

Call for evidence supporting an analysis of restriction options for PFAS

I. Reasons and aims of this analysis

The competent authorities for REACH of several member states, namely the Netherlands, Germany, Denmark, Sweden and Norway are currently preparing an analysis of restriction options for the PFAS group of substances (per- and polyfluoroalkyl substances) described below (as defined under Section II. Substances) since all these substances are considered to be persistent.

The consequences of this persistence include that the presence of these substances in the environment is practically irreversible, and pose an unacceptable risk to the environment and humans. All uses of PFAS (professional and industrial uses, consumer uses of mixtures and articles) result in emissions into the environment and contribute to the overall concentrations of PFAS in the environment. Many members of this group already occur ubiquitously in the environment and contaminate the ground- and untreated water due to their high mobility. In addition, some of these substances accumulate in biota and/or are suspected to be toxic.

In view of these properties, the abovementioned competent authorities for REACH are considering proposing EU-wide measures covering all PFAS (as defined under Section II. Substances) to reduce those risks.

This questionnaire is intended to generate data and knowledge with regard to PFAS and their uses in order to decide on the initial chemical scope as well as the use scope of a restriction proposal. The questionnaire further aims at understanding for which of the PFAS in scope chemical alternatives or technical replacements exist, voluntary measures or substitution processes etc. are ongoing. Based on that basic information appropriate options for a restriction proposal will be taken forward in the development of a REACH Annex XV Restriction Dossier.

II. PFAS in scope

As indicated by the name, per- and polyfluoroalkyl substances (PFASs) comprise a group of organic substances containing alkyl groups on which all or many of the hydrogen atoms have been replaced with fluorine as structural fragments.

Hence, as the scope of the current Call for Evidence have been selected:

Substances that contain at least one aliphatic -CF₂- or -CF₃ element.

Although all PFAS will be considered for regulation, a non-exhaustive list of the most frequently used substances and substance groups may be found in the supplementary document accompanying this

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questionnaire and consultation which can be downloaded under following link: [Supplementary document.docx](#)

III. Target group of this questionnaire

Questions are addressed to the whole supply chain including **manufacturers, importers, distributors and downstream users** (please see supplementary document for further explanation).

Of interest is information on **PFAS** and **alternatives to PFAS**. PFAS and PFAS contained in mixtures and articles are of relevance. Alternatives include chemical (non-fluorinated) as well as technical replacements for PFAS.

This questionnaire contains the possibility to redirect through blocks of questions depending on your type of information or data. Hence, you are able to specifically respond to the questions relevant to you.

IV. Information on institute/organisation/person & Data protection rights

Data subject rights: Access, rectification, erasure, blocking, right of revocation

By participating in this survey, personal data may be processed in terms of the General Data Protection Regulation (GDPR) of the European Union. "Personal data" is any piece of information that allows a natural person to be identified directly or indirectly, for example a name or a personified e-mail address. "Processing" may mean, for example, the collection, recording and storing of these data.

There is no legal obligation whatsoever to grant such permission. Your permission is granted at your free discretion.

Pursuant to Article 15 GDPR, you have at any time the right to request comprehensive **information** on the stored personal data concerning you from the German Federal Institute for Occupational Safety and Health. According to Article 16 et seq. GDPR, you may ask the Federal Institute for Occupational Safety and Health at any time to

rectify, erase and block individual personal data.

According to Art. 7(3) GDPR, you furthermore have the right to **withdraw this consent at any time**. The withdrawal may be sent by post or by e-mail to the data controller named below:

Bundesanstalt für Arbeitsschutz und Arbeitsmedizin / German Federal Institute for Occupational
 Safety and Health Division 5: Federal Office for Chemicals
 Postfach 17 02 02
 44061 Dortmund

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E-Mail: [REDACTED]@baua.bund.de

You can contact our [Data Protection Officer](#) under the postal address above or by e-mail to [REDACTED]@baua.bund.de. Should you be of the opinion that the BAuA does not process your data in accordance with applicable data protection regulations, you have the right to contact [The Federal Commissioner for Data Protection and Freedom of Information](#), Husarenstraße 30, 53117 Bonn

When exercising your rights, you will not incur any costs other than postage or transmission costs according to current base rates. Should you withdraw your consent, your personal data will be deleted immediately after receipt of the withdrawal notice. A withdrawal shall not affect the lawfulness of the processing of your data up until the time of the withdrawal. Your personal data will be stored until the present survey has been fully evaluated and until no further questions may arise.

Consent may be withheld, with the consequence of only participating in a survey without the option for asking the individual participant specific follow-up questions. In this case, company information will have to be provided.

PERMISSION FOR INFORMATION PURPOSES: I agree to the personal data I provide in the present survey, including my name and my e-mail address, to be collected, processed and stored for potential follow-up questions regarding this survey by the service provider of Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA), namely Webropol Deutschland GmbH, and to these being subsequently stored in the database of the Federal Chemicals Office.

*

☒ Yes

☐ No

The following information marked with * on institute/organisation/person are mandatory fields.

Information on institute/organisation/person

Name Nicolas

Surname Robin

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Name of institute/organisation

Fluoropolymers Product Group, a Sector Group of PlasticsEurope

E-Mail [REDACTED]!@plasticseurope.org

Can we contact you with follow-up questions? *

☒ Yes

☐ No

Are you interested in attending a meeting on specific uses of PFAS, mixtures and articles containing PFAS?

* ☒ Yes

☐ No

Note on Confidentiality of information and data

I understand that it is my responsibility not to include confidential information in responses to general comments and in any responses to requests for specific information (e.g. company name, email addresses, phone numbers, signatures etc.). The competent authorities for REACH will not be held liable for any damages caused.

*

☒ Yes

I understand that it is my responsibility to mark confidential data and attachments as confidential. *

☒ Yes

1. Please choose one of the following options. Do you have information on PFAS, PFAS-containing mixtures and articles or alternatives being able to replace PFAS.

*

☒ PFAS, PFAS-containing mixtures and/or articles

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- ☐ alternatives i.e. other substances, non-chemical or functional replacement

V. Questions - Section A -PFAS and PFAS-containing mixtures and articles

2. Please define your role(s) with regard to PFAS and/or PFAS-containing mixtures and articles (see above for definitions of different roles). Please choose according to your primary role but multiple roles can be indicated. (please see Supplementary document for further explanation)*

- ☐ Manufacturer of PFAS and/or PFAS-containing mixtures
- ☐ Manufacturer of PFAS-containing articles
- ☐ Importer of PFAS and/or PFAS-containing mixtures
- ☐ Importer of PFAS-containing articles
- ☐ Distributor of PFAS and/or PFAS-containing mixtures
- ☐ Distributor of PFAS-containing articles
- ☐ Downstream User of PFAS and/or PFAS-containing mixtures
- ☐ Downstream User of PFAS-containing articles
- ☐ Other (e.g. NGOs, Scientists)

Trade association representing European manufacturers of fluoropolymers

V. Questions - Section A -PFAS and PFAS-containing mixtures and articles

Information on substance identity and quantities *

10. ☒ I have information

11. ☐ I have no information

3. Please fill in following information for PFAS and/or PFAS contained in mixtures and/or articles:

- chemical names, trade names, CAS and EC numbers
- quantities you produce/import/use per year for each individual PFAS

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- number of manufacturing/use sites
- number of workers involved in handling at company/customer sites
- production process of your substance (electrochemically or other methods)
- description of the production of polymers, fluororesins or other complex perfluorinated compounds in detail.
- if relevant description of your fluorinated non-intentionally added substance(s) (NIAS) (e.g. oligomers, impurities) which might be present in your substance
- if relevant description of fluorinated substances produced/formed during the production process including e.g. volatile substances that could be released to the environment

This can be done using an Excel file which can be downloaded and expanded according to your needs via the following link: [Substance identity and quantities.xlsx](#)

Fluoropolymers are a distinct subset of 'fluorinated polymers.' They are made by (co)polymerisation of olefinic monomers, at least one of which contains fluorine bound to one or both of the olefinic carbon atoms, to form a carbon-only polymer backbone with fluorine atoms directly attached to it. These polymers are (a) chemically stable, except under extremely harsh conditions, in no way representative of the environment or biota; (b) biologically stable/inert; (c) incapable of forming perfluorohexanoic acid in the environment or biota, given their stability / inertness; (d) negligibly soluble in water; (e) non-bioavailable; (f) non-bioaccumulative; and (g) non-toxic.

'Fluoroplastics' and 'fluoroelastomers' are both subsets of the fluoropolymer family, as detailed below:

- **Fluoroplastics** are made by homo- or copolymerization of monomers including, but not limited to: tetrafluoroethylene (TFE), hexafluoropropylene (HFP), vinylidene fluoride (VDF), chlorotrifluoroethylene (CTFE), vinyl fluoride (VF), trifluoroethylene (TrFE) and perfluoroalkyl vinyl ethers (PAVEs) which include trifluoromethyl trifluorovinyl ether (PMVE), pentafluoroethyl trifluorovinyl ether (PEVE) and heptafluoropropyl trifluorovinyl ether (PPVE). In the case of copolymers, monomers that do not contain fluorine attached to the olefinic carbons may be used. These include, but are not limited to, ethylene, propylene and perfluoroalkyl-substituted ethylenes. Fluoroplastics that are produced by homo- or copolymerization of the monomers listed above include, but are not limited to: polytetrafluoroethylene (PTFE), the TFE-HFP copolymer (FEP), polyvinylidene fluoride (PVDF), polychlorotrifluoroethylene (PCTFE), polyvinyl fluoride (PVF), the ethylene-TFE copolymer (ETFE), the ethylene-CTFE copolymer (ECTFE), the VDF-HFP copolymer (VDF-co-HFP), the VDF-TFE copolymer (VDF-co-TFE), terpolymer of TFE, perfluoroalkyl trifluorovinyl ether and chlorotrifluoroethylene (CPT), terpolymers of TFE, HFP and VDF (THV), terpolymers of TFE, HFP and ethylene (EFEP), polytrifluoroethylene (PTrFE), and perfluorinated polymers with perfluoroalkoxy side-chains resulting from copolymerization of tetrafluoroethylene with either trifluoromethyl trifluorovinyl ether (MFA) or other perfluoroalkyl trifluorovinyl ethers (PFA).

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- **Fluoroelastomers or 'fluorocarbon elastomers'** are rubbery materials based mainly on several of the same monomers as used for producing fluoroplastics, including but not limited to VDF, HFP, TFE, CTFE, PAVEs and propylene, as well as 1-hydropentafluoropropene (HPFP) and 2,3,3,3-Tetrafluoropropene (HFO-1234yf). They are produced as highly viscous materials and then cross-linked (or 'cured', or 'vulcanized') to harden them and impart their elasticity. Cross-linking agents commonly used are bis-nucleophiles (diamines, bisphenols, diisocyanates), free-radical generators (peroxides), or radiation. **Fluoroelastomers can be regarded as a distinct subset of fluoropolymers.** While they are based on many of the same monomers as those used for synthesising fluoroplastics, the main difference between the two families is that **fluoroelastomers have unique elastomeric properties, resulting from the cross-linking process, with low sub-ambient glass transition temperatures (T_g).**

The definitions provided above would include, but not be limited to, the following:

- **ECTFE:** ECTFE is a copolymer of ethylene and chlorotrifluoroethylene having the formula $[(CH_2-CH_2)_x-(CFCl-CF_2)_y]_n$. ECTFE has a melting point range of 428o – 473oF (220o - 245oC) and is melt processable. It is available in the form of translucent pellets and as a fine powder.
- **EFEP:** EFEP is a copolymer of ethylene, tetrafluoroethylene, and hexafluoropropylene, with the formula $[(CH_2-CH_2)_x(CF_2-CF_2)_y(CF(CF_3)-CF_2)_z]_n$. EFEP polymers melt at 311o – 392oF (155 – 200oC). It is melt processable and is supplied in pellet form.
- **ETFE:** ETFE is a copolymer of ethylene and tetrafluoroethylene of the formula $[(CF_2-CF_2)_x-(CH_2-CH_2)_y]_n$. Depending on various grades, ETFE melts between 428oF – 518oF (220oC – 270oC). It is melt processable and is supplied in pellet and powder form.
- **F-TPV (fluoro thermoplastic vulcanizates):** "Ready to use" fluoro thermoplastic fluoroelastomers with superior extrusion behaviour and ultra-low permeation, melt processable, offering a unique combination of low permeation, low modulus (high flexibility), and excellent processability with a melting point about 230°C.
- **FEP:** FEP resin is a copolymer of tetrafluoroethylene and hexafluoropropylene with the formula $[(CF(CF_3)-CF_2)_x(CF_2-CF_2)_y]_n$. It has a melting point range of 473o - 536oF (245o - 280oC) and is melt processable. It is supplied in the form of translucent pellets, powder, or as an aqueous dispersion.
- **HTE:** HTE is a copolymer of hexafluoropropylene, tetrafluoroethylene, and ethylene. HTE is melt processable with melting points from 310o to 420oF (155o to 215o C) depending on grade. It is available in pellet or agglomerate form.
- **MFA:** MFA is a copolymer of tetrafluoroethylene and perfluoromethylvinylether. It belongs to the generic class of PFA polymers. MFA melts at 536o– 554oF (280o- 290oC). It is available in the form of translucent pellets and aqueous dispersions.
- **PCTFE:** PCTFE is a polymer of chlorotrifluoroethylene with the formula $[CF_2-CFCl]_n$. It has a melting point range of 410o- 428oF (210o - 220oC) and is melt processable. It is available in pellet,

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granular and powder form.

- **PFA:** PFA resins are copolymers of TFE fluorocarbon monomers containing perfluoroalkoxy side chains. PFA melts at 536 oF (280oC) minimum and is melt processable. It is available in the form of pellets, powder, and as an aqueous dispersion.
- **CPT:** CPT is terpolymer of TFE, perfluoroalkyl trifluorovinyl ether and chlorotrifluoroethylene. CPT has the melting point at 235C-255C (455F-491F). CPT is available in the form of pellets and powder.
- **PTFE:** PTFE is a polymer consisting of recurring tetrafluoroethylene monomer units, whose formula is $[CF_2-CF_2]_n$. PTFE does not melt to form a liquid and cannot be melt extruded. On heating the virgin resin, it forms a clear, coalescable gel at 626oF ± 18 o (330o C ± 15 o). Once processed, the gel point (often referred to as the melting point) is 18oF (10oC), lower than that of the virgin resin. It is sold as a granular powder, a fine powder, or an aqueous dispersion. Each is processed in a different manner.
- **PVDF:** PVDF is a homopolymer of vinylidene fluoride having the formula $[CH_2-CF_2]_n$ or a copolymer of vinylidene fluoride and hexafluoropropylene having the formula $[CF(CF_3)-CF_2]_x[CH_2-CF_2]_y$. Copolymers of vinylidene fluoride are also produced with (1) chlorotrifluoroethylene, (2) tetrafluoroethylene, and (3) tetrafluoroethylene and hexafluoropropylene. These are all sold as PVDF copolymers. PVDF polymers/copolymers melt at 194o-352oF (90o-178oC), are melt processable, and are supplied in the form of powder, pellets, and dispersions.
- **THV:** THV is a copolymer containing tetrafluoroethylene, hexafluoropropylene and vinylidenefluoride. THV is melt-processable with melting points from 240o to 455oF (115o to 235oC) depending on grade. It is available in pellet, agglomerate or aqueous dispersions

The information above is taken from the Guide to Safe Handling of Fluoropolymer Resins, which is currently being updated and will be shared once available. The most recent version is available here (<https://www.plasticseurope.org/en/resources/publications/108-guide-safe-handling-fluoropolymer-resins>) .

