lots of electrical and electronic component are used in automotive parts and vehicles. Many of these components are found on printed circuit board (PCBs):

- Semiconductors, e.g., ICs, ASICs, Controllers, MEMS sensors
- Capacitors
- Inductors and Magnetics
- Other sensors

like inductors, magnetics, ferrite, resistors, thermistors , varistors, polyswitches, capacitors (ceramic, tantalum, electrolytic, film), quartz, resonators, etc.


Fig. 1: Passive Electronic Components

- PFAS are also found in:
    - PCBs as such, e.g., in high-frequency PCBs,
    - Connectors,
    - Wires and cables,
    - Switches and
    - Fuses.

like discrete circuits (diodes, thyristors, transistors, MOS-FET, etc.), integrated circuits, power semiconductors (thyristors, IGBT´s, MOS-FET´s) any other performance module, etc.

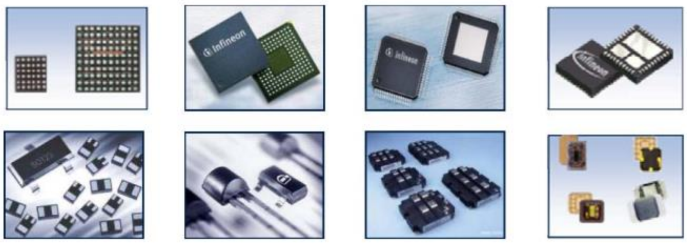


Fig. 2: Active electronic Components

**c) and others**

like terminals, heat sinks, relays, pins, sockets, plugs, and sensors as well as other electromechanical components /devices suitable to be used on a board.

Components in themselves can have ECB's with components like IC's, resistors, capacitors. Examples of such components are actuators and sensors.

[6]

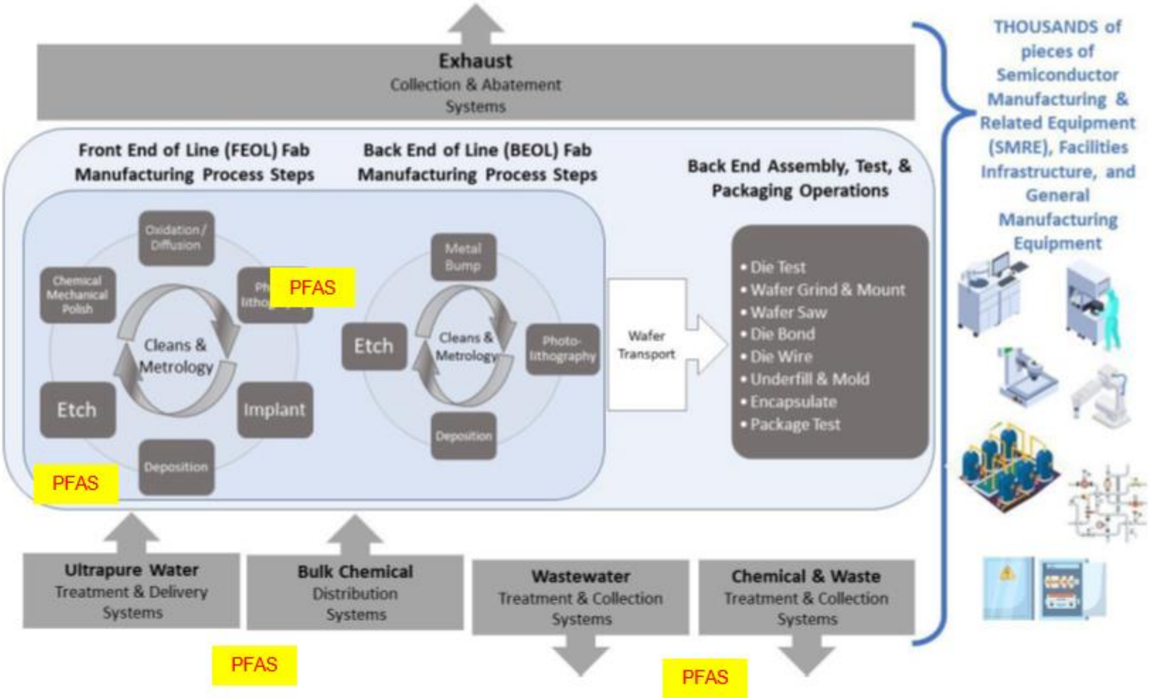
The dossier submitters have classified the uses in such a way to distinguish between electronics and transport. However, we would like to emphasize that there are many interlinkages between sector (main application) “Electronics and semiconductors” and “Transport”.

| Main applications | Sub-uses (non-exhaustive) of thoroughly investigated PFAS main applications | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Medical devices | Implantable medical devices | Wound treatment products | Tubes and catheters | Metered Dose Inhalers (MDIs), e.g. as coating and propellant | Cleaning and heat transfer: engineered fluids | Sterilization gases | Diagnostic laboratory testing | Rigid gas permeable (RGP) contact lenses and ophthalmic lenses | Packaging of medical devices |
| Transport | Body-, hull- and fuselage construction | Sealing applications | Combustion engine systems | Electrical engineering and information technology | Safety equipment (incl. fire prevention and protection) | Hydraulic fluids | HVACR*-systems | Coating and finishings | |
| Electronics and semiconductors | Wires and cables | Coating, solvents and cleaning | Electronic components | Heat transfer fluids | Advanced semiconductor packaging | Photolithography | | | |
| Energy sector | Photovoltaic cells | Wind energy | Coal based power plant | Nuclear power plant | Proton exchange membrane (PEM) fuel cells | Electrolysis technologies (not PEM) | (Lithium-ion) batteries | | |
| Construction products | Roofing | Bridge bearings | Sealings and adhesives | Processing aids and polymer processing aids | Coatings, paints, varnishes and impregnation | Coatings for wind turbine blades and solar cells | | | |
| Lubricants | Low viscosity lubricants | Solid/dry-film lubrication | Release-agents | Greases | | | | | |
| Petroleum and mining | Drilling fluids | Well stimulation chemicals | Anti-foaming agents | Water and gas tracers | Metal salts recovery | Lining of piping, seals, sensors, cables, etc. | | | |

# FUNCTIONAL USES – SEMICONDUCTORS – PFAS IN PRODUCTION PROCESS

PFAS are used in semiconductor manufacturing process and advanced packaging.

- ESIA elaborated on the PFAS use in the semiconductor manufacturing process.
- PFAS are used in three major manufacturing steps:
    - Photolithography
    - Wet chemistries (additional sub-use)
    - Plasma Etch / Wafer Clean (additional sub-use)



[2]

Figure 10-1 ASML Latest Extreme Ultraviolet Photolithography Exposure Tool.[79]

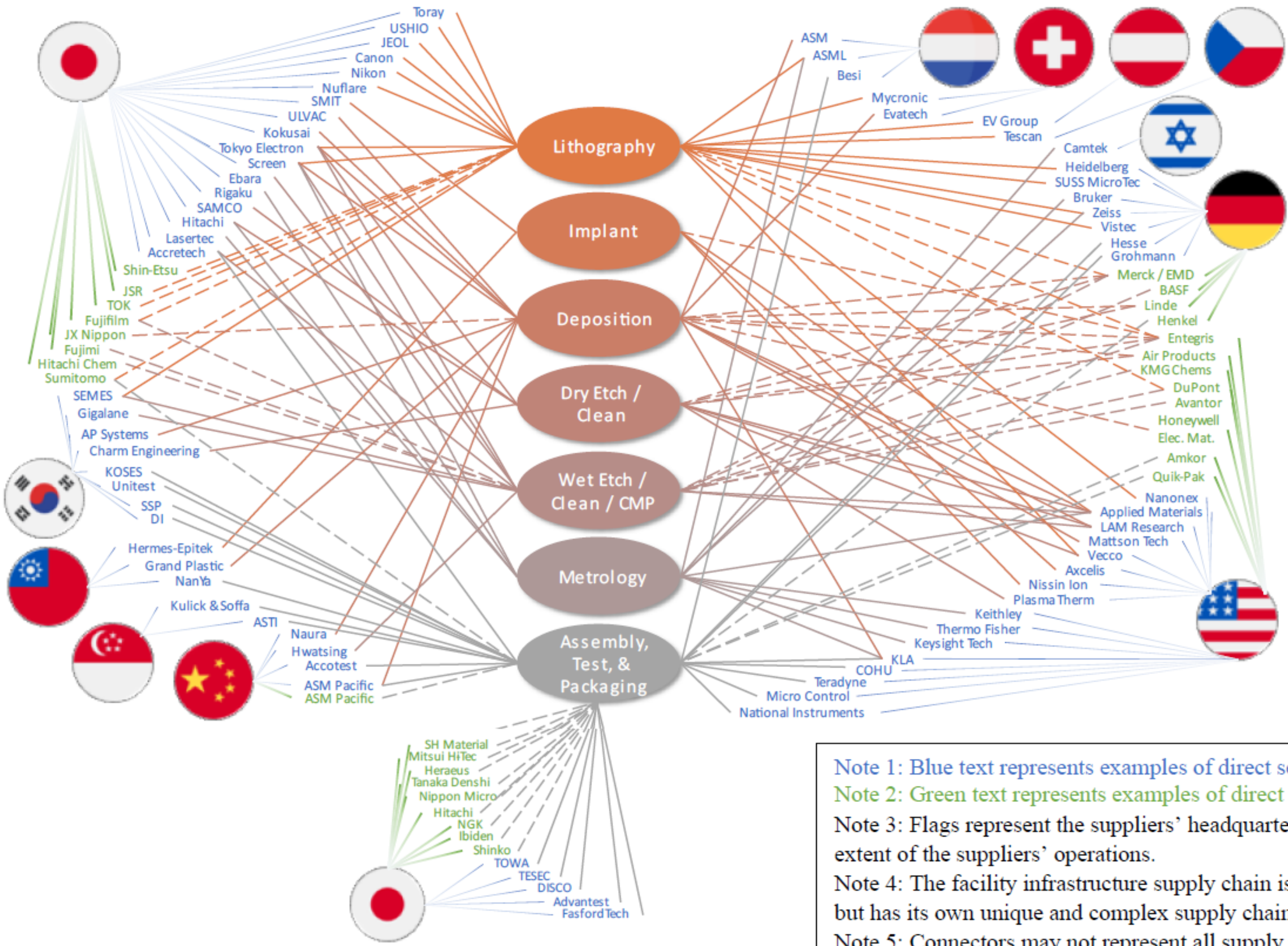
Here is an assessment of Alternatives for Photoacid generators (PAGs) used in photolithography manufacturing step.