Here, the Excel file "Substance identity and quantities.xlsx" can be attached to the questionnaire:

V. Questions - Section A -PFAS and PFAS-containing mixtures and articles

Information on hazards *

☒ I have information

☐ I have no

information

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The carbon-fluorine bonds are one of the strongest chemical bonds in organic chemistry. This means substances containing this chemical bond resist degradation when used, as well as in the environment. All PFAS subject to the description above (as defined in Section II.) could be considered to meet the criteria of persistence. Per- and polyfluorinated chemicals are thermally, chemically and biologically highly inert. Due to the very strong carbon-fluorine bond, these substances can resist degradation by acids, bases, oxidants, reductants, photolytic processes, microbes and metabolic processes (Parsons et al., 2008; Schultz et al., 2003; Siegemund et al., 2000).

4. Do you consider your PFAS and/or PFAS present in your mixtures and/or articles to be persistent including any impurity, known contaminants or degradation products?

*

☒ Yes
☐ No

5. If you do not consider your PFAS and/or PFAS present in your mixtures and/or articles to be persistent. Please explain why and ideally provide data why they are not persistent. Additional data can be uploaded at the end of the questionnaire.

The criteria for PFAS as described in the Call for Evidence includes many different substances with very different properties and environmental and safety profiles. While persistence in the environment may warrant further consideration, persistence alone does not imply that there is a present or future risk to human health or the environment. REACH has regulated persistence so far in the context of PBTs and vPvBs, where Persistence (P) must be associated with Bioaccumulation (B) and Toxicity (T) (or very Persistence (vP) must be associated with very Bioaccumulation (vB)) to justify qualification as a substance of very high concern (SVHC).

In REACH, persistence alone does not justify risk management measures. Considering the wide variety of persistent substances (including those that meet the definition of PFAS as described in the Call for Evidence), the level of priority in the assessment and management of persistent chemicals should vary not only on the basis of their respective level of persistence, but all other relevant factors.

Fluoropolymers may meet the REACH definition to be considered persistent but are not mobile in the environment given their negligible solubility, and have been demonstrated to have no systemic toxicity. The inertness and stability of fluoropolymers is precisely why they are used in many diverse applications of high societal value necessary for modern life (e.g. medical devices, renewable energy, and automotive and semiconductor applications).

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Further, an overly narrow focus on persistence could undermine societal sustainability goals, like the EU Green Deal, as durability is necessary to expand the lifecycle of products and contribute to the circular economy. While fluoropolymers may meet the REACH definition to be considered persistent, they do not present a hazard or exposure to biota or the environment (as implied in Question 4).

To summarise:

Fluoropolymers do not meet the REACH criteria for restriction

Fluoropolymers are stable, biologically inert, insoluble in water, and not mobile. and as polymers of low concern, they pose no significant risk. Therefore, they do not meet the REACH criteria for restriction.

Fluoropolymers are specialty plastics and pose no significant risk

The stability of fluoropolymers gives it unique, durable, lasting performance in critical uses and applications. A substantial body of scientific data demonstrates that fluoropolymers do not pose a significant risk to human health or the environment, because of their unique characteristics. Fluoropolymers have negligible solubility in water and cannot enter or accumulate in a person's bloodstream. Fluoropolymers have been demonstrated to meet the OECD's criteria for "polymers of low concern," as they do not present significant toxicity concerns and cannot degrade into other PFAS under normal conditions of use. Fluoropolymers do not pose a significant risk to water quality, human health, or the environment.

Please see the attached supplementary information regarding fluoropolymers fulfilment of the OECD criteria for polymers of low concern.

6. Please list any self-classification and hazards other than persistence relevant for human health and the environment known for each individual PFAS and/or PFAS present in the mixture and/or article that you manufacture, import and/or use? Please link this information with a corresponding CAS-number.

This can be done using an Excel file, which can be downloaded and expanded according to your needs via the following link: [Hazards.xlsx](#)

The Members of the PlasticsEurope Fluoropolymers Product Group strive for better chemicals manufacturing, which is essential in order to prevent unforeseen emissions to the environment. The Fluoropolymers Product Group is convinced that reducing emissions is of the utmost importance. Our manufacturing sites adhere to local and EU environmental regulation. Even so we are taking into account the continuous improvement via evaluation of additional measures that can further enhance responsible stewardship.

Similarly, and submitted along with this response to the Call for Evidence, you will find a "Guide for the Safe Handling of Fluoropolymer Resins" which provides information for the supply chain on the safe handling of fluoropolymer substances.

Here, the Excel file "Hazards.xlsx" can be attached to the questionnaire:

V. Questions - Section A - PFAS and PFAS-containing mixtures and articles

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Information on uses *

☐ I have information

☐ I have no

information

7. Which are the area(s) of use and application of your PFAS and/or PFAS containing mixtures and/or articles.

Please tick

Textiles, leather and apparel, and textile related products

☐

Cosmetic products

☐

Food contact materials and non-stick kitchenware

☐

Paper and packaging

☐

Firefighting foams

☐

Household articles/Consumer mixtures (e.g. non-sticking coating, impregnation agents, polishes etc.)

☐

Construction products (e.g. surface treatments (paints, coatings)

☐

Lubricants and greases

☐

Chrome plating (including mist suppressing agents)

☐

Semiconductors

☐

Ski waxes

☐

Medical devices and applications

☐

Applications of PFAS within oil, gas and mining (apart from firefighting foam)

☐

F-gases e.g. (PFC, HFC, HCFC, HFE,

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HFO) in air-conditioning, heat-pump equipment, aerosol cans, foams etc.

☐

Uses of C1 perfluorinated carboxylic and sulfonic acids (trifluoroacetic acid (TFA) or trifluoromethanesulfonic acid (triflic acid, TfOH))

☐

Please tick

Transportation (automotive, aviation etc.) other than listed above (e.g. greases)

☐

Photographic surface layers

☐

Other

☐

8. If possible, please assign or estimate annual quantities of your PFAS and/or PFAS containing mixture and/or article to the individual uses. If possible, list products in the relevant application area that contain your PFAS and provide information or an estimate on quantities (i.e. concentrations or applied amount per cm²).

This can be done using the Excel file, which can be expanded according to your needs under following link: [Quantities Concentrations per Use.xlsx](#)

All figures provided below cover fluoropolymers on the EU market in 2015 (for more information, see the attached socio-economic report, p. 6, and relevant information in the sections below)

- Transport: 18,000t, €300m, 13m employees
- Chemicals & Power: 16,000t, €220m, ca 3m employees
- Cookware: 3,500t, €60m
- Food & Pharma: 3,000t, €40m, 5m employees
- Textiles & Architecture: 3,000t, €40m, 2m employees
- Medical applications: 1,500t, €20m
- Renewable energy: 500t, €30m
- Electronics (incl. semiconductors): 3,500t, €40m, semiconductors market worth ca. €25bn

All employee figures are indirect employees whose jobs are supported by the usage of fluoropolymers. Please see the socio-economic report in the annex for details on usage.

In addition, some additional markets have significantly evolved since the time of the initial study (2015), such as the rechargeable battery market. PVDF for example is used in batteries for safe and durable use.

It is often challenging to quantify the concentrations per use (e.g. in a smartphone and or in an airplane) due to the numerous ways in which fluoropolymers are used. In most cases, articles are made from

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fluoropolymers (concentration often up to 100%) and those articles are then incorporated into end-use "articles", such as automobiles, aircraft, smartphones, etc.

Here, the Excel file "[Quantities_Concentrations_per Use.xlsx](#)" can be attached to the questionnaire:

9. You have ticked other(s), please specify the use(s) or area(s) of application respectively.

Agricultural Tools such as films for greenhouses

In greenhouses, ultra-thin ETFE films (ETFE foil) are used to substitute traditional glass roofs. It is treated with an anti-drip coating, designed to increase the yields of plants, flowers, fruits and vegetables grown inside commercial greenhouses. ETFE foils allows maximum UV light transmission to ensure early blooms, more colourful plants and sweeter fruit and vegetables. The film's durable chemical composition is self-cleaning.

Advantages

- Excellent light transmission up to 94%
- Anti-adhesion/Easy-cleaning
- Improves crop quality by UV light transmission ('UV cut' grade also available)
- Excellent durability due to minimal effect of ageing on tensile strength – a service life of over 30 years
- Less structural elements (steel) are required thanks to the lightweight properties of the film, so more sun can enter the greenhouse
- Stable at high and low temperatures (-100°C to 200°C)
- A double layered roof saves over 30% energy compared to a single layer glass roof
- No breaking/splintering, high resistivity against tear propagation
- Anti-dripping characteristics prevents condensation droplets from dripping down
- Non-flammable material certified B1 in DIN4202 part 1
- Improved light transmission at all angles of incidence, compared to other covering materials
- Same ETFE technology is used in prestigious architectural projects

Agricultural Machinery including but not limited to tractors, combine harvesters, ploughs, harrows, seed drill, planting machines and fertiliser spreader

Characteristics

- Low permeation, but also manufactured to allow for semipermeable structures;
- Chemical resistance (protecting components from corrosive fuels and engine oils and fluids);
- Low and high temperature resistance (from -200 °C to +260 °C for PTFE and PFA, with other elastomers offering a range of -40 °C to +230 °C);
- Non-stick and consequently non-fouling, alongside sufficient bonding in certain multilayer applications; Low friction coefficient;
- Long-term compression resistance of fluoroelastomers;
- Excellent dynamic properties;
- No flame propagation and low smoke generation; and
- Excellent electrical insulation.

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Benefits: Taken together, these characteristics enable functionality in vehicles, which delivers wider societal benefit, including:

- A. Lower fuel emissions.
- B. Better fuel economy from weight saving.
- C. Lower exhaust emissions (both carbon and NOx gasses).
- D. Increased lifetime of components.
- E. Better engine performance.
- F. Improved reliability and lower maintenance costs.
- G. Increased comfort (and noise reduction).
- H. Permits use of alternative fuels (like biodiesel).
- I. Increased safety (e.g. through reliable performance of parts)
- J. Cleaner environment by avoiding leakage (e.g. oil or coolant leaks).

Fluoropolymers are used in various engine parts, emission control and hydraulic systems and venting products. These include:

Engine Parts:

- **Fuel lines, fuel hoses and turbocharger hoses** [Benefits A, B, D, E, F, H]. Turbocharger hoses boost the performance of cars, increasing the air density entering the engine. Fuel lines and hoses move fuel within the vehicle and are typically made of multi-layered structures containing fluoroelastomers or fluoroplastics. More recently, some fuel hoses are made of fiberglass braids and PTFE liner bonds which can resist up to 800 °C for periods, preventing leaks and breakdowns. The range of characteristics make fluoropolymers ideal for these applications;
- **O-rings** [Benefits D, E, J]. O-rings are often made of fluoroelastomers, which are used as seals between two components to prevent leaks. They are widely used in fuel containment systems and fuel injectors; and
- **Cylinder head gaskets** [Benefits A, B, D, E, J]. An estimated 80% of new engines use multilayers of steel gaskets with a sealant coating made of fluoroelastomers between the cylinder heads and the engine block, with further growth expected. These gaskets seal the cylinders and prevent gas and liquid leakages (e.g. engine oil, coolants).

Hydraulic and emission control systems:

- **Hoses in hydraulic systems** [Benefits D, E, F, H, J]. PTFE is used in inner layer hose constructions in hydraulic systems. These are in contact with petroleum, synthetic or water-based hydraulic fluids, and need to resist high pressure. Non-stick properties prevent sedimentation, however bonding with other substances, such as silicone may also be possible. As above these avoid leaks and breakdowns
- **ABS break lines** [Benefit I]. The inner hose of PTFE with loose steel over-braiding allows for better brake efficiency and less aggressive brake pumping when the ABS is activated, thanks to the pressure absorption in the PTFE tube.
- **Shaft seals, valve stem seals** [Benefits E, J]. Shaft seals are used to seal engine or transmission components; here, fluoroelastomers or PTFE are used as a sealing element (lip). These seals are used to protect the transmission system from dust and aggressive lubricants. Valve stem seals, also made of fluoroelastomers, enable adequate lubrication of the valve while being durable and preventing permeability (which prevents evaporative emissions).
- **Air intake manifold gaskets** [Benefits A, B, D, E, G, J]. Air intake manifolds channel air into the

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engine. The gasket seals the system to ensure performance and minimise leaks. Fluoroelastomers are used as sealant beads for the gaskets. Here heat and stress resistance are essential as temperature and pressure are constantly changing in the air injection system; failure would lead to higher emissions and lower fuel efficiency. Alternatives are typically less resistant to solvents, oils and chemicals, in combination with heat exposure

- **Greenhouse emission controls** [Benefits B, C, D, E, F, J]. Fluoropolymers and fluoroelastomers play an important role in cutting carbon emissions via lambda, NOx or oxygen sensors which contain multiple fluoropolymer applications: wires, form hoses, grommets and filters, which all operate in hot engine exhaust gases to optimise engine combustion. They also contribute to the reduction of nitrous oxide emissions, with multiple fluoropolymer components in the SCR/AdBlue (Urea) systems, converting toxic mono-nitrogen gases to alternatives that are safer for the environment.

Venting Products:

- **Automotive venting products** [Benefits D, E, F]. Used for lighting, electronic control systems, sensors, motors, powertrains, interior electronics, as well as gas powered, hybrid and electric vehicles. Vents block water, automotive fluids and contaminants, while effectively reducing condensation, allowing components to vent during rapid temperature/pressure differentials

Please note, this information is taken from the US socio-economic study pages 23-25.

Energy and Renewable energy hydrogen

Characteristics

- Excellent chemical resistance (helping to prevent corrosion) and abrasion resistance (providing e.g. weatherability);
- Low and high temperature resistance (e.g. from -200 °C to +260 °C for PTFE and PFA);
- Allow high optical transparency, while removing ultraviolet light (crucial for photovoltaics);
- Electrical insulation; and
- Permeability and barrier properties.

Benefits: Taken together these characteristics enable outstanding functionality in renewable energy, supporting their development and delivering wider societal benefit, including:

- A. Increased lifetime of components.
- B. Lower maintenance costs.
- C. Increased efficiency from improved functionality and reduced failures.
- D. Increased efficiency in the manufacturing process.
- E. Indirectly: Enabling sustainable energy and facilitating remote location of installations.
- F. Design flexibility.
- G. Corrosion prevention.
- H. Pollution abatement

Enabling characteristics and socio-economic contribution

Alternative energy

- Alongside increasing operational lifetimes, fluoropolymers have decreased maintenance costs and increased energy generation potential. Fluoropolymers have contributed to the technical advances that have enabled US growth in wind and solar photovoltaic (PV) energy generation, as well as

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the development of lithium ion batteries. Increasingly cost effective and efficient energy generation is a prerequisite for progressively increasing the share of US energy needs met from renewable sources;

- The average cost of PV cells dropped by nearly 50% between 2014 and early 2019, driven by increases in technological efficiency. At the same time, installed PV capacity had increased to 62.5 gigawatts, sufficient to power 12 million American homes. Fluoropolymers provide optical transparency and electrical insulation to PV panels, as well as protecting them from wind, humidity, UV, extreme temperatures and chemicals. This increases the efficiency and lifetime, minimising failures, maintenance stoppages and associated costs. Failure rates are as low as 0.1% in recent designs using fluoropolymer film-based backsheets, compared to 45% in early designs;
- **Fluoropolymers in PV frontsheets and backsheets** are lightweight and allow for more efficient panel production, reducing production and distribution costs and easier installation. As an example, the production efficiency gains from using ETFE instead of glass in PV modules is illustrated below. Here the use of ETFE implies savings in the order of \$4 billion for US PV module manufacturers, or approximately \$140m for PV module customers in first quarter of 2019 alone (see US socio-economic report p.54);
- **Wind energy manufacturers** seek to reduce energy costs and reduce blade manufacturing cycles by producing wind blade structures more efficiently. Fluoropolymer based release films enable efficiency gains in wind turbine production. PTFE mould linings for wind turbine blades increase the number of blade cycles before replacement 10-fold; and
- **Fluoropolymers also facilitate advanced energy storage and conversion technologies, such as lithium-ion batteries.** Greater use of these technologies is important to meet growing energy demand, whilst also reducing carbon emissions. These uses of these batteries are growing rapidly, expected at a CAGR of some 11% from 2018 to 2025, worth some \$73 billion by 2025. While initial growth was driven by consumer electronics, and their use in mobile phones, tablets, and power tools, demand increases are expected from electric vehicles. As above, to increase uptake, cost-effectiveness needs to be increased, with decreasing costs alongside improved battery performance. Biaxially oriented polyvinylidene fluoride (PVdF) film has unique properties (e.g. abrasion and corrosion resistance), and its potential for use in bilayer films is expected to support the further development of lithium-ion battery technology. Similarly, reverse flow batteries (fuel cells) using PFSA are important for the emerging hydrogen economy.