Table 4-4 Comparison of the performance of PAGs versus alternatives.

| Performance criterion | PFAS PAGs/photoacids | CN5 non-PFAS PAG/photoacid | Thiophene sulfonate PAG/photoacid |
|---|---|---|---|
| **Photospeed**[39] | Excellent | Poor | Good |
| **Acid strength** | Excellent | Excellent | Good |
| **Diffusivity** | Good to excellent[40] | Lower than PFAS acids | High to too High |
| **Pattern quality/ Line width roughness** | Good | Line width roughness higher than commercial resists | Line width roughness much higher than commercial resists |
| **Transparency at all exposure wavelengths** | Excellent | Not transparent at 248nm | Not transparent at 248nm |
| **Solubility of PAGs in casting solvent** | Good | Good | Poor to moderate |
| **Lack of side reactions** | Excellent | Excellent | Excellent |
| **High process temperature requirement** | None | Yes | None |
| **Uniformity of PAG distribution** | Good | Good | Good |
| **Toxicity** | Moderate to high | High[41] | Moderate |
| **Environmental persistence** | Highly persistent | Assumed to be biodegradable | Assumed to be biodegradable |

[2]

There are no PFAS-free alternatives available for PAGs that fulfils all the required performances. The global semiconductors industry supply chain is complex, and as seen on the following figure, extend to several countries around the globes through dozens of companies. Regulating and monitoring the substances used in the process is especially complex.

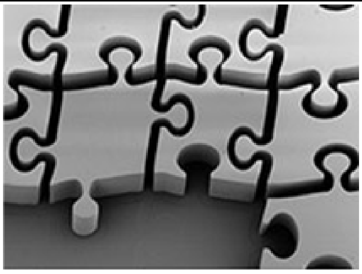



Note 1: Blue text represents examples of direct semiconductor equipment suppliers.
Note 2: Green text represents examples of direct semiconductor material suppliers.
Note 3: Flags represent the suppliers' headquarters and do not represent the global extent of the suppliers' operations.
Note 4: The facility infrastructure supply chain is not represented in the figure above but has its own unique and complex supply chain.
Note 5: Connectors may not represent all supply pathways but rather are representative.

**Figure 4: The semiconductor global supply chain in 2019: example tier-1 SMRE and material suppliers** *(The Center for Security and Emerging Technology 2019)*.

[3]

## FUNCTIONAL USES IN MANUFACTURING PROCESS – MEMS SENSORS

| 1. **Plasma dicing for thin wafers** |  Illustration 5: Test structure illustrating flexibility of design for plasma dicing [https://www.kla.com/advance/innovation/plasma-dicing-101-the-basics] |
|---|---|
| **PFAS substance/substance group:**<br>• C3F8, C4F8 | **PFAS-containing material/component:**<br>• Process gases |
| **Reason for PFAS Use/ Requirements Profile:**<br>• The use of plasma dicing eliminates chipping effects, particle contamination and heat damage. It allows a reduced kerf width and a flexible chip shape. Altogether this technology increases the yield per wafer and reduces the scrap rate. | |

[5]

Alternatives:

- C3F8, C4F8 (and CF4):
  - 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.

Fluoropolymers are also used in MEMS sensor, such as **PFPE:**

- 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. [5]

## FUNCTIONAL USES – PFAS IN ADVANCED PACKAGING

PFAS are also essential for advanced packaging in finished Semiconductors, which is the state-of-the-art technique. [2]

A semiconductor package encloses one or more semiconductor devices or integrated circuits protecting the device from the environment. The package connects the semiconductor to the printed circuit board (PCB), dissipates heat and provides protection from the surrounding environment particularly from moisture, shock/vibration, dust, etc.

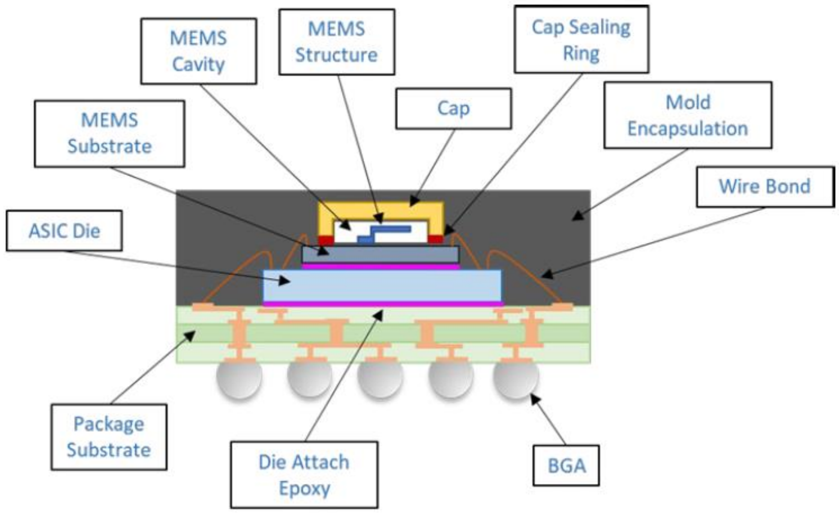
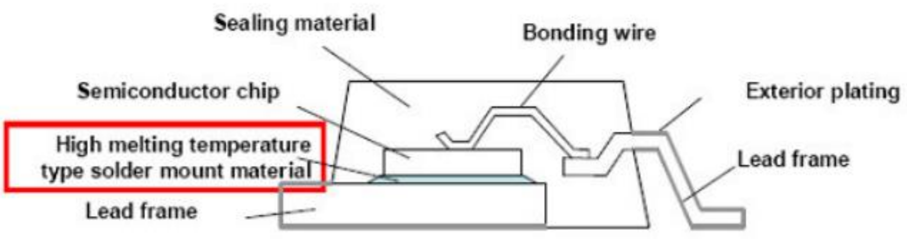



Figure 8-2 An example MEMS package.

Assembled packages go through multiple package types, to form three dimensional integrated circuits. Older technologies still use subsequent thermal and chemical steps to produce, therefore thermal and chemical stability in the assembled package are important.

For a few older die attach adhesive applications alternatives can be expected in the very near future (1+ year). However, for most adhesives and encapsulants it is expected to take from 10 to more than 13 years to find and implement alternatives.

**2. Die Attach**




However, for most package related uses of adhesives, in MEMS and Thermal Interface Materials System (TIMS), die overcoats, encapsulants and underfills, die passivation and substrate polymer there are no viable alternatives to the PFAS being used. For some of these technologies, alternatives have been sought for 18 years without success. For these uses it is likely that alternatives will take more than 20 years to find viable alternative chemistries or technologies and 6 years to implement. [2]

## FUNCTIONAL USES – PASSIVE ELECTRONIC COMPONENTS

Passive Electronic Components are components such as Capacitors, Resistors, Inductors (Coils, Chokes), Transformers (Magnetics), Resistors, Substrates & Interconnects, Energy and High Frequency Components [5] :

- Passive Electronic Components are used to give specific functions to electronic systems. Together with active components, they make it possible for any electronic device to function. Passive Electronic Components are usually mounted on Printed Circuit Boards (PCBs), either mounted directly on the surface (SMD technology) or fixed with leads (wires) using through-hole-technology.
- PFAS are essential for the functionality of Capacitors, Inductors and Sensors
- Mainly used polymeric PFAS in products: fluoropolymers, fluoroelastomers, perfluoropolyether

Uses and functionality of polymeric PFAS in Passive Electronic Components:

- Encapsulations and protective coatings to guarantee reliable usage in harsh environments.
- Electret foil (Electret with permanent electrical dipole) for microphones.
- Wire insulation, tubes, shrink tubes and membranes to provide electrical insulation and environmental resistance.
- Sealing material (O-rings, grommets, glues, …) and lubricants to prevent penetration of liquids and gases.
- Fluoroelastomer used as adhesive and passivation gel.
- Hydrophobic coatings.