Conventional energy

- Fluoropolymers also play an important role in **the oil and gas industry**. Fluorotechnology provides reliable and durable equipment which improves the safety and affordability of oil and pipe operations. Due to their ability to resist extreme heat and a variety of harsh chemicals, fluoroelastomers improve the reliability and safety of fuel system sealants, O-rings and field equipment. Furthermore, fluoropolymers provide acid resistant properties for crude oil transfer, in turn improving the safety of pipeline operations.

How are fluoropolymers used in this sector?

Photovoltaics: Fluoroplastics films are suitable for use in a wide variety of applications such as anti-corrosive linings, composite part mold release, industrial roll covers, circuitry, pharmaceutical cap liners, sterile packaging, cable insulation, hot melt adhesive, microphone electret membranes, photovoltaic cell glazing (back sheet), anti-graffiti coverings, erasable surface, coverings, automotive airbag systems, fuel hose permeation barrier, hot melt adhesive and more. The films can be adapted to conventional processes

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and secondary operations such as heat sealing, thermoforming, welding, heat-bonding, lamination, and dye-stamping. Each of the film grades is available in various, size, weight and thicknesses, meeting even the most specific requirements.

- **Front sheets** [Benefits A, B, C, E]. Frequently protected by fluoropolymers (e.g. ETFE, FEP and PVDF film), providing weather resistance (heat, water, abrasion, chemical), optical transparency (stable and high light transmittance), low surface energy (non-adhesiveness, easy clean), high barrier performance to oxygen, excellent fire resistance, flexibility and cost-effectiveness.
- **Backsheets** [Benefits 1A B, C, E]. Fluoropolymers (e.g. ETFE and PVDF) are widely used to improve their primary function, such as electrical insulation and protection from humidity and sunlight. The fluoropolymers used are resistant to sunlight degradation and are resistant to most chemicals (including environmental pollutants) and heat, while preventing the permeation of gases and liquids. They exhibit high dielectric strength and volume resistivity, as well as low flammability; and
- **Vents** [Benefits A, B, C, E]. Fluoropolymer-based vents are used in solar applications like junction boxes, concentrating photovoltaics (CPV) modules, inverters. They monitor for rapid pressure equalisation, contamination protection and condensation reduction.

Wind turbines:

- **Paints and coatings on the main towers and blades of wind power generators** [Benefits A, B, C, E]. Fluoropolymers (e.g. PTFE and PVDF) provide high weather resistance. Their use contributes to increased service life and reliable operation in harsh environments; the extension of maintenance cycles; and a more attractive appearance. They also contribute to friction reduction, and specific products have been developed to reduce ice build-up on turbine blades; and
- **Release film** [Benefit D]. Fluoropolymers-based (e.g. PVF and ETFE) release films support the production of wind turbine blades.

Other renewable energy sources [Benefits A, B, C, E]. Fluoropolymers are also used in solar thermal installations and coatings for geothermal plants.

Cables [Benefits A, B, C, E]. The various characteristics of fluoropolymers mean that they are used for cables, as discussed above; and

Energy storage systems: They are a crucial component of energy systems, which comprise an increasing share of renewable energy:

- **Lithium ion batteries** [Benefits A, B, C, E, F]. Fluoropolymers (e.g. VDF/TFE copolymer, PVDF) are used as electrode (cathode) binders for active materials in lithium ion batteries. They are used for their chemical resistance and endurance, ease of processing, adhesion and voltage stability. PVDF can provide superior flexibility, allowing for high electrode densities and higher power densities.

Polymer electrolyte membrane / proton exchange membrane (PEM) fuel cells [Benefits A, C, E]. Various fluoropolymers are used in several components, including the gas diffusion layer (PTFE, FEP), the separator (ETFE, coatings) and drainage piping (PFA). Useful fluoropolymer properties include protonic and electrical conductivity, permeability, as well as resistance to oxidation, chemicals and heat.

Conventional Energy

Power sector generation. Due to their heat, oil and chemical resistance, alongside mechanical properties, fluoropolymers are widely used in thermal and other power generators, as well as a range of further applications in the power sector: The main applications are:

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- **Filters** [Benefits A, B, F, H]. Due to the chemical resistance of PTFE, filters for dedusting of highly corrosive flue gases (e.g. humid SO_x, HCl, hydrofluoric acid) are often made from woven PTFE. This reduces pollution from fossil fuel power plants and waste incineration plants.
- **Flue gas heat exchangers** [Benefits A, B, F, G]. PTFE or PFA tubes are frequently used in flue gas heat exchangers for heat recovery and heat displacement. They help in corrosion reduction and aid with cleaning.
- **Cables** [Benefits A, B, C]. The heat, oil, and chemical resistance as well as the mechanical properties of fluoropolymers mean that they are often used for cables and other equipment – including at power generation plants.
- **Fluid handling, filtration and gas sampling in the nuclear industry** [Benefits A, B, C, E, F]. Fluoropolymers such as PFA are widely used for tubes, vessels etc. to handle corrosive liquids and provide a low metals background. Gas handling and filter mediums and casings in the nuclear industry are also often made from fluoropolymers; and
- **Coal fired boilers** [Benefits A, B, H]. Used in mercury control systems to reduce emissions. These simple systems are resistant to fouling, given their non-stick characteristics and that they can last over 10 years, removing up to 2 tonnes of mercury.

Oil and gas industry. In this sector, fluoropolymers and fluoroelastomers help achieve outstanding chemical and temperature resistance in processing parts, for example:

- **Rings, valves and pumps** [Benefits: A, B, G]. The utilisation of fluoropolymers reduces replacement and downtime of these components, which helps the extraction and handling processes. Fluoropolymers are well-suited as they can resist a variety of demanding chemical environments and mechanical stresses; and
- **Tubes and pipes** (Benefits A, B, C, G). Fluoropolymers used in the lining of down hole tubing for oil extraction provides chemical resistance and corrosion resistance to the oil extraction process. They are well-suited as they resist the demanding chemical and temperature environment of deep well extractions.

Selected examples of fluoropolymer enabled innovations:

- **Energy Flexible electric generators:** Polyvinylidene fluoride (PVDF) is a versatile material, whose properties allow it to generate charges when subjected to mechanical stress (piezoelectric). Recent research has made it possible to use this material to create wearable piezoelectric generators (PEGs), mechanisms that can harvest mechanical energy from human movement and convert it into electricity. For instance, PVDF PEGs have been embedded in shoes, allowing the wearer to generate a power and voltage up to 20 mW and 60 V, respectively. Another application is in backpack straps. Here, the mechanical strain of walking with a backpack can be converted into electricity by placing PVDF into the straps. Other kinds of PVDF PEGs are used to harvest mechanical energy from urban and natural environments, such as road deformation under vehicles passing, vibration and water flow. It is hoped that this technology may be capable of powering streetlamps and nearby buildings, as well as sensors for monitoring traffic density and the condition of the road.
- **Air Filtration for Gas Turbines:** Filters are susceptible to high pressure drop spikes as they reach the end of their service lifetime. This is due to swelling of particles in wet or humid conditions. HEPA filters are highly efficient and capture virtually all particles in an airstream over their lifetime. When the filters start approaching their end of life, trend monitoring begins to show sensitivity to wet and humid conditions. The hydrophobic HEPA filters - a synthetic composite with ePTFE membrane - delays this effect, allowing for a longer lifespan, even in harsh conditions.

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Please note, the information above is taken from the US socio-economic study pages 23-25, p. 34, pp. 53-55.

Chemical and Industrial Processes

Enabling characteristics and socio-economic contribution:

Fluoropolymers are used in many components and production systems in chemical and industrial processing. Their combination of properties supports increased production efficiency and speed, reduced effects of corrosion, avoiding unplanned maintenance and offering a longer operational lifespan for production machinery. Consequently, this reduces costs and aides in efficiency, driven in part to lower component replacements, waste and unplanned downtime. These are important trends in a sector competing with locations outside the US who operate with lower costs, and in the context of a declining US share of global chemical sales. Considering each issue in turn:

- Corrosion is a significant cost factor in both chemical and industrial processes.** A 2002 study estimated that the direct cost of metallic corrosion in the United States to the chemical, petrochemical and pharmaceutical industries as \$1.7b annually (0.5% of the gross value added of these sectors in the same year) and the direct cost of metallic corrosion to electricity generating plants as \$6.9b (3.8% of the gross value added (GVA) of the utilities sector in the same year). Applying this share of costs for the GVA of the equivalent sectors in the EU28 in 2013, this would imply total costs of corrosion of about €15bn for the chemical and power sectors. Simply making a highly conservative assumption in the absence of specific data - fluoropolymer use reduces this by 1% - suggests savings of around €150m per year. A more recent 2005 estimate by the same authors, estimated metallic corrosion costs – to all sectors – in the United States could be as much as \$276 billion, per year. These costs arise from a combination of: equipment and/or structural replacement; loss of product; maintenance and repair; the need for excess capacity and redundant equipment; costs of corrosion control; technical support; design; insurance and parts and equipment inventories. In the absence of detailed statistics on the extent of downstream fluoropolymer use and the net effect on corrosion prevention compared to other components, a conservative estimate would be that 10% of the industry uses these fluoropolymer components and that this reduces corrosion costs for users by just 1%. Direct and indirect savings around the figure of \$2.8 billion could be supported by their use, per year. This estimate does not include possible accidents and/or spills of hazardous chemicals due to material fatigue.
- Polymer Processing Additives (PPA)** can reduce the surface roughness of oil pipes, water pipes and tubing. In other applications they allow, in combination with resin, selection to downgauge films while maintaining mechanical properties. This results in better surface quality, less waste, increased productivity and longer continuous manufacturing runs; and
- Fluoropolymers also prolong the lifetime of plant and equipment, reducing maintenance costs.** Maintenance costs in the chemicals industry are typically around 5% of fixed capital costs. Yearly capital spending in the EU chemical industry has been around €20bn per year over the last 20 years. Hence, current maintenance costs are estimated in the region of €1bn. A chemicals manufacturer consulted as part of the study stated that the use of fluoropolymers in their equipment has increased lifespans by more than a factor of 2. This suggests that installations would have to undergo maintenance significantly less often, up to half as often, saving up to half the maintenance costs. In the absence of specific data, assuming conservatively that about 10% of the European chemicals industry use this fluoropolymer application and have managed to achieve savings on this scale, total savings to the sector as a whole could be in the order of up to €100m annually.

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- **Durable and reliable fluoropolymer components prevent leaks and facilitate cleaning** (via non-stick properties), which reduces the risk of accidents and exposure of the workforce to pollutants and dangerous chemicals. They also enable reliable applications that prevent or alleviate pollution, such as filters, membranes, scrubbers and heat exchangers.
- They also **enable reliable applications that prevent or remove pollution**, such as filters, membranes, scrubbers and heat exchangers. For instance, fluoropolymers enable heat exchanger technology that improves energy efficiency and therefore reduces greenhouse gas emissions. Based on a case study of a Polish Combined Heat and Power (CHP) plant, it is estimated that for CHP installations alone, heat exchanger technology enabled by fluoropolymers could contribute to energy savings worth around €8bn, with CO₂ emission reductions worth around €0.5bn at market prices, or €3bn considering the societal cost of CO₂. While heat exchanger technology is possible without fluoropolymers and thus the benefits are not incurred by fluoropolymers alone, heat exchangers are significantly less expensive and more durable with fluoropolymers when exposed to corrosive flue gases, according to evidence provided during downstream user consultation.
- Facing increasing competition, especially from companies in Asia with comparatively low energy and labour costs, it is especially important for the European chemicals industry to **maintain efficiencies to remain competitive**.
- Fluoropolymers also **provide health, safety and environmental benefits**. Durable and reliable fluoropolymer components prevent leaks and facilitate cleaning (via non-stick properties), which reduces the risk of accidents and exposure of the workforce to pollutants and dangerous chemicals. Exposure can cause a wide range of health effects and people place significant values on avoiding such consequences. For instance, the willingness to pay to avoid one acute episode of mild dermatitis lasting approximately two weeks, a relatively minor effect, has been estimated as €227. By helping to prevent exposure to chemicals that can cause these and other effects, fluoropolymers provide important benefits.

Chemical industry: By enabling efficiency and supporting safety, fluoropolymers play an important role in supporting economic activity in the chemicals industry in Europe and aiding its global competitiveness. This is particularly important given that the European chemicals sector is a major player worldwide. Of the 30 largest global companies, 12 are European. These registered more than €550bn in sales in 2014, which represented about 17% of global sales (CEFIC 2016). The EU chemicals sector accounts for significant trade volumes, with a trade surplus of €43.5bn in 2014. The chemical industry was the fifth largest industrial sector in 2012, contributing to about 7% of the total added value from all manufacturing activity in Europe. Germany is the largest producing Member State with €147bn sales in 2014, followed by France, Italy and the Netherlands. Those countries together account for about 60% of total EU chemicals sales. More than 1.2 million people are employed in the sector; typically, high skilled (gross added value is around €96,000 higher than the 2012 EU average of €54,000). The chemicals sector is strategically important as it underpins various other sectors in the economy.

Characteristics

- Inertness with an almost universal resistance to chemicals and oil;
- Low and high temperature resistance (e.g. from -200 °C to +260 °C for PTFE and PFA);
- Excellent insulation properties which enable downsizing and an overall reduction in weight;
- Low vapour and chemical permeability;
- Non-stick and low friction properties;
- High abrasion resistance;

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- Formulations can be made conductive, which helps to prevent static electricity build-up; and
- As polymer processing additives, in small quantities, they prevent raw materials sticking.

Benefits: Taken together these characteristics enable outstanding functionality, safety and innovation in the chemical and power industries, which delivers wider societal benefit, including:

- A. Increased lifetime of components.
- B. Lower maintenance costs through corrosion prevention.
- C. Increased productivity from reduced failures, improved flow of process substances.
- D. Higher production yields and quality from improved purity of process substances.
- E. Material cost savings through downsizing and less waste during production and over life cycle of the product.
- F. Lower levels and risk of pollutant emission and exposure of workforce to pollutants and chemicals.
- G. Increased energy efficiency.

How are fluoropolymers used in this sector?