## FUNCTIONAL USES – COATING OF ELECTRONIC COMPONENTS

| **Intended use in electrical and electronic equipment (EEE) [Derogations for EEE should be set at this level.]** | **Non-exhaustive examples of uses** | **Reasons why PFASs are un-replaceable** | **Functions of EEE requiring the use of PFAS** | **Functions of EEE requiring the use of PFAS (Link to Column G of List B (Annex 4))** |
|---|---|---|---|---|
| Functional coatings*<br>(*. "Functional coating" is a coating applied to an article in order to give it the required functions, as illustrated in the right cell (En).<br>"Functional coating" includes, but not limited to, "conformal coating" used to protect electronic materials.<br>In our response, we use the term "functional coating" because the required functions are not only to protect the objects.) | Electronic circuit boards, semiconductors, small electronic components (e.g. capacitors, resistors, coils, diodes, transistors, switches, connectors and their electrical junction points), casing, motors, voice coils, parts to protect optical features (e.g. liquid crystal panels, touch panels, optical sensors, LED, Toslink, optical fibers, lenses for electronic cameras, projection lenses, polarizers), printing process (Toner/ink adhesion prevention, toner/developing carrier themselves), oil barrier, fan, and so on. | Fluorine compounds are the only coating materials that can simultaneously provide and express multiple functions required for the proper functioning of electrical and electronic equipment in various environments, such as low refractive index, low dielectric constant and low dielectric loss tangent, electrical insulation, oil repellency, water repellency, heat resistance, chemical resistance, weather resistance, mold release and optical protection (i.e. for optical sensors, lenses and so on).<br>In addition to the above, toner/development carriers are also required to be fluidity, charging characteristics, and durability. | 1.Optical function<br>2.High speed communication and transmission function<br>4.Sliding function in mechanical section<br>6.Safety and safety functions<br>7.Functional surface | Camera, Lighting, Monitor/Panel, Optical cable, Smartphone, PC, Antenna, Base stations<br>Motor, Printer, Industrial equipment, Cable, Medical equipment, Electric appliance, Industrial control equipment, Cooking appliance, Touch panel,<br><br>All the EEE in RoHS categories 1- 11 would need this function. |

[4]

- Conformal Coating [9]

C6 SFP coatings are used to provide liquid and moisture protection of electronic components. The coatings are described as conformal coatings as they “conform” to the topography of a component or circuit to protect it from the environment and insure reliable performance.

- Anti-Solder coating [9]

Another use of C6 SFPs is anti-solder coating. In soldering of an electronic part, flux is always used to activate the bonding surface, which is included in a solder cream. If this flux penetrates the parts, it potentially causes contact malfunction or other imperfections. By using SC SFPs, penetration of the flux can be prevented without disturbing activation.

It is also used in wet chemical processes to facilitate the wetting/coating of difficult to treat surfaces for cleaning, coating, or anti-foaming purposes. They are also used in the manufacture of conductive seals and to help orientation of liquid crystals in liquid-crystal display.

Except for anti-flux migration coating, there are non-fluorinated alternatives for protective coating (acrylic type, silicon type, PU type, polyolefin type). However, these substances present several disadvantages: flammability, slower drying time, thermal instability, and excessive film thickness.

The nature of the coatings for electrical and electronic equipment, which is dependent on electric currents and electromagnetic fields and custom-made equipment for the generation, transfer, and measurement of such currents and fields to perform adequately, necessitates the use of C6 SFPs. Therefore, we suggest including the following derogation, in line with the SEAC opinion on the PFHxA restriction proposal:

## FUNCTIONAL USES - CAPACITORS

**1. Sealing capacitors against the environment**

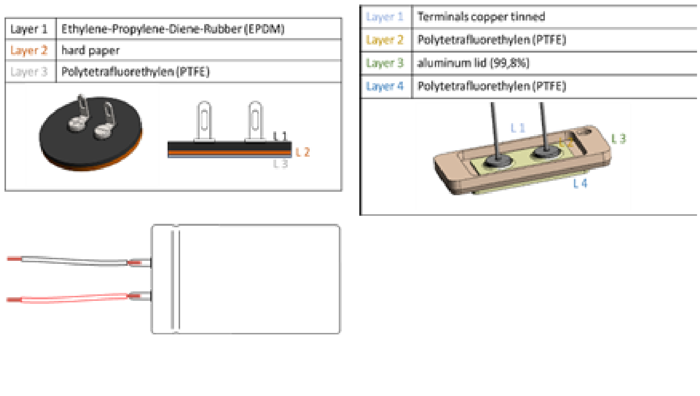



**Illustration 3:** PFAS sealing capacitors and isolating wires [ftcap GmbH]

**PFAS substance/substance group:**
- PTFE

**PFAS-containing material/component:**
- Cover discs
- Cable sheaths

**Reason for PFAS Use/ Requirements Profile:**
- Temperature stability
- Electrical insulation
- Chemical resistance against aggressive media (for example electrolytes)
- Resistance against climatic influences (e. g. moisture, wetness and dust)
- significant increase in life time due to prevention of molecular electrolyte diffusion through the capacitor lid
- Connection options by soldering high-temperature stable insulated cables to the respective terminals

[5]

## FUNCTIONAL USES IN MANUFACTURING PROCESS - CAPACITORS

**1. Achieve clearly defined free margins in the production of film capacitors**

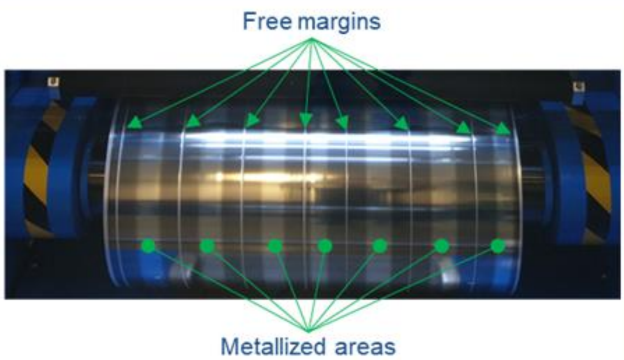



**Illustration 4:** Metallized foil with free margins [ELECTRONICON Kondensatoren GmbH]

**PFAS substance/substance group:**
- PFPE

**PFAS-containing material/component:**
- Masking film

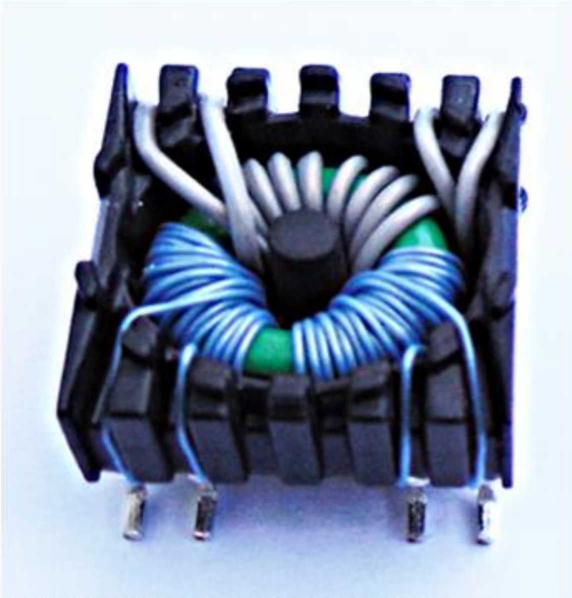
**Reason for PFAS Use/ Requirements Profile:**
- Chemical resistance against aggressive media (atmospheric oxygen)
- Heat resistance at extreme temperatures and non-flammability
- Electrical insulation; dielectric strength

[5]

Alternatives to **PFPE**:

- 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.**

## FUNCTIONAL USES – INDUCTORS AND MAGNETICS (CHOKES, COILS, TRANSFORMERS)

| | |
|---|---|
| **1. Insulation (insulated wire) of electronic components** |  Illustration 3: Transformers using PFAS insulated wire [SUMIDA AG] |
| **PFAS substance/substance group:**<br>• ETFE | **PFAS-containing material/component:**<br>• encapsulation |
| **Reason for PFAS Use/ Requirements Profile:**<br>• High temperature performance (up to 260°C)<br>• Electrical insulation; dielectric strength<br>• Safety requirements according IEC Standards<br>• Resistance against climatic influences (e. g. moisture and wetness)<br>• Good mechanical properties (winding tension…. | |

[5]

Alternatives to **PTFE, FEP, ETFE, PVDF or PFA:**

- Exemplary use cases: electrical insulation on electronic components (cable sheath, shrink tubes, 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 (>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**.**

- Evaluation of Alternatives for the coating of cables and wires:

| Application | PFAS | Non-PFAS alternatives | Reasons why PFAS cannot be replaced by non-PFAS |
|---|---|---|---|
| Wire insulation | PTFE, PFA, ETFE, FEP, | Silicone materials<br><br>FEPM, PFPE<br><br>Polyetheretherketone(PEEK)<br><br>mica<br><br>EPDM<br><br>Polyvinyl chloride<br><br>ceramic based polymer | In cable insulation materials, mechanical, thermal, volume resistance and electrical properties are important, and the alternatives listed as alternatives have low resistance to any of these properties and cannot replace them in applications where they need to be met simultaneously, and fluorinated materials need to be used. For example, silicone has low resistance to mechanical properties (susceptible to tearing/abrasion), PEEK has low electrical properties, mica is hard and not suitable as a cable, etc. |

[4]

- Supplier is producing **transformers**, choke coils, inductors.
- PFAS are contained in **the winding wire of transformers** in the **coating / insulation** around the wire.
- Supplier is claiming **PFAS alternatives for this application to be ready by 2024.**
- Supplier is saying that the derogations proposed in the current Restriction Dossier are sufficient to cover their needs of PFAS, since they plan on having an alternative before that.
- Using a PFAS-free alternative will not have an impact on waste and energy.
- The PFAS restriction will not impact research and development activities and timeframes. [12]

## FUNCTIONAL USES – RESISTORS

| **Intended use in electrical and electronic equipment (EEE) [Derogations for EEE should be set at this level.]** | **Non-exhaustive examples of uses** | **Reasons why PFASs are un-replaceable** | **Functions of EEE requiring the use of PFAS** | **Functions of EEE requiring the use of PFAS (Link to Column G of List B (Annex 4))** |
|---|---|---|---|---|
| Functional coatings*<br>(*. "Functional coating" is a coating applied to an article in order to give it the required functions, as illustrated in the right cell (En).<br>"Functional coating" includes, but not limited to, "conformal coating" used to protect electronic materials.<br>In our response, we use the term "functional coating" because the required functions are not only to protect the objects.) | Electronic circuit boards, semiconductors, small electronic components (e.g. capacitors, **resistors**, coils, diodes, transistors, switches, connectors and their electrical junction points), casing, motors, voice coils, parts to protect optical features (e.g. liquid crystal panels, touch panels, optical sensors, LED, Toslink, optical fibers, lenses for electronic cameras, projection lenses, polarizers), printing process (Toner/ink adhesion prevention, toner/developing carrier themselves), oil barrier, fan, and so on. | Fluorine compounds are the only coating materials that can simultaneously provide and express multiple functions required for the proper functioning of electrical and electronic equipment in various environments, such as low refractive index, low dielectric constant and low dielectric loss tangent, electrical insulation, oil repellency, water repellency, heat resistance, chemical resistance, weather resistance, mold release and optical protection (i.e. for optical sensors, lenses and so on).<br>In addition to the above, toner/development carriers are also required to be fluidity, charging characteristics, and durability. | 1.Optical function<br>2.High speed communication and transmission function<br>4.Sliding function in mechanical section<br>6.Safety and safety functions<br>7.Functional surface | Camera, Lighting, Monitor/Panel, Optical cable, Smartphone, PC, Antenna, Base stations<br>Motor, Printer, Industrial equipment, Cable, Medical equipment, Electric appliance, Industrial control equipment, Cooking appliance, Touch panel,<br><br>All the EEE in RoHS categories 1- 11 would need this function. |

[4]

## FUNCTIONAL USES – FUSES

Polyswitches, also called polyfuses or multifuses, use thermoplastic materials in the organic polymer matrix that gives the fuse its functionality. Currently, PVDF is in use as a thermoplastic PFAS.

Changing to a different polymer changes the functionality of the fuse: heating and expansion characteristics are different, causing the device to trip at a different current and to reset differently when cooling down.

Alternative materials exist, e.g., thermoplastic PE (Polyethylene), but will need time for full changeover in the portfolio. A minimum of 5 years derogation / 6.5 years transition period is necessary for full changeover. [12]

## FUNCTIONAL USES – PCB

PFAS fluoropolymers are used as a fiber-reinforced fluoropolymer layer in Printed Circuit Boards (PCBs), examples include, PTFE and PFA, for the following benefits:

- Stable dielectric constant
- Heat resistance
- Chemical resistance
- Non-stick and low frictional properties
- Water and oil repellent
- Low dissipation factor, i.e. reduced signal loss

They can be used in Rigid, Flexible and Hybrid PCBs. Other materials exist such as traditional FR-4 laminate material (glass-reinforced epoxy), but they show several disadvantages:

- Signal loss is higher.
- No stable impedance achievable: not possible for circuits require stable impedance (e.g., HF)
- Dielectric constant changes too strongly with temperature for applications that involve a wide range of temperatures.
- Absorbs moisture.
- Not suitable for applications where a high dielectric constant is necessary, e.g., Radios, antennas, filter circuits, power amplifiers, high-speed digital PCBs.

➔ for such requirements, PTFE-based laminates are the material of choice. All other laminate materials show disadvantages in at least one crucial requirement.

PFAS are also used in high frequency PCBs:

- It should be emphasized that specific PFASs (PTFE, PFA, FEP) are also the key material constituting the dielectric layer of the PCB itself. The PTFE and PFA are the key enabling constituents of the performance required of such PCBs for mission-critical applications due to their unique combination of properties:
    1. Highly ablative, without charring.

2. Low modulus allowing them to be formed around surfaces.

3. Low dielectric constant and low dissipation factor enabling superior electrical performance.

4. Stable at temperatures above 130°C, enabling stable performance during temperature excursions.

5. Inherently flame retardant.

In Table 1 and 2. PFAS-free alternatives are assessed. Fluoropolymers are the only material that delivers all the required key properties:

- High frequency range (<= 77 GHz)
- maximum operating temperature (MOT) > 130°C
- Flame retardancy
- Formable

**Time**: require significant investment in both time (a minimum of 5 years to invent a replacement, with an additional 5-10 years required to scale to commercial levels and demonstrate reliability

**Costs**: In addition to time, this is a minimum of 7-digit Euro required investment per application to develop such alternative, and a minimum of 6-digit Euro per customer, per application, to qualify such an alternative, if in fact, the alternative can be qualified at all.

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

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

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

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

[7]

Use Case by JEITA:

There are printed circuit boards where low dielectric constant, heat resistance and flame resistance are required, and fluorinated materials are suitable and actually used for this application. No non-fluorinated material exists that can satisfy these three properties simultaneously. There are non-fluorinated materials that have each of these properties, but they cannot be mixed to make an article that satisfies all three at the same time. Even if they could be mixed, the material mixed would not satisfy heat resistance, as the lowest property of the three substances would appear with regard to thermal properties. The same applies to transparency, low refractive index, low dielectric constant, weather resistance and chemical resistance. [4]

## FUNCTIONAL USES – SENSORS

Types of Sensors and uses of PFAS for Sensors [4], [5]:

- Coating of Sensors for insulation and for protection against the environment: Use case on next slide (ZVEI)
- Piezoelectric Material providing the essential function of Piezoelectric components such as Sensors (e.g. Pressure sensors, Acoustic elements): Use case on following slides (JEITA)
- Glue for attaching MEMS to pressure ports: Use case in semiconductor section (ZVEI)
- Semiconductor manufacturing process for MEMS sensors: Use case in semiconductor section (ZVEI)
- Semiconductor packaging process for MEMS sensors: Use case in semiconductor section (RINA study)

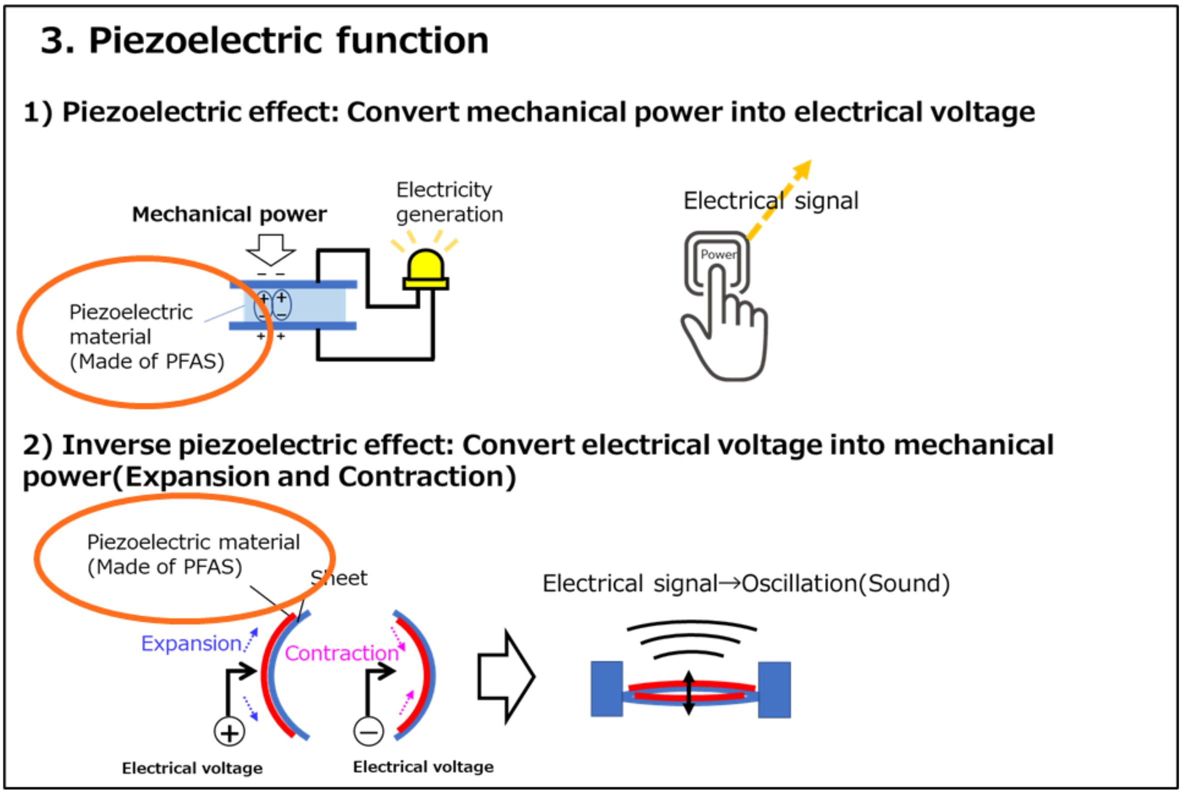
| | |
|---|---|
| **1. Insulation (coating/encapsulation) of electronic components** | <br>**Illustration 2:** Sensors using PFAS in encapsulation [TDK Electronics AG] |
| **PFAS substance/substance group:**<br>• Fluoropolymer | **PFAS-containing material/component:**<br>• encapsulation |
| **Reason for PFAS Use/ Requirements Profile:**<br>• High temperature performance (up to 260°C)<br>• Electrical insulation; dielectric strength<br>• Chemical resistance against aggressive media<br>• Resistance against climatic influences (e. g. moisture and wetness)<br>• Good mechanical properties (abrasion, …) | |

Alternatives to **fluoropolymers** and **perfluorpolyethers** in 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.
- **It is very likely that alternatives do not exist at all** (based on experience from extensive R&D efforts). [5]

## FUNCTIONAL USES – PIEZOELECTRIC ELEMENTS, E.G. PRESSURE SENSORS

| **Functions and properties required for EEE** | **Characteristic of parts and materials to achieve their functions and properties of EEE** | **Performance requirements for materials (PFAS)** | **(e.g.) Specific parts or components that accomplish the functions or characteristic of EEE** |
|---|---|---|---|
| Piezoelectric function (Conversion/Inversion between the mechanical power and electrical voltage) ＊Refer to separate sheet "3. Piezoelectric function" for functional explanation. | Piezoelectricity (pressure-sensitive detection) and good workability and durability | High Piezoelectricity (High piezoelectric coefficient) + Heat resistance, Flexibility | Speaker, Touch panel, Sensor, Actuator, etc. |