Chemical and industrial processing sectors. Fluoropolymers support applications for aggressive chemical fluids. They contribute to corrosion and leaching prevention, lower maintenance and prevention of emissions. Typical applications include:

- **Lining of piping, flowmeters and fittings, fluid-handling components, process vessels, tanks, storage and transport containers and piping** [Benefits A, B, C, D, E, F]. Frequently made from steel or reinforced plastic lined with fluoropolymers (e.g. PFA, FEP or PTFE) to prevent corrosion and leakage and to extend service life or for their non-stick and friction properties. Fluoropolymer linings can be made conductive to prevent static electricity build-up (which in turn causes dust pick up and spark generation) by adding conductive compounds.
- **Filters** [Benefits A, B, D, F]. PTFE is sometimes used as a filter medium and/or casing to ensure high chemical resistance in filtering particulate from fluids.
- **Sealants** [Benefits A, B, C, F]. Expanded sealants for flange sealing applications are often made of PTFE with a micro-fibrillated internal structure (i.e. a structure characterised by very small fibres) for enhanced stability.
- **PTFE packaging vents** [Benefits A, B, C, F]. Allows containers for industrial chemicals and cleaners, agricultural products and household chemicals and cleaners to equalise pressure without leaking and rupturing, thereby preventing harm to users and the environment when transported, stored and opened.
- **Labware products and medicine packaging** [Benefits A, B, D, E, F]. Fluoropolymers are used in sensitive analytical applications in the pharmaceutical sector because of their high purity, temperature and chemical resistance and low surface energy. In medical packaging, for example pills are protected from humidity and to preserve their effectiveness.
- **Non-stick surfaces:** Fluoropolymers help create non-stick surfaces in applications that require temperature resistance. They're used in lined pipes (see above), valves, pumps, tank and reactor linings, gaskets and seals. They're crucial to the safety of workers and the public, as they keep all kinds of equipment and chemical systems secured. They also benefit businesses by increasing productivity and decreasing the potential for accidents.
- **Polymer Processing Additives:** Low use levels of Polymer Processing Additives (100–1000 ppm) in other extrusion resins can reduce common processing issues like dye build-up and melt fracture. This results in better surface quality, less waste, increased productivity, and a smoother extrusion process from start to finish. They also allow for thickness reduction in film applications,

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reduction of clean outs, resulting in longer continuous manufacturing runs.

- **Water Filtration Membrane:** Ultrafiltration membranes for drinking water production, seawater prefiltration, process water preparation or reuse and wastewater treatment. Chemical Name: Ethene, 1,1-difluoro-, homopolymer (polyvinylidene fluoride), CAS N°: 24937-79-9
- **Fluorinated ion exchange membranes (IEMs):** [Benefits A, C, D, G]. Fluoropolymers, more specifically fluorinated ion exchange membranes (IEMs) are used in electrolyzers at electrolysis plants to produce fundamental commodity chemicals for the entire European industry such as chlorine, caustic soda, and caustic potash. Fluorinated ion exchange membranes provide excellent chemical stability in harsh electrochemical operating conditions of chlor-alkali production.

Selected examples of fluoropolymer enabled innovations

- **Air Filtration for Gas Turbines:** Filters are susceptible to high pressure drop spikes as they reach the end of their service lifetime. This is due to swelling of particles in wet or humid conditions. HEPA filters are highly efficient and capture virtually all particles in an airstream over their lifetime. When the filters start approaching their end of life, trend monitoring begin to show sensitivity to wet and humid conditions. The hydrophobic HEPA filters - a synthetic composite with ePTFE membrane - delays this effect, allowing for longer lifetime even in harsh conditions.

Information on alternatives:

- High performance nickel alloys for pipes, vessels, valves, pumps: According to the consultation, these alloys have very high melting points and good resistance to corrosion, but less corrosion-resistant than fluoropolymers. Nickel alloy products provide less design flexibility.
- Glass-lined pipes are feasible for some applications. Installation considerations.
- Metal Cables for the complete installation considerations. Fluoropolymers also allow for smaller and more compact cables.

Please note that this information is taken from the US socio-economic report pp. 49-51, p.19, and Annex B and the EU socio-economic report pp. 42-45.

Transportation: (all information taken from the US Socio-economic report, Chapter 2.2. and 4.3 and case studies from p. 47)

Characteristics

- Low permeation, but also manufactured to allow for semipermeable structures;
- Chemical resistance (protecting components from corrosive fuels and engine oils and fluids);
- Low and high temperature resistance (from -200 °C to +260 °C for PTFE and PFA, with other elastomers offering a range of -40 °C to +230 °C);
- Non-stick and consequently non-fouling, alongside sufficient bonding in certain multilayer applications;
- Low friction coefficient;
- Long-term compression resistance of fluoroelastomers;
- Excellent dynamic properties;
- No flame propagation and low smoke generation; and
- Excellent electrical insulation.

Benefits: Taken together, these characteristics enable functionality in vehicles, which delivers wider societal benefit, including:

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- A. Lower fuel emissions.
- B. Better fuel economy from weight saving.
- C. Lower exhaust emissions (both carbon and NOx gasses).
- D. Increased lifetime of components.
- E. Better engine performance.
- F. Improved reliability and lower maintenance costs.
- G. Increased comfort (and noise reduction).
- H. Permits use of alternative fuels (like biodiesel).
- I. Increased safety (e.g. through reliable performance of parts).
- J. Cleaner environment by avoiding leakage (e.g. oil or coolant leaks).

Automotive components: Fluoropolymers are used in various engine parts, emission control and hydraulic systems, venting products and in electric vehicles. These include:

Engine Parts:

- **Fuel lines, fuel hoses and turbocharger hoses** [Benefits A, B, D, E, F, H]. Turbocharger hoses boost the performance of cars, while increasing the air density entering the engine. Fuel lines and hoses move fuel within the vehicle and are typically made of multi-layered structures containing fluoroelastomers or fluoroplastics. More recently, some fuel hoses have been made of fiberglass braids and PTFE liner bonds which can resist up to 800 °C for periods, preventing leaks and breakdowns. The range of characteristics make fluoropolymers ideal for these applications;
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- **Shaft seals, valve stem seals** [Benefits E, J]. Shaft seals are used to seal engine or transmission components; here, fluoroelastomers or PTFE are used as a sealing element (lip). These seals are used to protect the transmission system from dust and aggressive lubricants. Valve stem seals - also made of fluoroelastomers - enable adequate lubrication of the valve, while being durable and preventing permeability (which prevents evaporative emissions).
- **Air intake manifold gaskets** [Benefits A, B, D, E, G, J]. Air intake manifolds channel air into the engine. The gasket seals the system to ensure performance and minimise leaks. Fluoroelastomers are used as sealant beads for the gaskets. Here heat and stress resistance are essential as temperature and pressure are constantly changing in the air injection system; failure would lead

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to higher emissions and lower fuel efficiency. Alternatives are typically less resistant to solvents, oils and chemicals, in combination with heat exposure

- **Greenhouse emission controls** [Benefits B, C, D, E, F, J]. Fluoropolymers and fluoroelastomers play an important role in cutting carbon emissions via lambda, NOx or oxygen sensors which contain multiple fluoropolymer applications: wires, form hoses, grommets and filters, which are all operating in hot engine exhaust gases to optimise engine combustion. They also contribute to nitrous oxide emission reductions with multiple fluoropolymer components in the SCR/AdBlue (Urea) systems, converting toxic mono-nitrogen gases to alternatives that are safer for the environment.

Venting Products:

- **Automotive venting products** [Benefits D, E, F]. Used for lighting, electronic control systems, sensors, motors, powertrains, interior electronics, as well as gas powered, hybrid and electric vehicles. Vents block water, automotive fluids and contaminants, while effectively reducing condensation. This allows components to vent during rapid temperature/pressure differentials

Alternative energy vehicles Fluoropolymers are used in **battery/fuel cells for electric vehicles**:

- **MEAs (Membrane Electrode Assemblies)** [Benefits B, D, E, F]. These are a key component in proton exchange membrane fuel cells. The MEA facilitates the conversion of hydrogen and oxygen into energy within the fuel stack, enabling the car to go. These products also feature in stationary applications.
- **Fuel cells and batteries in electric vehicles** [Benefits A, C]. Fluoropolymers are key components for the most novel types of fuel cells and batteries. Examples where fluoropolymers are unavoidable are cathode binders, battery gaskets and fuel cell membranes: in these applications they help achieve high voltage and safety of electrolyte systems, required for next-generation batteries.
- **Lithium ion batteries and electronic systems.** Fluoropolymers provide a host of important characteristics in electronic components, used extensively in automobiles.

Marine sector:

- **Submarines** [Benefits D, F]. Submarine hulls can be coated with fluoropolymers to reduce encrustation, which increases drag and maintenance.
- **Boats** [Benefits D, F]. The smoothness and slickness of fluoropolymer coatings repels dirt and contaminants. Their resistance to corrosion also protects components from salt and mineral damage, reducing maintenance time and costs.

Aerospace industry. The same characteristics as noted above make fluoropolymers suitable for demanding aerospace applications. This includes, but is not limited to aircraft and spacecraft manufacturing:

- **Insulation for cables and wires in aircraft and spacecraft** [Benefits D, F, I, J]. Wires and cables insulated with fluoropolymers show improved signal integrity for critical data transmission. They are particularly important in aircraft interiors, because of their broad temperature and UV resistance, flexibility, durability and chemical resistance to solvents and hydraulic fluids, as well as low smoke generation and flame resistance.
- **Leaky Feeder Antennas** [Benefits B, D, F, I]. Improves in-flight connectivity to wireless networks. Fluoropolymers (e.g. PTFE) are used to ensure low smoke generation, flame resistance and durability and allow more protocols to run through one antenna, reducing the number of antennas

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required;

- **Aircraft interior coating** [Benefits D, F, I]. Coated with fluoropolymers due to their flame retardancy, non-fouling, and ease of cleaning

Enabling characteristics and socio-economic contribution

Conventional automotive

- In automotive applications fluoropolymers prolong the useful life of various components critical for performance, emission control and safety. They provide durable and effective protection against heat, aggressive fuels, humidity, vibrations and compression. This contributes to increased reliability and durability of parts, and therefore to a reduction in both the cost and extent of maintenance and breakdowns. Fluoropolymers are used because of their resistance to very high temperatures, other chemicals, and the increase of under-hood temperatures in vehicles, alongside the need to prevent fuel and other leaks.

Alternative Energy Transportation

- Results of the downstream consultation highlighted that fluoropolymer applications are a key element of fuel cell technology. A fuel cell is an electrochemical cell that converts the chemical energy of a fuel and an oxidising agent into electricity – yielding higher efficiencies than diesel or gas engines, alongside lower emissions and reduced noise. Maintenance of fuel cells is also easier due to its few moving parts.
- Fuel cells are generally 60% energy efficient, while the typical efficiency of a combustion engine car is 25%. Fuel cells also have less emissions than combustion engines – with hydrogen fuel cells emitting only water vapor. As such, there are no carbon dioxide emissions and no air pollutants. The consultation results indicate that fluoropolymer components are used in over 90% of the fuel cell industry in end products, while accounting on average for ca. 2% of the total weight of the average fuel cell. The electrochemical cell – which converts chemical energy from fed-in fuel and oxidants into electrical energy - dissipates heat in an isothermal process. Using fluoropolymers in this component of the final product has increased the performance and energy output of the fuel cells, thanks to their ability to withstand a wide range of temperatures.

Aircraft

- Fluoropolymers enhance reliability, safety and communication in aircraft. They help, alongside other advanced materials, to deliver performance under challenging environmental conditions, providing durable and effective protection against heat, UV aggressive fuels, while facilitating weight reductions. Their flame retardance enhances safety for travellers and employees. They are used in various critical components such as in seals, hoses and tubing as well as various electronic data and communication equipment.
- Recent developments in fluoropolymer application in aerospace has also enhanced communication, internet access and telecommunications. For example, cable-based antennas developed with fluoropolymers and light coaxial cable led to a reduction in hardware capital costs, making it more cost effective for in-flight entertainment.

Case study: Avoiding corrosion damage – AIRBUS A320 family

Airbus A320 operators required cargo protection systems that were durable, cost effective and protected structures from corrosion damage. Traditional foam sealant had not proved effective at preventing cargo

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(which included seafood and harsh fluids) leaking and soaking through floorboard seams and initiating corrosion, which was identified only when the aircraft was inspected during routine maintenance.

Fluoropolymer aerospace tapes made from ePTFE were applied and proved effective. They were resistant to water, thus preventing moisture and debris from leaking and initiating corrosion. Inspections which were undertaken as part of the 24-month maintenance cycle of the Airbus A320, showed the ePTFE tapes had protected floorboards and the internal structure from corrosion. Operators noted that an A320 airbus installed with ePTFE Aerospace Tape had 93% corrosion reduction after being in service for 2 years. As such, time-consuming and costly maintenance, as well as extended aircraft downtime was reduced when these tape sealants were used, compared with the previously used foam sealants.

Case study: Preventing chafing and friction damage – Apache and Black Hawk Helicopters

UH-60M Black Hawk helicopter operators in the US Army required a material that would prevent helicopter chafing damage that was occurring during daily operations. The damage was “caused by the abrasion of tail rotor gearbox fairing and access panels against the tail boom structure.” An engineered ePTFE tape was installed on the helicopter’s gearbox fairing, tail boom and vertical stabilizer structure. The ePTFE tape acted as a protective barrier and absorbed the effects of continuous vibration and prevented damage from chafing, avoiding costly structural repairs and replacements. Operators of the AH-64 Apache Helicopter faced similar challenges, resolved with the same product, noting that traditional anti chafe products have proven ineffective over time in preventing damage.

10. V. Questions - Section A - Specific Uses: Textiles, leather, apparel and textile related products What specific functions do PFAS fulfil?

Fluoropolymers provide a combination of waterproofing, breathability, as well as low weight and thinness to clothing and footwear. This increases comfort and performance for professionals and consumers (see the attached socio-economic report, p.49).

An intelligent material construction using two ePTFE membranes: A highly breathable layer of thermal protection of a fire fighting jacket is positioned directly under the outer material of the garment. The membrane attached to the outer side of this layer prevents liquid penetration from the outside. This thermal insulation layer is combined with a moisture barrier that faces inwards towards the body. This second membrane quickly wicks moisture away and transports it to the outside. It is a lightweight, breathable, and waterproof system that delivers high levels of thermal protection in firefighter gear, while reducing the risk of burn injuries and heat stress in wet and dry condition. See the attached socio-economic report, p.33).

An **ePTFE** membrane is created when PTFE — a linear polymer consisting of fluorine and carbon molecules — is expanded, creating a microporous structure with very desirable characteristics, including a high strength-to-weight ratio, biocompatibility, high thermal resistance and many others.

11. In what types of textiles are they used?

All information is from the socio-economic report pp. 22-23, for details see the Annex.

- **Raincoats, jackets, trousers and more:** Membranes created from fluoropolymers (for instance ePTFE (Expanded Polytetrafluoroethylene)) have a microporous semipermeable structure. This provides waterproofing, breathability and other protective properties to clothes for personal and professional uses, including in particularly demanding environments. Thin, lightweight, durable,

and breathable moisture barriers protect against exposure to blood, body fluids, chemicals, electrical discharge, and water.
• Footwear: Fluoropolymer membranes can also be applied to footwear, to manufacture waterproof shoes for consumers and professionals. This also allows feet to transpire, offering protection against chemicals or other liquids.
• Aerospace suits: Astronauts wear suits which contain fluoropolymers membranes or PTFE coated glass fabric. due to their resistance to low temperatures and to fire, alongside durability and electrical insulation properties.
• Membranes for composting: Fabric with ePTFE membrane are used as key component for a composting solution for the treatment of organic waste (green waste, food waste, source separated organics, biosolids or Municipal Solid Waste - MSW).
• ePTFE sewing thread, fibers and weaving yarn: Used for outdoor applications like awnings, umbrellas, furniture, boat covers, and sails, industrial filtration applications in demanding environments and high-performance ropes.