[4]

## FUNCTIONAL USES - PVDF IN PRESSURE SENSORS

| Intended use in electrical and electronic equipment (EEE) [Derogations for EEE should be set at this level.] | Non-exhaustive examples of uses | Reasons why PFASs are un-replaceable | Functions of EEE requiring the use of PFAS | Functions of EEE requiring the use of PFAS (Link to Column G of List B (Annex 4)) |
|---|---|---|---|---|
| Piezoelectric elements | Piezoelectric elements pressure sensitive films, speakers, microphones, piezo pickups for acoustic guitar | PVDF and its copolymers with unique dielectric and piezoelectric properties, which are also excellent in durability, electrical insulation property, and heat resistance are used in piezoelectric elements used in EEE and its components. Therefore, it is impossible to substitute to the Non-PFAS alternatives mentioned in the ANNEX XV RESTRICTION REPORT. | 3.Piezoelectric function | Touch panel, Speaker, Various sensor<br><br>Other products in RoHS categories 1- 11 would need this function if they use touch panels or sounds for example. |

[4]

# FUNCTIONAL USES - CONNECTORS

Connectors are parts or devices used for electrically connecting or disconnecting circuits etc. They can connect and disconnect by hands or with simple tools without requiring special tools or processes such as soldering. We interrogated several suppliers of such components to assess the impact of the PFAS restriction proposal on their activities. [12]

**Supplier 1**: We are not aware of a single replacement insulation material that does not belong to the PFAS group (Insulators with Ɛr = 2,05 dielectric constant), because the characteristic impedance is depending on the value of the dielectric constant.

- PTFE (CAS Nr 9002-84-0) is also used as insulating material by coaxial connectors and very rarely Fluorosilicon rubber (FVQM) (CAS Nr: 63148-56-1) as sealing gasket → The insulators are used for assembling the connector.
- There are alternatives but will need longer time and higher capacity for redesign.

The biggest problem is capacity because in all the cases where PFAS material are used (almost in every case PTFE), there is a redesign necessary. The design departments have no capacity to handle all the requested changes:

- Redesign to reach PFAS free will generate more waste because of bigger components (connectors, cables etc.). Design will need to be larger in size to still achieve the desired characteristic. Moreover, bigger components could have a big impact in the redesign of the final vehicles.
- Since PEEK, SPS, PBT and LCP have a higher dielectric constant than PTFE, the connectors, cables etc. will need to be larger in size to still achieve the desired characteristic impedance of the transmission channel. Larger connectors do mean heavier connectors, which in turn means more waste of resources, and more weight that vehicles will have to carry around. Thus, the result of the switch away from PTFE will inevitably lead to a higher carbon footprint.
- Possible future bans on other plastic material would also impact the research for alternatives.

It is not feasible, will have significant price increases by low and medium quantities, a larger carbon footprint and more waste. According to Supplier 1 - the only solution is to use PTFE in connector (and cable industry) without limitations.

**Supplier 2**: No derogation for connectors will have a very big impact: loss of business as there are no alternative with the right functionality known.

**Supplier 3**: Supplier is not aware of any alternatives. A PFAS-free alternative will imply more waste and more energy consumption. The research and development activities will be impacted, innovation will be hindered and will require longer timeframes.

**Supplier 4:** This supplier claims to use alternatives for PTFE in the future. But: no one-size-fits-all solution as with PTFE. Instead, every application will have to be substituted with a specific material, depending on the requirements.

Depending on the substitution material, will result in larger or heavier connectors, more costly materials, materials that are more difficult to process.

This requires R&D effort and redesign downstream of the supply chain which means increased costs.

- Time estimate:
    - 3 years for a complete portfolio change only from supplier side.

## FUNCTIONAL USES – SWITCHES

| **Intended use in electrical and electronic equipment (EEE) [Derogations for EEE should be set at this level.]** | **Non-exhaustive examples of uses** | **Reasons why PFASs are un-replaceable** | **Functions of EEE requiring the use of PFAS** | **Functions of EEE requiring the use of PFAS (Link to Column G of List B (Annex 4))** |
|---|---|---|---|---|
| Sliding elements in mechanical section | Plain bearings<br>Conductive plain bearings<br>**Sliding parts of various electric components** (motors, connectors, **switches**, etc.)<br>Sliding parts of various mechanical components (bearings, gears, winder, etc.)<br>Fixing and photoconductive components, etc., in printing equipment | **Fluoropolymers** with multiple functions such as excellent self-lubrication (low coefficient of friction), electrical insulation property, chemical resistance, releasability, heat resistance and flame retardancy are used in sliding elements in mechanical section of EEE and its components to function normally in various environments.<br>The Non-PFAS alternatives mentioned in the ANNEX XV RESTRICTION REPORT cannot be used as they exibit the worst performance.<br>In addition, some components are required to maintain their indispensable sliding characteristics over a long period of time under severe conditions such as high temperature, high pressure, high voltage, and high friction. Fluoropolymers are the only materials that resist such severe conditions, and substituting other materials is impracticable. | 4.Sliding function in mechanical section | Motor, Printer, Industrial equipment, Camera<br><br>All the EEE in RoHS categories 1- 11 would need this function. |
| Functional coatings*<br>(*. "Functional coating" is a coating applied to an article in order to give it the required functions, as illustrated in the right cell (En).<br>"Functional coating" includes, but not limited to, "conformal coating" used to protect electronic materials.<br>In our response, we use the term "functional coating" because the required functions are not only to protect the objects.) | Electronic circuit boards, semiconductors, small electronic components (e.g. capacitors, resistors, coils, diodes, transistors, **switches**, connectors and their electrical junction points), casing, motors, voice coils, parts to protect optical features (e.g. liquid crystal panels, touch panels, optical sensors, LED, Toslink, optical fibers, lenses for electronic cameras, projection lenses, polarizers), printing process (Toner/ink adhesion prevention, toner/developing carrier themselves), oil barrier, fan, and so on. | **Fluorine compounds** are the only coating materials that can simultaneously provide and express multiple functions required for the proper functioning of electrical and electronic equipment in various environments, such as low refractive index, low dielectric constant and low dielectric loss tangent, electrical insulation, oil repellency, water repellency, heat resistance, chemical resistance, weather resistance, mold release and optical protection (i.e. for optical sensors, lenses and so on).<br>In addition to the above, toner/development carriers are also required to be fluidity, charging characteristics, and durability. | 1.Optical function<br>2.High speed communication and transmission function<br>4.Sliding function in mechanical section<br>6.Safety and safety functions<br>7.Functional surface | Camera, Lighting, Monitor/Panel, Optical cable, Smartphone, PC, Antenna, Base stations<br>Motor, Printer, Industrial equipment, Cable, Medical equipment, Electric appliance, Industrial control equipment, Cooking appliance, Touch panel,<br><br>All the EEE in RoHS categories 1- 11 would need this function. |

[4]

Examples of switches I the automotives industry are Hazard switches, power seat switches, power window switches, sliding door switches, etc.

PTFE is used as a structural material for various switches and has waterproof and dustproof functions for the contact area and moderate flexibility functions to transmit the ON/OFF feeling to the fingertip when the button is pressed. It also satisfies the reflow resistance required for the component materials during mounting. The following table shows specific characteristics for PTFE compared to other materials. Each of these properties is found to be superior to the other materials:

: Physical property value not achieved

| Feature | Required characteristics | Material | | | | | |
|---|---|---|---|---|---|---|---|
| | | PTFE | PET | PE | PP | PI | PPS |
| water repellency | Contact angle to $H_2O$ 90° or more | 120-130 | 65-90 | 100-115 | 105-115 | 65-75 | 100-110 |
| antifouling property | Must be a non-porous film | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Flexibility | Tensile strength 20Mpa or more | 20-35 | | 19-39 | 35 | 82 | 162 |
| | Elongation 100-500% | 200-400 | | 10-1200 | 700 | 2 | 1.3 |
| Reflow resistance | Melting point 260℃ or more | 327 | 256 | 120-140 | 160 | ＞500(Tg) | 277 |

There are no alternatives to PTFE sheets and PTFE-based adhesive tapes that have the flexibility suitable for switches and the necessary functions of water repellency, stain resistance, and reflow resistance. There is no evidence that new materials with these properties will be developed in the future. [14]

## FUNCTIONAL USES – CABLES

### Evaluation of alternatives by JEITA

| Application | PFAS | Non-PFAS alternatives | Reasons why PFAS cannot be replaced by non-PFAS |
|---|---|---|---|
| Wire insulation | PTFE, PFA, ETFE, FEP, | Silicone materials<br>FEPM, PFPE<br>Polyetheretherketone(PEEK)<br>mica<br>EPDM<br>Polyvinyl chloride<br>ceramic based polymer | In cable insulation materials, mechanical, thermal, volume resistance and electrical properties are important, and the alternatives listed as alternatives have low resistance to any of these properties and cannot replace them in applications where they need to be met simultaneously, and fluorinated materials need to be used. For example, silicone has low resistance to mechanical properties (susceptible to tearing/abrasion), PEEK has low electrical properties, mica is hard and not suitable as a cable, etc. |

[4]

Wires and cables are mainly insulated with fluoropolymer materials. There characteristics are :

- Resistance to high temperature
- Chemical inertness
- Excellent ageing
- Tenacity
- Excellent dielectric properties
- Negligible humidity absorption
- Good resistance to atmospheric exposure

The production process used differs according to the materials:

- **PTFE** presented in the form of powder is worked using a discontinuous extrusion process.
- **PTFE** tapes use a continuous taping process.
- **ETFE** and **FEP** are thermoplastic materials in the form of granules and use a continuous extrusion process.

- For the polyimide insulated wires, AXON uses POLYIMIDE tapes with a FEP for heat sealing. These tapes are worked using a continuous taping process. A FEP or PTFE lacquer is added for coloration. AXON also offers equipment wires with POLYIMIDE and PTFE tapes. These products are mainly used for applications where the risk of arc tracking must be avoided. [13]

It is not possible to achieve similar performances with others existing materials due to physical reasons.

Next are summarized for each potential raw material alternative, what are the limitations justifying why the material cannot be used as material.

| Potential alternative to Fluoropolymers (FEP/PFA/ETFE, PTFE) | Products or product groups examined | Technical feasibility (performance, technical characteristics, etc.) | Economic feasibility (cheaper, more expensive, reason) |
|---|---|---|---|
| Polyethylene (PE) Polypropylene (PP) and others Polyolefin-based materials | Wire and Cables | Limited temperature use (<100°C)<br>Poor Flexibility (Elastic Modulus >1000MPa)<br>Not Flame retardant for dielectric applications | This is not an alternative product |
| PVC | Wire and Cables | Limited temperature use (<100°C)<br>Low volume resistivity <10E+14 ohm.cm<br>High (poor) Dielectric constant (>4) | This is not an alternative product |
| Glass / Ceramics / Mica | Wire and Cables | Very stiff (Elastic Modulus >5000MPa)<br>Low volume resistivity <10E+13 ohm.cm<br>Low Breakdown Voltage<br>Poor Ductility ( Elongation at break <10%)<br>Susceptible to Humidity / water | This is not an alternative product |
| Polysulfones (PSU, PPSU, PPS, and Polyetherketones (PEEK, PEKK, PEKEKK,PEK) | Wire and Cables | Limited temperature use (<180°C)<br>Very stiff (Elastic Modulus >3000MPa)<br>Too High dielectric constant (ε > 3)<br>Amorphous polymers susceptible to stress cracking | This is not an alternative product |
| Polyimides | Wire and Cables | Very stiff (Elastic Modulus >3000MPa)<br>High (poor) dielectric constant (ε > 3)<br>Susceptible to Arc tracking<br>Susceptible to hydrolysis | This is not an alternative product |

[13]

<u>The potential alternatives to Fluoropolymers are not alternative, as their performances and technical characteristics are not at the level of Fluoropolymers.</u>

## <u>Conclusion</u>

- Fluoropolymers must be distinguished from other PFAS. This is particularly true because fluoropolymers have very different toxicological profiles from other PFAS substances.
- According to OECD criteria, they are considered "Polymers of low concern (PLC)", "Fluoropolymers are non-toxic, not bioavailable, non-water soluble and non-mobile molecules and are deemed as such to have no significant environmental and human health impacts".
- They are used in a large number of applications, some of which bring considerable benefits to society, up to meeting the ambitions of the European Union in terms of climate, energy, health, and Industry.

- Currently, there is no alternative material that can replace fluoropolymers. And there is nothing to suggest that it could be otherwise in the short, medium or long term.
- Therefore, Axon Cable is requesting the Fluoropolymers not to be included in the Restriction proposal.

## FUNCTIONAL USES – SMALL BATTERIES

Use Case "small batteries" means batteries used in Automotive, that are not EV Batteries, and not starter batteries, such as:

- Battery in E-Call system
- Battery in Tire pressure sensor
- Battery in Key
- Etc

Both rechargeable and non-rechargeable (primary) cells use PFAS for several key functionalities within the battery

**Example for Use in primary (non-rechargeable) Lithium cells:**

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

**PFAS Emissions** [8], [12]:

- During battery **manufacturing**: on empty bags and equipment used on manufacturing process.
- During battery **use** : under normal and reasonably foreseeable conditions of use, no end-user of this battery will be exposed to any chemical substances. No PFAS emissions are foreseen during battery use.
- During battery **recycling** : no unintended and uncontrolled PFAS emissions are foreseen during battery recycling.

## FUNCTIONAL USES – OPTICAL ELEMENTS, E.G. LCD PANELS

Functional use of **Fluoropolymers** and **Fluorinated polyimides** in elements with optical function (LCD panels, manufacturing process of LCD panels, transparent circuit boards).

| **Intended use in electrical and electronic equipment (EEE) [Derogations for EEE should be set at this level.]** | **Non-exhaustive examples of uses** | **Reasons why PFASs are un-replaceable** | **Functions of EEE requiring the use of PFAS** | **Functions of EEE requiring the use of PFAS (Link to Column G of List B (Annex 4))** |
|---|---|---|---|---|
| LCD panels | Anti-fingerprint layer on panel surface and unti reflection (high light transmittance) layer | The **fluoropolymer** on the panel surface has a refractive index of 1.3, which is almost half the refractive index of 1.0 for air and 1.5 for TAC film of the polarizer, and suppresses surface reflection. This translates to a 3% increase in backlight utilization efficiency (i.e. energy efficiency). In addition, since the visibility of the panel is improved by preventing fingerprint stains on the surface, the brightness of the panel can be reduced. Only fluoropolymer has the above properties. It cannot be substituted with silicone or other resins that are considered substitutes. | 1.Optical function | Camera, Lighting, Monitor/Panel, Optical cable, Smartphone<br><br>Other products in RoHS categories 1- 11 would need this function if they use optical function in control panels for example. |
| Transparent electronic circuit board and circuit | Transparent printed circuit board for touch panels | **Fluorinated polyimide** has transparency, heat resistance, and low water absorption required for touch panels used in smartphones and tablets. The high water absorbency of transparent heat-resistant plastic (polyether sulfone) reduces low dimensional stability and impairs the linearity of touch panels, so it cannot be used. | 1.Optical function | Camera, Lighting, Monitor/Panel, Optical cable, Smartphone<br><br>Other products in RoHS categories 1- 11 would need this function if they use optical function in control panels for example. |
| Liquid crystal display element (LCD) | vertical alignment liquid crystal display device<br><br>Interlayer spacer to control the cell gap of LCD panels.<br><br>Liquid crystal materials (small molecules) | **Fluorinated polyimides with long-chain fluorinated alkyl groups in the side chains** have high heat resistance and stable orientation over a wide temperature range. This cannot be replaced by polyimides with hydrocarbon side chains.<br>The structural materials for maintaining uniform cell gap of a large-sized liquid crystal panel are required to have leveling properties, no contamination of the optical system in the manufactureing process, chemical resistance, and heat resistance at the same time. These are not able to be replaced by silicone or acrylic resin.<br>Fluorinatad Liquid Crystal materials have low-voltage driving, high-speed responce, and low temperature dependence of drive voltage, which are required for low power consumption video displays requireing multiple functions simultaneously. Cyano-based crystal materials do not meet those properties at the same time. | 5.Display function(Liquid crystal display / LCD) | Liquid crystal display panel (TV, Monitor for various device)<br><br>Other products in RoHS categories 1- 11 would need this function if they use control panels or monitors for example. |

[4]

| Functions and properties required for EEE | Characteristic of parts and materials to achieve their functions and properties of EEE | Performance requirements for materials (PFAS) | (e.g.) Specific parts or components that accomplish the functions or characteristic of EEE |
|---|---|---|---|
| Optical function | No interference of light transmission<br>(Transparency) | Low refractive index, High transmissivity<br>+<br>Water and oil repellency, Flexibility, Flame retardancy | Optical fiber, Optical Lens, LED, Monitor/Panel, Fiberglass, Optical adhesive, Protective coating material, Anti-reflective material, etc. |
| Display function(Liquid crystal display / LCD) | Low voltage drive and fast response<br>(Low anisotropic refractive index and low viscosity) | Low anisotropic refractive index, Low viscosity, Low voltage drive<br>+<br>Heat resistance, Durability | Liquid crystal panel (TV, various monitor), etc. |

[4]

## SUPPLIER INFORMATION ON PFAS IN LCD PANELS

**What are liquid crystals?**

- Substances with a PFAs moiety have properties between liquids and solid crystals.
- Liquid crystal may flow like a liquid, but its molecules may be oriented in a crystal-like way.

**Properties:**

- Very low water solubility/vapor pressure.
- No surface-activity feature.
- Electronegativity of Fluorine leads to electrical dipole of molecule.
- Due to very specific properties all substitution efforts not successful.

**Why do Liquid Crystal Displays Need PFAS?**

- The rod-shaped LC molecules need a dipole moment to orient in the electric field direction. Fluorine atoms are a mandatory part of LC molecules for this purpose.
- Transmittance of an IPS/FFS-LCD-pixel (IPS/FFS: In Plane Switching/Fringe Field Switching) is increasing with increasing voltage – reason is the changed LC orientation depending on the applied voltage.

**Need for FFS LCDs on Automotive applications: In comparison to other LC technologies FFS features a combination of:**

- higher light transmittance which results in energy saving particularly on high brightness applications.
- improved safety thanks to readability under various viewing conditions to meet different driver and co-driver and backseat passenger requirements.
- good switching behavior under various operating temperatures.
- To assure readability even under bright sunlight automotive displays must be capable of high brightness over the lifetime of the car.
- In general, device lifetime of LC-displays is unprecedented. Alternative technologies might suffer from demanding environmental conditions such as high brightness at high temperatures which could lead to a replacement before EOL of an automobile.

## FEEDBACK FROM SUPPLIERS

The suppliers are not aware of PFAS-free alternative viable materials - not the right functionality, not available on the market or too high development cost. The supplier is testing alternative material IC/PCBA/Photoresistance/LC for application in their panel product, but they see higher defect rate and worse display effect.

Using PFAS-free alternative will result in more waste (worse display effect, higher defect rate, etc.) and longer development timeframes.

For the time being, PFAS-free components will greatly affect product performance such as the advection of photoresist will decrease, leading to a decrease in the display effect of the screen. And the anti-static effect of POL will deteriorate, which will cause higher defect rate of our screen, etc. If no derogations were to be granted, all the jobs in the EU would be lost at the supplier's company.[12]

# EMISSIONS

## ELECTRONIC COMPONENTS

**During manufacturing of electronic components**

- PFAS are handled with care and in accordance with applicable regulations regarding hazardous chemicals, occupational health and safety as well as emissions to the environment.
- Closed systems, extraction and separation plants are commonplace.