12. In what types of personal protective equipment are PFAS used?

Aerospace suits: Astronauts wear suits which contain fluoropolymers membranes or PTFE coated glass fabric, due to their resistance to low temperatures and to fire, alongside durability and electrical insulation properties (All information from the socio-economic report pp. 22).

As above question 10: An intelligent material construction using two Expanded Polytetrafluoroethylene (ePTFE) membranes: A highly breathable layer of thermal protection is positioned directly under the outer material of the garment. The membrane attached to the outer side of this layer prevents liquid penetration from the outside. This thermal insulation layer is combined with a moisture barrier that faces inwards towards the body. This second membrane quickly wicks moisture away and transports it to the outside. It is a lightweight, breathable, and waterproof system that delivers high levels of thermal protection in firefighter gear while reducing the risk of burn injuries and heat stress in wet and dry conditions (See the attached socio-economic report, p.33).

13. What PFAS-substances or PFAS-groups are used?

PTFE, ePTFE, ETFE
Polytetrafluoroethylene (PTFE)
Expanded Polytetrafluoroethylene (ePTFE)
Ethylene tetrafluoroethylene (ETFE)
Please note, this lists typical fluoropolymers for this sector, but is not an exhaustive list.

14. Please give information for every textile you are producing/using on the tonnage of PFAS you are producing/using per year.

All figures provided below cover fluoropolymers on the EU market in 2015 (for more information, see the attached socio-economic report, p. 6)

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Textiles & architecture: 3,000t, €40m, 2m indirect employees

15. Please indicate the concentration (or concentration range) of the PFAS(s) in your textile products and uses. Please also indicate the technical function of the PFAS(s) in the products.

16. Please also specify potential PFAS-impurities, residues or intended additives and indicate their possible concentration ranges.

17. Please specify any robust data you might have on reduced service life when only water- repellent properties are available (but no grease-, stain-repellence).

18. Please specify any information you might have on technical textiles (e.g. can you differentiate between essential and non-essential uses in automotive/aerospace, quantities used in medical applications would be valuable, information on sacks/tarpaulins. Do they mainly need water repellence?)

Fluoropolymers are crucial to many components, technologies, industrial processes and products used in everyday life. Fluoropolymers bring a unique combination of properties and performance characteristics. They provide specific functionality in a wide range of processes, components and end products. They offer a wide variety of benefits both essential to high technology products and unobtainable in other materials yet are often invisible. They are plastics which are virtually chemically inert, non-wetting, non-stick, highly temperature and fire resistant, and highly weather resistant. It is this specific combination of properties that makes them so valuable.

See also our answers to questions 10 and 12 in this section.

As an example of a technical textile, an intelligent material construction using two ePTFE membranes: A highly breathable layer of thermal protection is positioned directly under the outer material of the garment. The membrane attached to the outer side of this layer prevents liquid penetration from the outside. This thermal insulation layer is combined with a moisture barrier that faces inwards towards the body. This second membrane quickly wicks moisture away and transports it to the outside. It is a lightweight, breathable, and waterproof system that delivers high levels of thermal protection in firefighter gear, while reducing the risk of burn injuries and heat stress in wet and dry conditions (see the attached socio-economic report, p.33).

V. Questions - Section A - Specific Uses: Cosmetic Products

10. What specific functions do PFAS fulfil?

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N/A

11. In what types of cosmetic products are they used?

N/A

12.. What PFAS-substances or PFAS-groups are used?

N/A

13. Please give information for every cosmetic product you are producing/using on the tonnage of PFAS you are producing/using per year.

N/A

14. Please indicate the concentration (or concentration range) of PFAS(s) in your cosmetic product and uses. Please indicate the technical function of the PFAS(s) in the products.

N/A

15. Please also specify potential PFAS-impurities, residues or intended additives and indicate their possible concentrations or concentration ranges.

N/A

16. Some large manufacturers have been able to phase out PFAS or pledged to phase out PFAS soon from all their products (NGO initiative). How fast can you follow this?

N/A

17. If you use alternative substances, do you have any information on their risk profiles?

N/A

18. Please specify any information you have on reformulation costs.

N/A

19. Please specify any information you have on impact on exports.

N/A

V. Questions - Section A - Specific Uses: Food contact materials (fcm) and non-stick kitchenware (not from paper and board)

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10. Please give information on PFAS containing fcm, you are producing/using (e.g. pan, storage vessel).

The members of the Fluoropolymer Product Group are manufacturers of fluoropolymers that offer a number of important benefits in food contact materials. Taken together, these characteristics enable functionality in cookware and bakeware including:

- A. Increased lifespan of the product to up to 20 years (hence consumer savings from less frequent replacement).
- B. Non-stick cooking, avoiding marks/burns.
- C. Easier cleaning, including use in dishwashers.
- D. Reduction of fat/oil use in cooking.

Fluoropolymers are specifically approved for food and drug processing in the European Union this is approved by EFSA, the European Food Safety Agency. See also European Commission Regulation (EU) No. 10 (2011) incl. all amendments which provide a positive list for monomers and additives, in this regulation also specific migration limits and residual contents are outlined. The positive list is regularly updated based on the latest scientific findings. The European Commission is currently evaluating the Regulation.

Pans, pots and baking trays:

- PTFE powder coatings have extremely high temperature resistance as well as excellent surface release properties because of their carbon backbone and fluorine atoms directly attached to these carbons. Fluoropolymers' low surface energy, stability, and chemical resistance provide non-stick properties to prevent food sticking/burning, facilitate easy cleaning, provide durability and corrosion prevention. This makes them suitable for use in dishwashers, and reduces the use of fat/oil in cooking.
- PTFE-coated pans and pots have been in commercial use for some 50 years. While some alternative coatings have been developed, studies have found that PTFE coating systems typically last several times longer than these alternatives. In a survey conducted amongst US consumers in 2012, the majority (66%) stated that they use non-stick cookware. Moreover, 65% of those surveyed stated that PTFE delivers the highest quality.
- They are designed to be used safely at high temperatures (up to +260 °C) above the smoke point of most cooking oils and fats.

Components of food, dairy, beverage and pharmaceutical manufacturing and processing equipment.

- 1) **Lining of valves, piping, tubing, filters, seals, gaskets and other standard fluid handling components:** Made from or coated with fluoropolymers. Their heat and chemical resistance provide corrosion resistance against aggressive foods, beverages and cleaning products and exhibit a low propensity to impart flavours on other products. Non-stick properties in processing equipment to ensure efficient processing, preserve the purity of the products and facilitate cleaning.
- 2) **Vessels, tanks, and belts:** Fluoropolymer coatings are frequently used for vessels to protect the equipment from corrosion, and the build-up of bio-films and other residues, preventing product contamination. Fluoropolymer coatings can be applied to virtually any metal substrate, and belts can be impregnated for anti-stick performance and easy cleaning. Freeze-drying trays use ePTFE

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membranes because they provide a high vapour transmission rate in combination with highly effective barrier protection.

- 3) Among others, fluoropolymer **components or coatings** are often used in beer, wine and other alcoholic beverage production, to make fruit juices, dairy products, meat and poultry processing, soft drink & coffee dispensers, as well as in the processing of sauces and condiments.
- 4) **Labware products:** Fluoropolymers are used in sensitive analytical applications in food – and especially – pharmaceutical sectors because of their high purity, temperature and chemical resistance and low surface energy.
- 5) **Medicine packaging:** Fluoropolymers protect the contents from humidity and preserve their effectiveness.

Enabling characteristics and socio-economic contribution

- Fluoropolymers enable durable processing equipment to ensure high purity of food and pharmaceuticals, even when ultra-pure substances, extreme temperatures and/or aggressive substances are required. In pharmaceuticals, high purity is vital for the effectiveness and safety of (often lifesaving) drugs. In food, it ensures safety and avoids contamination. For both sectors, fluoropolymers play an important role in production efficiency.
- In the European biopharmaceutical industry alone, €270m was saved between 2008 and 2012 alone due to increased prevention of contamination and material failure in biopharmaceutical manufacturing (see Box 4.2, attached socio-economic report, p.47). The biopharmaceutical industry accounted for just 5% of the food and pharmaceutical manufacturing in 2012, so savings across the sector could be much larger. Such improvements can be attributed to a range of factors, but fluoropolymers play an important role in the prevention of contamination and material failure, and hence offer efficiency gains.
- Fluoropolymer coatings and components enable a high level of efficiency by preventing corrosion and facilitating cleaning, thus reducing maintenance, material consumption, etc. Corrosion prevention has a large potential for cost savings in the food and pharmaceutical industries. For instance, a 2002 study estimated the direct cost of metallic corrosion to the food processing industry as \$2.1bn (about €2.5bn) in the United States, suggesting similar costs in Europe.
- Polymer Processing Additives (PPA) can reduce the surface roughness of oil pipes, water pipes and tubing. In other applications they allow, in combination with resin, selection to downgauge films while maintaining mechanical properties. This results in better surface quality, less waste, increased productivity and longer continuous manufacturing runs and a smoother extrusion process from start to finish. They also allow for thickness reduction in film applications, reduction of clean outs, further resulting in longer continuous manufacturing runs. High performance Fluoropolymer PPA's are essential in the manufacturing of new light weight packaging materials and contribute to lower volumes of waste, helping in the processing of new types of polyolefins e.g. specific mLLDPE (Metallocene Low Linear Density Polyethylene) resins and are intrinsically needed to achieve cost efficient and high-quality manufacturing.

Fluoropolymers play an important role in food safety and cost-efficiency of food and beverage manufacturing. This sector, in turn, plays an important role in the European economy. As with other sectors, efficiency is important in global competitiveness, keeping costs to consumers low. Avoiding contamination in production is essential. FoodDrinkEurope estimated that the sector accounted for 15% of turnover and some 13% added value of the manufacturing industry in 2012. Around 289,000 companies were involved, employing some 4.2 million people and generating turnover of €1.2tr as of 2013. By Member State, the largest turnover in the food production sectors were registered in Germany (€173bn), France (€155bn) and Italy (€111bn) respectively. A large number of companies in the sector are small

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and medium enterprises (SMEs) – some 286,000 accounting for 99% of all companies, half of turnover and two thirds of employment. Annual R&D expenditure is around €2.8bn. The EU is a major exporter of food: 21% of global food exports are from within the EU, with a sales value of almost €92bn in 2014. (Food Drink Europe, 2016).

Alternatives:

- Sol-gel ceramic can be used as cooking ceramics for non-stick cookware, but some tests indicate their non-stick properties are less durable.

Overall, while some alternatives might have a similar performance to fluoropolymers for a parameter or property, it is the combination of properties required for the applications that sets fluoropolymers apart from the alternatives. Implications of a transition could include lower performance, lower durability and reliability, and increased weight (with associated effects on fuel consumption and fuel efficiency). Economic implications include regression of advanced technologies and the reduced ability of Europe to attract high and medium technology manufacturing investment, efficiency losses, higher capital and maintenance costs. The diversity of fluoropolymer applications would mean major product qualification issues in addition to design implications. Environmental / health and safety implications include potential higher safety risks to medical patients and consumers, as well as increases in emissions from technical regression.

See the attached socio-economic report pp. 17, 20, 21, 47-49 for more details.

11. Please give information for every fcm you are producing/using on the tonnage you are producing/using per year.

N/A

12. Please give information for every fcm you are producing/using on the material group it is produced from (e.g. plastics, rubber).

13. Please give information for every fcm you are producing on the fluorinated substance(s) (including polymers and non-intentionally added substances (NIAS)) occurring in the production, its annual tonnage and technical function (if any).

N/A

14. Please give information (if you have any) for every fcm you are producing/using on the residues of PFAS contained in the fcm.

N/A

15. Please give information (if you have any) for every fcm you are producing/using on the migration or release of PFAS contained in the fcm into food(simulants).

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At the end of 2017, the Consumer Council Tænk Kemi selected 16 frying pans from the Danish market. They were sent to a laboratory which tested the frying pans for the release of unwanted fluorine (F) substances. In the test, the frying pans were first washed. They were then filled with olive oil and put in the oven at 200 degrees for 30 minutes. The olive oil was then tested for the content of 22 specific fluorine substances. It was also tested for so-called total organic fluorine, which is a broad term for fluorine substances. "We found that: No release of fluorine substances was found in any of the frying pans. However, the test shows that the frying pans tested did not release these substances to food. If frying pan material contains fluorine substances in their non-stick coating, the substances are therefore "well bound" in the pan's material." <https://kemi.taenk.dk/test/test-kemi-i-stegepander>

16. Please give information (if you have any) on analytical methods used for determination of residues, migration or release of PFAS from your fcm.

The migration test requirements can be found in the European Commission Regulation (EU) No. 10 (2011). Further details can be found in the Declaration of Compliance documents issued by the company offering the substance for food contact applications.

Some member companies might have residual monomer data and analytical method information, if so, this will be provided by their individual contributions to the call of evidence.

V. Questions - Section A - Specific Uses: **Paper and board**

10. Please give information on paper and board articles, you are producing/using (e.g. packaging, popcorn bags etc.) and give information whether or not the product is intended for food contact.

N/A

11. Please give information for every article you are producing/using on the tonnage you are producing/using per year.

N/A

12. Please give information for every article you are producing on the fluorinated substance(s) (including polymers and NIAS) occurring in the production, its annual tonnage and technical function (if any).

N/A

13. Please give information (if you have any) for every article you are producing/using on the residues of PFAS contained in the article.

N/A

14. Please give information (if you have any) for every article you are using on the release of PFAS contained in the article into food(simulants) or other relevant media.

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N/A

15. Please give information on analytical methods used for determination of residues or release of PFAS from you article(s).

N/A

V. Questions - Section A - Specific Uses: Firefighting foams

Defence sector

10. In which area did you or are you planning to shift to fluorine free foams (e.g. seagoing units, storage of fuel)?

N/A

11. What are/were the challenges when performing such a transition?

N/A

12. Are you using AFFF for training purposes? If yes, please specify why.

N/A

13. Are you using AFFF for testing purposes? If yes, please specify why.

N/A

Storage tanks - If working in a sector with storage tanks with a surface area above 500m²:

14. What are/were the challenges when performing a transition to fluorine free foams that are in store for fire of storage tanks with a surface area above 500 m²?

N/A

15. Do you think an adaptation of testing requirements (such as application rate, application techniques etc.) will allow the usage of fluorine free foams for such cases of fire? If not, please specify why.

N/A

16. If you already have substituted to non-fluorine fire-fighting foam: what is your experience with the

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fluorine free foam? Did you gain experience using this foam in case of fires of a storage tank of the mentioned size? Are you aware of tests of the use of your foam in cases of fires of a storage tank of the mentioned size?

N/A

17. If you have not substituted yet: Does the foam you are currently using/having in store for such a case of fire contain a fluorosurfactant based on a perfluorohexane or a perfluorooctane chain? Did you gain experience using this foam in cases of fire of a storage tank of the mentioned size? Are you aware of the use of your foam in cases of fires of a storage tank in the mentioned size?

N/A

V. Questions - Section A - Specific Uses: Household articles/Consumer mixtures

10. To whom do you supply the consumer mixtures and/or articles (containing PFAS) you manufacture/import/formulate?

N/A

11. Please describe the relevant use(s) of the PFAS in your household articles/consumer mixtures. If possible, specify for each product the amount of the mixture/article per use and the estimated frequency of use by consumers.

Please note consumer goods coming into contact with food are not included in this section, but in the section on food contact materials.

The members of Fluoropolymers Product Group are not manufacturers of household articles but provide fluorochemistry to its downstream users, who are producing consumer products or providing service to consumers. Therefore, the following information is on behalf of them. Hereafter are a few examples of fluoropolymer uses that fall under a wide definition of "household and consumer appliances". While the list is by far non-exhaustive, it gives an idea of how numerous the uses can be.

Characteristics

- Low permeation but allows for semipermeable structure;
- Chemical resistance;
- Helps prevent corrosion;
- Low surface energy, low friction;
- Low and high temperature resistance (e.g. from -200 °C to +260 °C for PTFE and PFA);
- UV resistance and transmittance (e.g. articles can be made translucent);
- Flexibility;
- No flame propagation and low smoke generation;

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- Non-stick; and
- Durability.

Benefits: Taken together these characteristics enable outstanding functionality, safety and innovation in the chemical and power industries, which delivers wider societal benefit, including:

- A. Increased lifetime of the product (hence consumer savings from less frequent replacement).
- B. Non-stick cooking, avoiding marks/burns.
- C. Easier cleaning, including use in dishwasher.
- D. Reduction of fat/oil use in cooking.
- E. Combination of waterproofing, breathability and comfort (thin and light).
- F. Waterproof properties.
- G. Fireproof properties.
- H. Chemical resistance.

- **PTFE packaging vents:** Allows containers for industrial chemicals and cleaners, agricultural products and household chemicals and cleaners to equalise pressure without leaking and rupturing, thereby preventing harm to both users and the environment (for more information see the attached socio-economic report, p.15).
- **Semiconductors:** Furthermore, fluoropolymers are used in semiconductors which are present in millions of components and power devices, optical sensors and light emitters in industrial operations, consumer electronics and healthcare applications. These include PCs (personal computers, laptops, servers and tablets), communications (broadband internet, mobile phones, smartphones, etc.) and other consumer electronics appliances (television sets, music players, gaming consoles, household appliances and fitness gadgets), as well as various medical devices (for more information see the attached socio-economic report, p.47, and the section on semiconductors in this call of evidence).
- **Wood Decks:** To limit maintenance and provide longer life to outdoor surfaces such as wood decks, fluoropolymer-based stain release agents are applied to wood furniture inside and outside of a house and can improve product lifetime.
- **Solar Cells:** As of today, solar cells and panels have become a consumer product in the drive to reduce energy consumption at home. To manufacturers of solar cells and panels, fluoropolymer resin grades provide weather resistance, which are used for surface protection. They contribute to efficient photovoltaic power generation by extending the lifespan of solar cells and reducing power generation cost.
- **Faucets:** Applying fluoropolymer coatings over faucets can substantially improve its anti-smudge properties and add water repellence. Therefore, such faucets are always clean from water stains and fingerprints, for a more premium appearance. Furthermore, thanks to their chemical resistance, the faucets stay cleaner for longer, reducing the need to clean the faucet with household cleaning products, saving water. Coatings are available to manufacturers, not end customers.
- **External Walls:** Fluoropolymer-based solutions protect walls exposed to sunlight, wind and rain, limiting the need for maintenance three times less than when compared to standard paint. Formulated with a hydrophilic agent, the film also becomes resistant to stains and soils. These fluoropolymer solutions are not directly available to the end customer but only to manufacturers/service providers in the housing industry.

Textile. Fluoropolymers are employed in various textile applications, where products need to have specific

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characteristics, such as being water-proof or breathable.

- Raincoats, jackets, trousers [Benefits A, E]. Membranes created from fluoropolymers (for instance ePTFE) have a microporous semipermeable structure to provide waterproof, breathability and other protective properties to clothes for personal and professional uses, including in particularly demanding environments. Thin, lightweight, durable breathable moisture barriers protect against exposure to body fluids, electrical discharge and water.
- Footwear [Benefits A, E]. Fluoropolymer membranes can also be applied to footwear, to manufacture waterproof shoes for consumers and professionals that also allow feet to perspire, alongside protecting against chemicals or other liquids.
- ePTFE sewing thread, fibers and weaving yarn [Benefits A, E]. Used for outdoor applications like awnings, umbrellas and furniture (also used in boat covers and sails, industrial filtration applications in demanding environments and high-performance ropes).

12. Please give information for every household article/consumer mixture you are producing/using on the tonnage of PFAS you are producing/using per year.

N/A

13. Please indicate the concentration (or concentration range) of the PFAS in your consumer articles and/or mixtures and uses. Please also indicate the technical function of the PFAS in the articles and/or mixtures.

N/A

14. Please also specify potential fluorinated impurities, residues or intended additives and indicate their possible concentrations or concentration ranges.

N/A

15. Can you exclude the possibility that further PFAS are present in your articles and/or mixtures (e.g. as residues or impurities)? If yes, please explain why.

N/A

16. Does the handling of the aforementioned consumer article and/or mixtures by the intended user possibly lead to an aerosol formation or processes by which the included PFAS become(s) air-borne (e.g. final article and or mixture in form of sprays or powders)?

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N/A

17. How are the final article and/or mixture intended to be used by consumers (e.g. as spray, diluted before application etc.)?

N/A

18. If available, could you provide the safety data sheet and/or other technical data sheets for your consumer article and/or mixture containing PFAS? Is it a data sheet created by yourself or is it provided to you within your supply chain?

N/A

19. Is your application of PFAS an application/use, which can lead to emissions to the environment? If not, please explain why, e.g. by what measures are possible emissions controlled?

N/A

20. Would it be possible for the application referred to in question 19 to switch to an application without environmental emissions?

N/A

21. Is your application of PFAS an application/use, which can lead to exposure of workers? If so, please describe the way of application, e.g. spraying, dipping, rolling and time of exposure. Which risk management measures are in place?

22. Please describe alternative substances or alternative technologies for your uses of PFAS.

Overall, while some alternatives might have a similar performance to fluoropolymers for a parameter or property, it is the combination of properties required for the applications that sets fluoropolymers apart from the alternatives. Implications of a transition could include lower performance, lower durability and reliability, and increased weight (with associated effects on fuel consumption and fuel efficiency). Economic implications include regression of advanced technologies and the reduced ability of Europe to attract high and medium technology manufacturing investment. This could result in efficiency losses, as well as higher capital and maintenance costs. The diversity of fluoropolymer applications would pose major product qualification issues in addition to design implications. Environmental / health and safety implications include potential higher safety risks to medical patients and consumers, alongside increasing emissions from technical regression.

23. What would be the technical and economic impact for you and your customers if using the alternative substances/technologies? What would be the costs of switching to these alternatives?

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Overall, while some alternatives might have a similar performance to fluoropolymers for a parameter or property, it is the combination of properties required for the applications that sets fluoropolymers apart from the alternatives. Implications of a transition could include lower performance, lower durability and reliability, and increased weight (with associated effects on fuel consumption and fuel efficiency). Economic implications include regression of advanced technologies and the reduced ability of Europe to attract high and medium technology manufacturing investment, efficiency losses, higher capital and maintenance costs. The diversity of fluoropolymer applications would pose major product qualification issues in addition to design implications. Environmental / health and safety implications include potential higher safety risks to medical patients and consumers and increases in emissions from technical regression.

24. Which time frame would you require for a change from PFAS to alternative substances/technologies? Please substantiate the given time frame.

N/A

25. In your situation: Are there uses or articles and/or mixtures for which a change to alternative substances or technologies would be possible? If yes, which uses would this be and why is a change not possible?

N/A

26. In general: Are there uses for which the technical functions provided by the PFAS cannot be replaced by other substances?

Overall, while some alternatives might have a similar performance to fluoropolymers for a parameter or property, it is the combination of properties required for the applications that sets fluoropolymers apart from the alternatives. Implications of a transition could include lower performance, lower durability and reliability, and increased weight (with associated effects on fuel consumption and fuel efficiency). Economic implications include regression of advanced technologies and the reduced ability of Europe to attract high and medium technology manufacturing investment, efficiency losses, higher capital and maintenance costs. The diversity of fluoropolymer applications would pose major product qualification issues in addition to design implications. Environmental / health and safety implications include potential higher safety risks to medical patients and consumers and increases in emissions from technical regression.

V. Questions - Section A - Specific Uses: Construction Products

10. What specific function do PFAS fulfil in construction products?

The members of the Fluoropolymer Product Group are manufacturers of fluoropolymers that offer a number of important benefits for use in construction products. For example, fluoropolymers provide durable, fire-safe, easy-to-clean building materials, whose mechanical attributes enable progressive

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architectural designs that would not be feasible with other materials. Fluoropolymer coatings (PVDF coatings) are more durable than conventional coating technology for construction textiles, lasting 2-5 decades; requiring fewer re-coatings and do not create VOCs (volatile organic compounds). With conventional technologies, each re-coating creates VOC, thus, the fewer re-coatings the better.

The unique combination of properties of fluoropolymers makes them a product of choice for many challenging applications in architecture. Many landmark buildings of the last few decades have utilised these properties. Specific coating systems can reduce building cooling costs and the associated energy use (by between 4% up to 22%, depending on colour, geographical location, climate conditions, and substrate type). Reducing carbon emissions from the housing sector, including through improved temperature management, is a goal of the European Green Deal. Architectural design plays an important role as part of the European “creative industry”. Activities in this sector had a turnover of €36.2bn, with some 493,000 jobs (registered architects) in the EU as of 2012.

The benefits of fluoropolymers include:

- Combination of waterproofing, breathability and comfort (thin and light)
- Increased lifetime of the product or building component, even in extreme environments
- Reduced maintenance of building structures
- Novel architectural designs requiring flexibility and thin materials
- Weight reduction of building structures
- Improved fire safety - No flame propagation and low smoke generation
- Improving energy efficiency of buildings
- Facilitates composting
- Non-fouling and easy clean

(Please see the attached socio-economic report, pp.49-50).

11. In what types of construction products are they used?

The following information is taken from the socio-economic report, p.33 and the US socio-economic report p. 28:

“Cool roof” technology: A group of multidisciplinary scientists developed a new type of PVDF emulsion resin that did not require the use of solvents and high bake temperatures. This resin has been used as the base of reflective white roof coatings, which is known as “cool roof” technology. This PVDF resin enables roofs to have a total solar reflectance of above 65%, which is required to obtain an Energy Star® rating. Moreover, these roofs must maintain at least 50% of this reflectance for 3 years after receiving this rating. A typical white paint based on this new resin has an initial total solar reflectance of 81% and maintains 78% up to five years later (3% reduction). As a result, these roofs provide excellent energy efficiency and have a lower life cycle cost than most traditional coatings.

Coatings for architectural applications: Includes fluoropolymer-based paints, fluoropolymer coated glass fabric roofs, and laminated coatings, amongst others. They provide resistance to UV radiation, water, oil, dirt and corrosion and are impermeable to gases, which makes them excellent for outdoor applications, especially on rooves of large infrastructure constructions, such as airports, stadia, tents in Mecca and skyscrapers. When used in paints, they maintain paint properties (notably colour and shine). They prevent mould and moss growth and are fire resistant, an essential property for the safety of the thousands of

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people who gather inside these buildings. There is also evidence that specific coating systems can reduce building cooling costs (between around 4% up to 22%, depending on colour, geographical location, climate conditions, and substrate type).

Bridge and offshore bearing pads: Made from PTFE as it has the lowest friction coefficient of all plastics. Fluorourethane coatings have an effective life exceeding 50 years and can reduce life cycle costs for coatings on steel and concrete bridges.

Architectural films: Films from fluoropolymers such as ETFE are used as parts of the rooves in stadia, domes and other structures. They can be made translucent; allowing some natural light through but keeping out heat, improving energy efficiency for buildings and stadia. They are usually shaped as panels or cushions and may be accompanied by a LED-light system enabling external colour and colour changes.

Innovative designs for stadia: Since the construction of Allianz Arena in 2005 and Beijing National Aquatics Centre in 2008, many other new-build stadia have included fluoropolymer cushions and films. ETFE transparent roofs are used in domes and stadia. They permit natural light, while preventing dampness. Fluoropolymers' excellent insulating properties allow for less material to be used, reducing the weight of the structures. They can be made translucent, allowing natural light but keeping out heat, improving energy efficiency. They enable a much lighter and versatile design with possibilities of enhancing the public experience with LED-lights and other effects. Modern stadia and sport centres built for major events such as the Olympics or renovated stadia for sports teams such as FC Barcelona, FC Puebla and Atlanta Falcons use architectural films made of fluoropolymers, providing lightweight, durable and safe designs.

Buildings that are protected by PVDF coatings require zero recoating (each recoat is VOC emitting), thereby ensuring extra-long service life. The durability of PVDF coatings means that they extend the useful service life of the underlying substrate, thereby greatly lowering maintenance requirements that would result in downtime for the building. Furthermore, PVDF coatings are used in super-durable cool roof systems, whose long-life solar reflectivity is well documented in terms of long-term energy usage minimization and infrequent recoating steps.

12. What PFAS-substances or PFAS-groups are used?

Polyvinylidene fluoride or polyvinylidene difluoride (PVDF)

Expanded Polytetrafluoroethylene (ePTFE)

ETFE

Fluorinated ethylene propylene (FEP)

Please note, this lists typical fluoropolymers for this sector, but is not an exhaustive list.

13. Please give information for every construction product you are producing/using on the tonnage of PFAS you are producing/using per year.

All figures for 2015 for fluoropolymers (please see the attached socio-economic report, p. 6)

Textiles & architecture: 3,000t, €40m, 2m indirect employees

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14. Please indicate the concentration (or concentration range) of the PFAS(s) in your construction products and uses. Please also indicate the technical function of the PFAS(s) in the products.

N/A

15. Please also specify potential PFAS-impurities, residues or intended additives and indicate their possible concentrations or concentration ranges.

N/A

16. Please specify any robust data you might have on reduced service life when only water- repellent properties are available (but no grease-, stain-repellence) for coated construction products.

N/A

17. If you use alternative substances, do you have any information on their risk profiles?

N/A

18. Please specify any information you have on reformulation costs.

N/A

V. Questions - Section A - Specific Uses: Lubricants and greases

10. What specific function do PFAS fulfil in lubricants and/or greases?

PTFE in the form of **micropowder** are added into various matrix materials to reduce surface friction and mechanical wear. In thermoplastic compounds they reduce or avoid the need for lubrication of the finished components, both injections moulded or extruded. Extrusion rate and quality can be improved, increasing out-put rate, avoiding marking, surface defects, reduce surface contamination and sagging. This also improves scratch and chemical resistance, and minimise water uptake.

Typical applications are automotive, aerospace, industrial machinery and semiconductor industries. This reduction of friction is important for the proper functionality of the numerous industrial and equipment parts used in these sectors. In sliding materials, they are used as additives to inks, paintings, thermoplastics, elastomers, synthetic oils, and greases. They may also be used as additives to fluorinated oils.

Some applications include:

- **Thermoplastics:** parts made with the addition of micropowders, like gears, benefit from improved wear resistance, reduced friction, and elimination of stick-slip behaviour.
- **Elastomers:** Standard elastomer processing methods can be used to incorporate PTFE micropowders to enhance wear resistance, reduce friction and facilitate mould release.

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- **Lithographic, flexographic, and gravure inks:** micropowders give better image protection and higher productivity, on top of better slip and surface smoothness,
- **Greases:** PTFE micropowders properties, such as chemical inertness and non-flammability, are key elements for greases to obtain approval to operate in environments where gases and other hazardous products are present.
- **Coatings:** The main benefits provided by micropowders are abrasion resistance and anti-friction properties, especially important on coatings for industrial applications.
- **Paints:** the addition of PTFE micropowders helps give paintseasier cleanability thanks to improved anti-fouling properties, and present easier and higher spreading rate thanks to the extra lubricity provided.