**During use of electronic components**

- No reasonably foreseeable emission of PFAS into the environment during use.

**During electronics recycling**

- 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. [5]

## FUNCTIONAL COATINGS OF ELECTRONIC COMPONENTS

As coatings for the electronic devices need to be applied in clean room-type working conditions, the emissions during applications are effectively zero.

End of life of the components coated with these coatings are covered by the proper treatment defined in the Waste from Electrical and Electronic Equipment (WEEE) and the separate collection defined in the Directive of the Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS). This ensure that emissions at end of life are effectively zero.[9]

### SEMICONDUCTOR PACKAGING, INCL. MEMS, ASICS

There should be no release of PFAS during normal use of consumer or other end products, for those that include PFAS containing semiconductors. The concentrations of PFAS in assembly, testing, and packaging (ATPS) chemistries are low (parts per billion range) and any releases are anticipated to be minimal and only at the end of the product's useful life, during electronics recycling or disposal. Some of the electronic reclamation processes are thermal and may cause a break-down of PFAS, but this would require further investigation.[2]

## ANALYTICAL METHODS FOR DETECTING AND IDENTIFYING PFAS

There are currently no available analytical methods capable of measuring the total speciated PFAS concentration in products. The methods mentioned in Annex E are either :

1. targeted methods or
2. provide results for fluorine, which do not translate in PFAS concentrations.

I. Targeted methods:
   - Are available for limited number of PFAS only, and not all commercially available (lab scale only).
   - are not all validated and certified, especially the TOPA technique mentioned in the Restriction Dossier.
   - Make use of expensive or very expensive equipment .

II. Total fluorine content methods:
   - Are useful for general screening, but.
   - do not give an indication of the type of PFAS species that were/are present and their concentration.
   - Are mostly not validated and certified, nor commercially available (lab scale only).
   - Make use of expensive or very expensive equipment and are labor intensive.

III. Mixed methods: "Distinguishing between PFAS substances (i.e., a molecule containing at least one carbon on which two fluorine atoms are bound) and non-PFAS organofluorine substances (i.e., molecule containing one fluorine atom bound onto one carbon atom) when measuring the total fluorine content of a product would require highly sophisticated procedures, including target and non-target analyses, that would be able to make the distinction which, to the best of our knowledge, are not yet available." [15]

The absence of harmonized analytical methods and suitable analytical standards would pose serious implementation and enforceability challenges to both industry and regulators.

Please refer to ATCS Response to the Public Consultation on Restriction Proposal on all PFAS: Part II – Specific Information Requests (ref 4273) for a detailed Overview of Analytical Methods for Measuring PFAS. [15]

# SOURCES FOR PFAS IN ELECTRONICS

[1] ESIA (Ref. 4447): ESIA comments on Annex XV restriction report (2023)

[2] SIA PFAS Consortium (RINA): "The Impact of a Potential PFAS Restriction on the Semiconductor Sector" (2022)

[3] Semiconductor PFAS Consortium: "Background on Semiconductor Manufacturing and PFAS" (2023) (via Ref. 6016 DuPont)

[4] JEITA (Ref. 4543)

[5] ZVEI (Draft input)

[6] ACEA /CLEPA Industry Guide (public.mdsystem.com/documents/10906/17094/imds_and_technical_definitions_for_elv_exemptions.pdf/87f2bed7-4f98-4ccb-82bd-bc4ed3e099a0)

[7] Rogers (Ref. 6006 Rogers BV)

[8] RECHARGE: Application for derogations from PFAS REACH restriction for specific uses in batteries, First submission (2023) (https://rechargebatteries.org)

[9] ATCS (Ref. 6395), ATCS 2nd Public Consultation Contribution, p. 46 ff

[10] Infineon (Ref. 4549),

[11] SEMI (Ref. 4304)

[12] Continental (own data)

[13] Axon Cable (Ref. 4456)

[14] JAPIA (Ref. 4413), Japan Auto Parts Industries Association (JAPIA) Position to Annex XV Restriction report on 22 March 2023 about a proposal for a restriction on Per- and polyfluoroalkyl substances (PFASs), p.29 ff

[15] ATCS (Ref. 4274), ATCS 1st Public Consultation Contribution – Specific information requests, p. 37 ff

# III. LUBRICANTS

## SUMMARY

The uses of PFAS in lubricants has already been presented in our first submission from May 24$^{th}$. However, we collected some more insight from suppliers and OEM and wished to bring some addition to the data presented in our first submission.

## AUTOMOTIVE USES

PFPE is used in case of extreme conditions, e.g., extreme temperature differences, maximum durability, possibly in some production plants, Sunroofs to minimize friction, bearings, inside engines etc.

| Impacted parts in automotive | | |
|---|---|---|
| High Pressure Ducts<br>Hoses And Reservoirs<br>Console Unit<br>Restraining Devices – Diagnostic<br>Rear Shock Absorbers<br>Housing And Seals<br>Internal Hydraulic or Mechanical Controls and Pumps<br>Power Take-Off<br>Turbocharger<br>Supercharger<br>Exhaust Gas Recirculation<br>Mufflers<br>Sensors<br>Signal Conditioning Devices<br>Stabilizer Bar<br>Rear Suspension Members<br>External Controls – Hydraulic<br>Overhead Console<br>Wheels<br>Traction Battery<br>Actuator<br>Window<br>Display Modules | Strut<br>Front Suspension Members<br>Emission Control - Distributor Mechanisms<br>Jack And Jack Handle<br>Differential Assembly<br>Housing<br>End Couplings and Yokes<br>Parking Brake Controls (Cable)<br>Spare Wheel Frame Mounting<br>Coolant Pump and Flow Control<br>Hinges & Check Side Doors<br>Electric Horns<br>Driver-Operated External Controls - Floor Shift<br>Main molding & lid<br>Manual Control Unit<br>Compressor<br>Transmission<br>Door components<br>Clutch<br>Steering Column<br>Brake by Wire<br>Pulley in alternator<br>Electrical turbocharger<br>Electric motor for battery electric vehicle (BEV)<br>Fuel cell compressor | Driver-Operated External Controls<br>Front Shock Absorbers<br>Power Closure Mechanisms<br>Suspension Levelling Power Source<br>Steering Column and Shaft<br>Cab Suspension Levelling Mechanism<br>Multiple Function Controls<br>FEM Carrier Subframe<br>Floor Console Switches<br>Receiver<br>Tubes And Hoses<br>Automatic Control Unit<br>Master Cylinder<br>In-Vehicle Entertainment System<br>Cab Tilting Mechanisms<br>Engines<br>Seats<br>Bearing<br>O-Rings<br>Air conditioner<br>Mirror<br>Steer by Wire |

## IMPACTS TO THE END USER (CONSUMER) AND END OF LIFE/ DISPOSAL (IF APPLICABLE)

It might also lead to higher costs for consumers/vehicle owners as parts that usually outwear the whole lifetime of a vehicle must be changed during the lifetime of the vehicle, e.g. engines to move an outer mirror or seats etc. Further use cases are still under evaluation.

# IV. NON-EXHAUSTIVE LIST OF APPLICATIONS OF FLUOROPOLYMERS AND FLUOROELASTOMERS

| System Description | | | |
|---|---|---|---|
| 48 Volt Power Cabling | Exhaust Manifold | Interior NVH Pads | Rear Suspension Knuckle Assembly |
| AC Compressor | Exterior Usability Appearance and Protection | Internal and External Noise Synthesis | Rear Suspension Links/Arms Upper & Lower |
| AC Inverter | External Communications & Connectivity | Jack and Emergency Tools | Rear Wheel Arch Liners and Baffles |
| AC Lines, Receiver Drier and Accumulator | Fasteners | Keyless Vehicle | Rear Wheel Steering Actuation |
| Accessory Drive (FEAD, READ) | First Row Door Window Lift Assy | Lighting - Ambient Instrument Panel (IP) & Consoles | Restraint Electronics |
| Acoustic Control Components | Fixed Roof Glazing | Load Compartment Floor Trim | Road Wheel and Tyre Assembly |
| Active Anti-Roll | Floor Console Armrest/Lid | Load Compartment Fuse Box / Passive | Roof Bars and Roof Rack |
| Air Cleaner | Floor Console Main Moulding | Load Compartment Side Trim | Seat Belts |
| Air Distribution Duct Components | Forward Looking Camera (IPMA) | Load Compartment Transverse Trim | Seat console |
| Air Suspension | Forward Looking Radar | Low Pressure Ducts | Seats |
| Alarm Horns and Sirens | Front Bumper Skin, Foams and mounted Grilles | Low Voltage Power Electronics | Second Row Door, Qtr & Rear Closure Window Lift Assy |
| Applied Decorative Trim - (IP) | Front Door BIW | Main Floor Trim | Side Door Latches and Exterior Handles |
| Applied Decorative Trim - Floor Console | Front Door Exterior Frame Finisher | Module - Auto or Powershift Trans as Shipped | Side Doors Hinges and Checks |
| Applied Decorative Trim - Side Doors | Front Door Interior Frame Finisher | Module - Body Part Assembly | Spare Wheel and Tyre Assembly |
| Applied Parts - (IP) | Front Door Trim Panel | Module - Cockpit complete | Speakers |
| Applied Parts - Floor Console | Front Drive Unit | Module - Cooling Pack | Special Protective Structures |
| Automatic / Automated Manual Selector Assembly | Front End Module Carrier | Noise Insulation, Hood and Engine Bay | Stability Control Systems |
| Auxiliary Water Pump | Front Fenders | NS Powertrain Mounting System | Starter Motor |
| Badging | Front Floor | Oil Filter, Level Indicator and Cooler | Static Sealing and Structural Adhesive |
| Battery 48V Super Capacitor and Ancillaries | Front Foundation Brakes | Onboard Charger | Steering Column |
| Battery Cables | Front Propshaft | Overhead Console | Steering Wheel |
| Battery, Heat Shield & Battery Management System | Front Side Door Dynamic Weatherstrip | Parcel Shelf / Blinds | Sun Visors |
| Belt Driven Integrated Starter Generator (BISG) | Front Side Door Glass | Passenger Entertainment Displays | Sunroof Assembly |
| Body Control Module | Front Springs and Dampers | Pedals | Supplemental Front Lamps |
| Body Dash and Cowl | Front Stabilizer (Anti-Roll) Bar | Pillar Trim Lower | Supplemental Rear Lamps |
| Body Side | Front Structure | Pillar Trim Upper | Supplementary Heat Source |
| Booster, Master Cylinder and Reservoir Assembly | Front Sub-Frame Complete | Power Amplifier | Surround Cameras |
| Brake Pipes and Hoses | Front Suspension Knuckle Assembly | Power Outlet & Lighter | Suspension Controls |
| Cabin Rear Trim | Front Suspension Links / Arms Upper and Lower | Power Side Door Mechanism | Switch gear |
| Cargo Retention | Front User Interface Display | Power Transfer Unit | Towing and Recovery Attachments |
| Center Stack | Front Wheel Arch Liners and Baffles | Powertrain and Auxiliary Control Modules | Towing Electrical |
| Charge Port Bowl and Flap | Fuel Cell | Powertrain Control Modules: Mounting Hardware | Traction Battery |
| CHMSL (Center High Mount Stop Light) | Fuel Distribution | Powertrain Control: Sensors and Actuators | Traffic Horns (Electric) |
| Cladding, Body and Wheel Arch | Fuel Evaporative Control | Radiator | Transmission Dress Items (Auto) |
| Climate Sensors | Fuel Filler (Refueling) | Radiator Grill (non-bumper mounted) | Transmission Dress Items (Manual) |
| Closure Panel or Knee Bolster - (IP) | Fuel Filler and Flap | Radio Frequency Key | Transmission Oil Cooler |