11. In what types of applications are PFAS containing are lubricants and/or greases used?

A wide variety of industries depend on **PTFE micropowders** for specific benefits, such as their ability to infuse hosts with some of PTFE's more unique properties.

Some applications include:

- **Thermoplastics:** parts made with the addition of micropowders, like gears, benefit from improved wear resistance, reduced friction, and elimination of stick-slip behaviour.
- **Elastomers:** Standard elastomer processing methods can be used to incorporate PTFE micropowders to enhance wear resistance, reduce friction and facilitate mould release.
- **Lithographic, flexographic, and gravure inks:** micropowders give better image protection and higher productivity, on top of better slip and surface smoothness,
- **Greases:** PTFE micropowders properties, such as chemical inertness and non-flammability, are key elements for greases to obtain approval to operate in environments where gases and other hazardous products are present.
- **Coatings:** The main benefits provided by micropowders are abrasion resistance and anti-friction properties, especially important on coatings for industrial applications.
- **Paints:** the addition of PTFE micropowders helps give paints easier cleanability thanks to improved anti-fouling properties, and present easier and higher spreading rate thanks to the extra lubricity provided.

12. What PFAS-substances or PFAS-groups are used?

PTFE (micro powders)

Please note, this lists typical fluoropolymers for this sector, but is not an exhaustive list.

13. Please give information for every lubricant and grease you are producing/using on the tonnage of PFAS you are producing/using per year.

N/A

14. Please indicate the concentration (or concentration range) of the PFAS(s) in your lubricants and/or greases. Please also indicate the technical function of the PFAS(s) in the products.

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N/A

15. Please also specify potential PFAS-impurities, residues or intended additives and indicate their possible concentrations or concentration ranges.

N/A

16. If you use alternative substances, do you have any information on their risk profiles?

N/A

17. Please specify any information you have on reformulation costs.

N/A

18. Please specify any robust data you might have on reduced service life, when non-PFAS lubricants and/or greases are used.

N/A

V. Questions - Section A - Specific Uses: **Chrome plating**

10. For which chrome plating process(es) do you use PFAS (e.g. decorative chrome plating or functional/hard chrome plating)?

N/A

11. Please give information for every PFAS you are producing/using on the tonnage of PFAS you are producing/using per year for chrome plating.

N/A

12. Do you know what effects switching to fluorine-free alternatives will have on your chrome plating process(es)?

N/A

13. Is it possible to use a closed loop process technology for your application?

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N/A

V. Questions - Section A - Specific Uses: Semiconductors

10. Please give information for every PFAS you are producing/using on the tonnage of PFAS you are producing/using per year for semiconductors.

The members of the Fluoropolymer Product Group are manufacturers of fluoropolymers that offer a number of important benefits to the electronics sector.

Fluoropolymers exhibit the following characteristics, which are particularly important in the electronics sector applications:

- High purity.
- Chemical resistance.
- Low and high temperature resistance (e.g. from -200 °C to +260 °C for PTFE, PVDF and PFA).
- High abrasion, stress-crack and cut-through resistance.
- Electrical insulation.
- Low dielectric constant, low variations of conductivity.
- Non-stick properties.
- No flame propagation and low smoke generation.

Taken together these characteristics enable outstanding functionality in electronic equipment on which we rely every day, and which delivers wider societal benefit, including:

- A. Ever improving and affordable microchips and LEDs due to higher production yields in semiconductor manufacturing.
- B. Manufacturing cost savings (component lifespan increases, lower maintenance cost, lower material consumption).
- C. Reduced environmental risk (leak prevention, lower exposure of workforce to chemicals).
- D. Improved performance of high-volume data transmission.
- E. Increased reliability and lifetime of electronics.
- F. Facilitation of cleaning of electronics.
- G. Improved reliability of electronic systems that control a majority of safety critical operations in industrial use.
- H. Improved fire safety.
- I. Facilitate/enables/improves

All figures are for 2015 for fluoropolymers (see the attached socio-economic report, pp. 6, 47) in electronics (incl. semiconductors): 3,500t, €40m, semiconductors market worth ca. €25b

Transport (incl. semiconductors): sales in the EU 18,000t worth €300m, employing >13 million people

Semiconductors are used in millions of components in power devices, optical sensor and light emitters in industrial operations, consumer electronics and healthcare applications. These include PCs (personal computers, laptops, servers and tablets), communications (broadband internet, mobile phones, smartphones, etc.) and other consumer electronics appliances (television sets, music players, gaming

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consoles, household appliances and fitness gadgets), as well as various medical devices (discussed separately). Europe accounted for 11% of global demand in 2013 – in terms of manufacturing location of the semiconductor itself, but they are used in millions of other applications throughout Europe. Other data from the same year suggests the EU accounts for €24.7bn, equivalent to 9% of the global sales revenue (€274.3bn). The global semiconductor market has grown quickly, by an average of 7% between 1993 and 2013. It is predicted that it will continue to grow to approximately €344.7bn in 2018. Semiconductors contribute to improved energy efficiency and performance and are present in virtually all modern electronic devices. Ranked as the most R&D intensive sector by the European Commission, the European semiconductor market supports some 200,000 jobs directly and up to 1,000,000 indirect jobs in related activities in Europe.

Fluoropolymers are critical to the semiconductor manufacturing process. Semiconductor processing requirements are highly specific. Here various fluoropolymer components can stand up to the aggressive etching chemicals and provide the necessary purity required in the production of microchips and other electronics, where even trace contaminants can severely affect production yield. Semiconductors are “extremely intolerant of particulate and chemical contamination, which, even in trace amounts, can cause severe decrease in electricity yields” in the ultimate product, with significant implications for their downstream use. Annual benefits of fluoropolymers in semiconductor manufacturing are substantial - estimated in a 2006 study at some €10bn, per year. Semiconductors, in turn, are found in millions of products which are becoming ever more powerful, but compact (see the attached socio-economic report, p. 4, see also US socio-economic report pp. 41-2).

- 1) **Semiconductor and other electronic manufacturing:** Fluoropolymers are of critical importance for the manufacturing of semiconductors and other electronics. They play a major role in their production, by allowing the use of various piping, vessels, valves and pumps that can withstand the harsh environment of the aggressive etching chemicals. They can help enable the high purity required to make semiconductors function. The fluoropolymer components include: Fluid handling components (e.g. tubing, piping, fittings, valves, pumps, vessels, instrumentation): Fluoropolymers such as PTFE, PFA and PVDF are used as the main material, coating or lining for components handling crucial aggressively reactive and/or high-purity processing fluids. This enables greater integration, reduced/avoided contamination (e.g. ionic contaminants) and very low extractable and leachable levels, providing greater reliability and endurance. These properties are compatible with aggressive chemicals but can also deliver the required purity. They make fluoropolymers crucial in semiconductor and electronics manufacturing (see the attached socio-economic report, p. 18).
- 2) **Semiconductor and printed circuit equipment parts and packaging:** Semiconductors, microchips, cables and other electronics components which are manufactured with or contain fluoropolymer components are used in a very wide range of other applications and sectors. These in turn enable much of the functionality in a host of other products, such as modern cars, lighting, the internet, medical devices, home appliances and televisions (see the attached socio-economic report, p. 18).
- 3) **Semiconductor equipment parts:** Made from PTFE, PFA and ETFE for their heat resistance, UV-resistance and chemical /contamination resistance (see the attached socio-economic report, p. 18).
- 4) **Alongside other substances and technological developments, fluoropolymers have played an important role in achieving the so called “Moore’s law”** – a remarkably accurate prediction made in 1965 that computing power would dramatically increase in power, while decreasing in relative cost. This, in turn, is driven by increases in the number of transistors per square inch in a microchip. As above, this is evident in increased processing speeds and greater computing power in physically smaller components (US socio-economic report, p.42).

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Electronics/'Internet of things': Modern semiconductors are not conceivable without the use of fluoropolymers. Their chemical resistance in the manufacturing of ever more complex and bigger semiconductors, (Micro-electro-Mechanical Systems (MEMS) and chips, alongside excellent data cable insulation for higher processing speeds and lower data losses. There are 6.4 billion items connected to the internet. This includes smart TV, smartphones, smartwatches, smart kitchen appliances (e.g. fridges, kettles), and more. In the case of home appliances, this is not only to enhance users' experience, but is also envisaged to play a key part in the so-called "energy on demand" concept, in which electricity demand is shaped by smart devices at a regional or national level, shaping peaks and reducing energy supply costs. In this sector fluoropolymers are used in many of the manufacturing pipes, vessels, valves, pumps and other etching and cleaning components/semiconductor components, in printed circuit boards, release films and coatings, wiring and cabling. They further play a key role thanks their resistance to chemicals, temperature, avoidance of fluid degradation and metallic contamination, enabling the manufacturing of the smart devices mentioned above (see the attached socio-economic report, p. 32).

For example, fluoropolymers provide a host of **important characteristics in electronic components**, used extensively in transportation (automotive, aircraft). One example includes the cables for individual inflight entertainment. It should be noted that several uses in this sector are common to other sectors. For instance, rings, seals, hoses and tubing; circuit boards, semiconductors and wire insulation (see the attached socio-economic report p.14).

A host of other sectors indirectly rely on the **functionality provided by semiconductors**. They are used in millions of components in power devices, optical sensors and light emitters in industrial operations, consumer electronics and healthcare applications. These include PCs (personal computers, laptops, servers and tablets) and communications (broadband internet, mobile phones, smartphones, etc.) and other consumer electronics appliances (television sets, music players, gaming consoles, household appliances and fitness gadgets), amongst others. Alongside other substances and technological developments, fluoropolymers have played an important role in these developments.

11. Do you, regardless of a possible restriction of PFAS, plan to change your process of semiconductor production, because the current fabrication processes are approaching technological limits?

A potential alternative to be used in the electronics sector are "non-conductive plastics", historically used in semiconductor manufacturing. However, these have become unviable. The modern semiconductor industry has stringent requirements. Fluoropolymers are the only material that can currently protect the processing equipment in which semiconductors are etched and cleaned from the chemicals used in the manufacturing process, while at the same time offering the highest purity. Microprocessors and chips need to be increasingly small, yet powerful, preventing metallic contamination and corrosion in order to maximise chip yields (see attached socio-economic report, p.C4).

12. Do you consider the processes of atomic layer deposition (ALD) and atomic layer etching (ALE) as suitable alternatives to the conventional processes of photolithography and continuous etching in semiconductor production? If not, please explain why.

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Overall, while some alternatives might have a similar performance to fluoropolymers for a parameter or property, it is the combination of properties required for the applications that sets fluoropolymers apart from the alternatives. Moving away from fluoropolymers could result in lower performance, lower durability and reliability, and increased weight (with associated effects on fuel consumption and fuel efficiency). Economic implications include regression of advanced technologies and the reduced ability of Europe to attract high and medium technology manufacturing investment, efficiency losses, higher capital and maintenance costs. The diversity of fluoropolymer applications would pose major product qualification issues, in addition to design implications. Environmental / health and safety implications include potential higher safety risks to medical patients and consumers and increases in emissions from technical regression.

13. Is it possible to use a closed loop process technology for your application?

N/A

V. Questions - Section A - Specific Uses: Mixtures for treatment of ski (ski wax)

10. Which PFAS-substances or PFAS-groups are used in products/mixtures for the treatment of skis?

N/A

11. What specific functions do PFAS fulfil for this application?

N/A

12. In what types of products are PFAS used?

N/A

13. Please give information for every mixture for treatment of ski you are producing/using on the tonnage of PFAS you are producing/using per year.

N/A

14. Please indicate the concentration (or concentration range) of PFAS(s) in the relevant products and uses.

N/A

15. Please also specify potential PFAS-impurities, residues or intended additives and indicate their possible concentrations or concentration ranges.

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N/A

16. What are the volumes of your manufacture, import and use of PFAS-containing mixtures for the treatment of skis? Can you provide any time trend?

N/A

17. If you use alternative substances to PFAS for the treatment of skis, do you have any information on their chemical identity and risk profiles?

N/A

18. Please specify any information you have on reformulation costs.

N/A

V. Questions - Section A - Specific Uses: Medical devices

10. What specific function do PFAS fulfil?

To ensure patient safety, medical devices need to be made of very high-quality materials. Fluoropolymers provide an effective solution to the most challenging medical device demands, due to their traits.

The below information is an example of the importance of fluoropolymers to medical applications and is taken from the socio-economic report p.25 and the US socio economic report pp. 59-60:

Characteristics

Thanks to their unique combination of properties, fluoropolymers are the material of choice – exhibiting excellent performance - in a wide range of medical applications:

- Chemical inertness.
- Biocompatibility.
- Durability.
- Corrosion prevention (resistance to chemical attack and low permeation).
- Low coefficient of friction and low surface energy.
- Low and high temperature resistance (e.g. from -200 °C to +260 °C for PTFE, PVDF and PFA) which demonstrates clinical safety.
- Flexibility.

Benefits

Taken together, these characteristics enable outstanding functionality and safety in health care, which delivers wider societal benefit, including:

- A. Reduced risk of cross-infections and thus medical complications.
- B. Increased lifetime of implants reducing risk of failure and risk of replacement.
- C. Allows tissue attachment and cell adhesion without an adverse reaction, reducing risk of complications.

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- D. Higher consistency of dosages, increasing effectiveness and safety of drugs.
- E. Less frequent clogging and thus less frequent re-application/replacement for the patient (e.g. catheters, tubes).
- F. Improved functionality of medical equipment (e.g. filtering and venting).
- G. Facilitates non-invasive surgical procedures with guidewires, reducing risk of complications.
- H. Facilitates miniaturisation for keyhole surgery.
- I. Material characteristics ideal for minimally invasive procedures, such as endovascular repair.

- Fluoropolymers are used for example in **surgically implantable medical devices such as vascular grafts**: Often made with expanded PTFE, grafts are critical in current surgery technology to replace damaged vessels in various body parts. Minimally invasive medical devices, with examples including Stent Grafts or Septal Occluders, are often used for life-saving operations such as repair of aortic aneurisms or holes in the cardiac septum. Guide wires lined with PTFE facilitate surgical procedures, helping to shorten their duration, reducing patient risk and facilitating complicated procedures. Other implantable devices include for instance surgical meshes for hernia repair and sutures for use in vascular, cardiac, and general surgery procedures. The durability and biocompatibility of implants made with fluoropolymers reduces the risk or frequency of the implant having to be replaced.
- Fluoropolymers play an essential role in **enabling medical imaging and analysis** (via electronic chips and semiconductors in X-ray, MRI, CT scan and echography) as well as medical analysis (blood, tissue, urine analysis).
- Likewise, fluoropolymers are used in **heart patches**: For cardiac reconstructions or repair, where it is important that complications associated with the formation of tissue attachment to the material be minimised to facilitate reoperation. Heart patches made with fluoropolymers usually have three layers. External layers made of expanded PTFE and a middle layer made of an elastomeric fluoropolymer.
- **PVDF flat sheet filtration membranes** exhibit extremely fine porosity for highly selective filtrations of medical serums and solutions and body fluids. The high purity and durability of PVDF makes it safer for human healthcare applications where highly selective size exclusion filtration is required.

11. In what types of medical devices are they used?

Fluoropolymers enable excellent performance and long lifetimes in medical equipment, such as surgically-implantable medical devices, catheters, guide wires, filters and pumps. This reduces the risks of failure, replacements, cross-infections and clogging of medical equipment, contributing to the reduction/avoidance of medical complications and the associated pain and public cost (see the attached socio-economic report, p.4).