| | | | |
|---|---|---|---|
| Clutch Actuation Assembly | Fuel Tank Assembly | Rear AC Control Module | Transmission Oil Cooler Pipes |
| Column Cowl | Gear Shift Module (GSM) | Rear Bumper Skin and Foams | Turbocharger or Supercharger |
| Consumer Electronics Interface Module | Generator/Alternator | Rear Closure BIW Panel | Under Engine Closures, Rock Shields and Engine Bay Air Guides |
| Convertible Top Assembly | Grille Opening Panel/Front Sheet Metal | Rear Closure Dynamic Weatherstrip | Underfloor Closures |
| Cooling Fan and Shrouds | Headlamp Cluster | Rear Closure Exterior Handle and Actuation | Upper Exterior and Roof Finish |
| Cross-Car Beam (IP) | Headliner Assembly | Rear Closure Finishers | Vacuum Distibution Components |
| Curtain Airbag System | Heat Insulation and NVH Shields - Engine Bay & Underfloor | Rear Closure Hinges | Windscreen & Tailgate Washer System |
| Cylinder Block | High Pressure Ducts | Rear Closure Interior Trim Panel | Wiper Assembly Front |
| DCDC Converter | High Voltage Fuse Box | Rear Closure Latches | Wiper Assembly Rear |
| Dressed Engine Exterior Covers | High Voltage Power Cabling | Rear Closure Support & Checks | Wiring harnesses |
| Driver Airbag and Cover | Hood BIW Panel | Rear Combination Lamp | Accessory Drive Belt (V, micro-V) |
| Driver Information Module (Instrument Cluster) | Hood Hinges | Rear Door BIW | Tensioner, Idler and Pulley |
| EDS Components & Fasteners | Hood Latch & Actuation | Rear Door Exterior Frame Finisher | Mechanical or Electrical Water-pump |
| Electric Vehicle Supply Equipment (EVSE) | Hood Support and Struts | Rear Door or Rear Quarter Trim Panel | Cooland Hose |
| Electric Water Pump | Hose Set - Coolant (includes Expansion Tank) | Rear Drive Unit | Fuel Hose |
| Emission Control Components | HVAC Auxiliary Unit | Rear Floor | Thermostat |
| Emissions Additive Storage, Supply and Conditioning | HVAC Main Unit | Rear Foundation Brakes | Coolant Thermostat |
| Engine Bay Fuse Box / Passive | Infotainment Antennas and Cables | Rear Propshaft | Radiator Cap |
| Engine Compartment Trim / E-Box | Infotainment Head Unit | Rear Side Door Dynamic Weatherstrip | Expansion Tank Cap |
| Engine Cooling | Infotainment Remote Control and Headphones | Rear Side Door Glass | Electrical-turbocharger |
| Engine Covers | Inner Handles | Rear Spoiler | Electric motor for battery electric vehicle |
| Engine Ventilation | Instrument Panel Main Molding | Rear Springs and Dampers | Fuel Cell Compressor |
| EW Powertrain Mounting System | Interior Lighting | Rear Stabilizer (Anti-Roll) Bar | Synchronous Belt |
| Exhaust Gas Recirculation | Interior Mirror | Rear Sub-Frame Complete | |

## V. NON-EXHAUSTIVE LIST OF PFAS USED IN LACQUERS AND IMPACTED PARTS

| **Identification** | | | | **Function of PFAS in the material** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Short description of product | Affected components / mixtures | Affected components / mixtures | CAS number | Low | Heat resistance / Temperature retention | Chemical / fuel stability | Durability | Pressure equalization (membrane) | Others |
| Lacquers | Lacquer, topcoat | Horn Spring | 9002-84-0 | X | | | X | | |
| | Lacquer, topcoat | Buckle spring | 9002-84-0 | X | | | | | |
| | Lacquer | Metal pillar loop | 9002-84-0 | X | | | X | | |
| | Lacquer, topcoat | Screw | 9002-84-0 | X | | | | | Noise reduction |
| Paints - mixtures | paints for our MAKE parts (decoration) | | 9002-84-0 | X | | | | | Noise reduction |
| Assembly elements | screws, nuts, bolts, headlamps, rearlamp | | 9002-84-0 | X | | | | | |
| Valve Actuators | Pressure Equalizing Membrane | Actuators | 9002-84-0 | | | | | X | X |
| | Filter: die Cut Filter Media | | 9002-84-0 FMACP | | | | | | X |
| | Gear: Torque regulation | Actuators | PTFE 5 | X | | | X | | |
| Sealing ring | Gas Tightness Products | Exhaust system | 25190-89-0 | | | | | | X |
| Washers, screws, nuts | Coating: e.g. Zinc flake with topcoat (GEOMET 500B acc. ISO 10683) | | 69991-61-3 | X | | | | | |
| Bearings | | Exhaust Valvle | 9002-84-0 | X | | | | | |
| Bushings | Slotted bushing in actuator housing drive unit | | 69991-61-3 | X | | | | | |
| Bushings | | | 370097-12-4 | X | | | | | |
| Process - Raziol Drylub WA 03 T | Process lubricant (shrinking, stuffing) | Canning | 9002-84-0 | X | | | | | |

# VI. NON-EXHAUSTIVE LIST OF PFAS USED IN TEXTILES

| Identification | | | | Function of PFAS | |
|---|---|---|---|---|---|
| Short description of product | Affected components / mixtures | PFAS | CAS number | Durability | Others |
| Thread | PA66<br>5.1.b unfilled Thermoplastics | 5% FAA/ Fluoroalkyl Acrylate<br>as 9.2 Lubricants | | (X) | |
| Spacer fabric | PET<br>5.1.b unfilled Thermoplastics | 2% PTFE | | | |
| Textile – Insert – deep garnet | PET 5.5.2 Textiles (in polymeric compounds) | FAA mat class 6.2 Adhesives, sealants | | | Anti soiling |
| Seat trim cover | | Propane, 1,1,1,2,2,3,3-heptafluoro-3-((trifluoroethenyl)oxy)-, polymer with tetrafluoroethene and trifluoro(trifluoromethoxy)ethene | 165178-32-5 | | |
| | | Propanoyl fluoride, 2,3,3,3-tetrafluoro-2-(1,1,2,3,3,3-hexafluoro-2-(heptafluoropropoxy)propoxy)-, polymer with trifluoro(trifluoromethyl)oxirane, reaction products with 3-(ethenyldimethylsilyl)-N-methylbenzenamine | 185701-88-6 | | |
| | | Propanenitrile, 3,3'-[[4-[[2-bromo-4-nitro-6-(trifluoromethyl)phenyl]azo]phenyl]imino]bis- (9CI) | 246871-16-9 | | |
| | | Ethene, tetrafluoro-, polymer with trifluoro(trifluoromethoxy)ethene | 26425-79-6 | | |
| | | Perfluoropolyether | 60164-51-4 | | |
| | | Ethene, tetrafluoro-, homopolymer | 9002-84-0 | | |
| | | Ethylene, tetrafluoro-, polymer | 9002-84-0 | | |
| | | Propene, 1,1,2,3,3,3-hexafluoro-, polymer with 1,1-difluoroethene | 9011-17-0 | | |
| | | Propane, 1,1,1,2,2,3,3-heptafluoro-3-((trifluoroethenyl)oxy)-, polym. | 26655-00-5 | | |
| | | 2,2,2-Trifluoroethyl acrylate | 407-47-6 | | |
| | | 1-Hexene, 3,3,4,4,5,5,6,6,6-nonafluoro-, polymer with ethene and tetrafluoroethene | 68258-85-5 | | |