Lining of valves, piping, tubing, filters, seals, gaskets and other standard fluid handling components: Made from or coated with fluoropolymers. Their heat and chemical resistance provide corrosion resistance against aggressive foods, beverages and cleaning products and exhibit a low propensity to impart flavours on other products. Non-stick properties in processing equipment to ensure efficient processing, preserve the purity of the products and facilitate cleaning (see the attached socio-economic report, p.20).

Vessels, tanks, and belts: Fluoropolymer coatings are frequently used for vessels to protect the equipment from corrosion and the build-up of bio-films, and other residues, preventing product contamination. Fluoropolymer coatings can be applied to virtually any metal substrate, with belts being able to be impregnated for anti-stick performance and easy cleaning. Freeze-drying trays use ePTFE membranes because they provide a high vapour transmission rate in combination with highly effective barrier

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protection (see the attached socio-economic report, p.20).

Labware products: Fluoropolymers are used in sensitive analytical applications in food – and especially – pharmaceutical sectors because of their high purity, temperature and chemical resistance and low surface energy (see the attached socio-economic report, p.20).

See also answer to question 10 in this section.

12. What PFAS-substances or PFAS-groups are used?

Expanded Polytetrafluoroethylene (ePTFE)

Polytetrafluoroethylene (PTFE)

Perfluoroalkoxy Polymer- Chemical Compound (PFA) PFA is a co-polymer product of PTFE

Poly Vinylidene Fluoride (PVDF)

Please note, this lists typical fluoropolymers for this sector, but is not an exhaustive list.

13. Please give information for every medical device you are producing/using on the tonnage of PFAS you are producing/using per year.

All figures are for 2015 for fluoropolymers (see the attached socio-economic report, p.6) in:

Medical applications: 1,500t, €20m

Electronics (incl. semiconductors): 3,500t, €40m, semiconductors market worth ca. €25bn

14. Please indicate the concentration (or concentration range) of PFAS(s) in your medical devices and applications.

N/A

15. Please indicate the technical function of the PFAS(s) in the products.

This answer follows on from some of the examples provided in questions 10 and 11:

Characteristics

Because of their unique combination of properties fluoropolymers are the material of choice – exhibiting excellent performance - in a wide range of medical applications:

- Chemical inertness.
- Biocompatibility.
- Durability.
- Corrosion prevention (resistance to chemical attack and low permeation).
- Low coefficient of friction and low surface energy.

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- Low and high temperature resistance (e.g. from -200 °C to +260 °C for PTFE and PFA).
- Flexibility.

Benefits

Taken together these characteristics enable outstanding functionality and safety in health care, which delivers wider societal benefit, including:

- A. Reduced risk of cross-infections and thus medical complications.
- B. Increased lifetime of implants, reducing risk of failure and risk of replacement.
- C. Allows tissue attachment and cell adhesion without an adverse reaction, reducing risk of complications.
- D. Higher consistency of dosages, increasing effectiveness and safety of drugs.
- E. Less frequent clogging and thus less frequent re-application/replacement for the patient (e.g. catheters, tubes).
- F. Improved functionality of medical equipment (e.g. filtering and venting).
- G. Facilitates non-invasive surgical procedures with guidewires, reducing risk of complications.
- H. Facilitates miniaturisation for keyhole surgery.

16. Please also specify potential PFAS-impurities, residues or intended additives and indicate their possible concentrations or concentration ranges.

N/A

17. Would you be able to phase out PFAS or pledged to phase out PFAS soon from all your products?

Overall, while some alternatives might have a similar performance to fluoropolymers for a parameter or property, it is the combination of properties required for the applications that sets fluoropolymers apart from the alternatives. Moving to alternatives could result in lower performance, lower durability and reliability, and increased weight (with associated effects on fuel consumption and fuel efficiency). Economic implications include regression of advanced technologies and the reduced ability of Europe to attract high and medium technology manufacturing investment, efficiency losses, higher capital and maintenance costs. The diversity of fluoropolymer applications would pose major product qualification issues, in addition to design implications. Environmental / health and safety implications include potential higher safety risks to medical patients and consumers, alongside increases in emissions due to technical regression.

18. If you use alternative substances, do you have any information on their risk profiles?

N/A

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19. Please specify any information you have on reformulation costs.

N/A

20. Please specify any information you have on impact on exports.

N/A

V. Questions - Section A - Specific Uses: Applications within oil, gas and mining industry

10. Which PFAS-substances or PFAS-groups are used in mixtures in oil, gas and mining industry?

Perfluoroalkoxy alkanes (PFA)

Fluorinated ethylene propylene (FEP)

Polytetrafluoroethylene (PTFE)

Fluoroelastomers

Poly Vinylidene Fluoride (PVDF)

Please note, this lists typical fluoropolymers for this sector, but is not an exhaustive list.

11. What specific functions do PFASs fulfil for these applications?

Chemical: Fluoropolymers support applications for aggressive chemical fluids as they contribute to corrosion and leaching prevention, lower maintenance and prevention of emissions. Typical applications include:

- 1) Lining of piping, flowmeters and fittings, fluid-handling components, process vessels, tanks, storage and transport containers and piping: Frequently made from steel or reinforced plastic lined with fluoropolymers (e.g. PFA, FEP, PVDF or PTFE) to prevent corrosion and leakage and to extend service life, or for their non-stick and friction properties. Fluoropolymer linings can be made to be conductive, preventing static electricity build-up by adding conductive compounds.
- 2) Filters: PTFE or PVDF are sometimes used as a filter medium and/or casing to ensure high chemical resistance in filtering particulate from fluids.
- 3) Sensors: Capacitive sensors could not be made without high-purity fluoropolymers, and their connecting cables are often shielded with fluoropolymers.
- 4) Sealants: Expanded sealants for flange sealing applications are often made of PTFE with a microfibrillated internal structure (i.e. a structure characterised by very small fibres) for enhanced stability.
- 5) PTFE packaging vents: Allow containers for industrial chemicals and cleaners, agricultural products and household chemicals and cleaners to equalise pressure without leaking and rupturing, thereby preventing harm to both users and the environment.

(For all see the attached socio-economic report, p. 15)

Oil & Gas: Fluoroelastomer products provide excellent high temperature and aggressive fluid resistance in sealing and fluid transport applications.

They also combine the most effective stability to all sorts of chemicals and fluids, such as oil, diesel or ethanol mix. With a low permeation rate, fluoroelastomers enable the meeting of stringent regulations on

gas emissions by reducing leakage significantly. Drilling processes and other downhole fluids contain additives likely to degrade standard rubber.

Chemicals: Fluoroelastomers allow stable extrusion and moulding processes for every type of technical rubber parts and fitting in a wide range of processing constraints, reducing the risk of failures and increasing productivity.

12. Please give information on the tonnage of PFAS you are producing/using per year for applications within oil, gas and mining industry.

All figures are for 2015 (please see the attached socio-economic report, p. 6)

Transport: 18,000t, €300m, 13m indirect employees

Chemicals & power: 16,000t, €220m, ca.3m. indirect employees

13. Please indicate the concentration (or concentration range) of the PFAS(s) in the relevant use areas.

N/A

14. Please also specify potential PFAS-impurities, residues or intended additives and indicate their possible concentrations or concentration ranges.

N/A

15. What are the volumes manufactured, imported or used of PFAS-containing mixtures in the oil, gas and mining industry? Can you provide any time trends?

N/A

16. If you use alternative substances to PFAS in the oil, gas and mining industry, do you have any information on their chemical identity and risk profiles? Please provide CAS numbers for the alternative substances, if possible.

N/A

17. Please specify any information you have on reformulation costs.

N/A

V. Questions - Section A - Specific Uses: F-gases (PFC, HFE, HFC/HFO, HCFC/HCFO) and refrigerants

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10. Which F-gas substances fulfilling the PFAS definition (at least one -CF₂- unit) are used in your products (e.g. foam blowing agents, coolants and refrigerants)?

N/A

11. What is the specific function of the PFAS substances in your products?

N/A

12. In what types of products are PFAS substances used?

N/A

13. Please give information for every product you are producing/using on the tonnage of PFAS you are producing/using per year.

N/A

14. Please indicate the concentration (or concentration range) of the PFAS(s) in the relevant products and uses.

N/A

15. Please also specify potential PFAS-impurities, residues or intended additives and indicate their possible concentrations or concentration ranges.

N/A

16. Are you familiar with any known degradation of your PFAS substances in the environment, and what is in that case the final degradation product?

N/A

17. What are the volumes of your manufacture, import and use of F-gases and refrigerants for your application? Can you provide any time trends?

N/A

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18. If you use alternative substances to PFAS as foam blowing agents, coolants or refrigerants, do you have any information on their chemical identity and risk profiles?

N/A

19. Please specify any information you have on reformulation costs.

N/A

20. Do you know of any other types of uses for these substances?

N/A

V. Questions - Section A - PFAS and PFAS-containing mixtures and articles

Information on functionality and final mixtures/articles *

- ☐ I have information
- ☒ I have no information

27. Please describe the technical function of the PFAS, also with regard to the presence of PFAS in mixtures.

N/A

28. Please specify the final mixtures/articles (with industrial, professional and consumer relevance) resulting from the use(s) of your PFAS. Please indicate whether your substance(s) is/are a component(s) of mixtures and/or articles. List the nature of these articles/mixtures as precisely as possible.

N/A

29. Please give information for every mixture/article you are producing/using on the tonnage of PFAS you are producing/using per year.

N/A

30. To whom do you supply the PFAS and mixtures/articles containing PFAS you manufacture/import?

N/A

31. If possible, indicate the concentration (or concentration range) of PFAS or application levels

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(i.e. in mg per m²) for the PFAS and/or PFAS in your articles/mixtures, including polymers, and uses. Are they impurities, residues or intended additives?

N/A

32. Which minimum concentration of PFAS alone or in your mixtures including polymers is feasible using the best available technique?

N/A

33. Is the concentration mentioned in question 32 necessary for the performance of your substance, mixture, polymer? What is the minimum concentration of PFAS, mixtures including polymers that is necessary to maintain its function?

N/A

V. Questions - Section A - PFAS and PFAS-containing mixtures and articles

Information on releases and exposure *

☒ I have information

☐ I have no

information

34. Does your manufacturing process lead to releases to the environment? If yes, please provide some information on potential pathways (including released quantities). Please provide information about the assumed release fractions or even the annual emission/release amounts. If not, please include reasoning why you assume no release and describe the risk management measures.

N/A

35. Is your application of PFAS a (technical) application/use that can lead to emissions into the environment? If not, please provide data.

Environmental / health implications of substituting fluoropolymers with available alternatives include the potential for a higher risk of exposure of staff to hazardous substances, higher safety risks (vehicle or aircraft failure) and increases in emissions arising from technical regression (in transport, for example this includes inferior car emission sensors, inferior internal seals, increased fugitive emissions or weight increases). This could put at risk Europe's ability to meet its climate and energy goals (see the attached

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socio-economic report, p.5)

Air intake manifold gaskets: Air intake manifolds channel air into the engine. The gasket seals the system to ensure performance and minimise leaks. Fluoroelastomers are used as sealant beads for the gaskets. Here heat and stress resistance are essential as temperature and pressure are constantly changing in the air injection system; failure would lead to higher emissions and lower fuel efficiency. Alternatives are typically less resistant to solvents, oils and chemicals in combination with heat exposure (see the attached socio-economic report, p.12).

In the chemical sector, fluoropolymers present lower levels and risk of pollutant emission, as well as broader exposure of the workforce to pollutants and chemicals. They support applications for aggressive chemical fluids as they contribute to corrosion and leaching prevention, lower maintenance and prevention of emissions. Typical applications include:

- 1) Lining of piping, flowmeters and fittings, fluid-handling components, process vessels, tanks, storage and transport containers and piping: Frequently made from steel or reinforced plastic lined with fluoropolymers (e.g. PFA, FEP, PVDF or PTFE) to prevent corrosion and leakage and to extend service life or for their non-stick and friction properties. Fluoropolymer linings can be made conductive to prevent static electricity build-up by adding conductive compounds.
- 2) Filters: PTFE or PVDF are sometimes used as a filter medium and/or casing to ensure high chemical resistance in filtering particulate from fluids.
- 3) Sensors: Capacitive sensors could not be made without high-purity fluoropolymers, and their connecting cables are often shielded with fluoropolymers.
- 4) Sealants: Expanded sealants for flange sealing applications are often made of PTFE with a microfibrillated internal structure (i.e. a structure characterised by very small fibres) for enhanced stability.
- 5) PTFE packaging vents: Allow containers for industrial chemicals and cleaners, agricultural products and household chemicals and cleaners to equalise pressure without leaking and rupturing, thereby preventing harm to both users and the environment (See the attached socio-economic report, p.15).

In the electronics sector fluoropolymers reduce the environmental risks (leak prevention, lower exposure of workforce to chemicals) in the following applications:

Semiconductor and other electronic manufacturing: Fluoropolymers are of critical importance for the manufacturing of semiconductors and other electronics. They play a major role in their production, by allowing the use of various piping, vessels, valves and pumps that can withstand the harsh environment of the aggressive etching chemicals. They can help enable the high purity required to make semiconductors function. The fluoropolymer components include:

- Fluid handling components (e.g. tubing, piping, fittings, valves, pumps, vessels, instrumentation): Fluoropolymers such as PTFE, PFA and PVDF are used as the main material, coating or lining for components handling crucial aggressively reactive and/or high-purity processing fluids. This enables greater integration, reduced/avoided contamination (e.g. ionic contaminants) and very low extractable and leachable levels, providing greater reliability and endurance. These properties are compatible with aggressive chemical but can also deliver the required purity. They make fluoropolymers crucial in semiconductor and electronics manufacturing.
- Filters: Fluoropolymers are also used as membranes and casings for filters such as ultra-low penetration air filters (please see the attached socio-economic report, pp.18-19).

In the food and pharmaceuticals sector, fluoropolymers support lower levels and risk of exposure of workforce and environment to chemicals, including avoiding leaks in the following applications:

Components of food, dairy, beverage and pharmaceutical manufacturing and processing equipment,

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labware products (please see the attached socio-economic report, p.20).

Raincoats, jackets, trousers and more: Membranes created from fluoropolymers (for instance ePTFE) have a microporous semipermeable structure to provide waterproof, breathability and other protective properties to clothes for personal and professional uses, including in particularly demanding environments. Thin, lightweight, durable breathable moisture barrier protects against exposure to bodily fluids, chemicals, electrical discharge and water (see the attached socio-economic report, p.22).

36. Is your application of PFAS an application/use that can lead to exposure of workers? If so, please provide exposure estimates, describe the way of application, e.g. spraying, dipping, rolling and time and amount of exposure. What risk management measures are in place?

For an extensive overview of risk management measures please see the industry's "Guide to the Safe Handling of Fluoropolymer Resins", attached to this submission. Chapter 3 provides information on hazards and precautions during the manufacturing process, while Chapter 4 informs on the approach to Industrial Hygiene.

37. Please describe the measures you are taking to reduce emissions of PFAS into the environment. Please quantify the degree of efficiency of the emission reduction measures.

This question will be address by the member of the Fluoropolymer Group via their company submissions.

38. Please describe the measures you are taking to reduce worker exposure of PFAS. Are these measures described in your safety data sheet and would you be willing to provide it to the authorities in the scope of this consultation?

For an extensive overview of risk management measures please see the industry's "Guide to the Safe Handling of Fluoropolymer Resins", attached to this submission. Chapter 3 provides information on hazards and precautions during the manufacturing process, while Chapter 4 informs on the approach to Industrial Hygiene.

39. Which emission reduction measures do you specify in your safety data sheets in order to reduce the entry into the environment under the intended conditions of use (please do not specify any measures for behaviour in "accident situations" here)?

N/A

V. Questions - Section A - PFAS and PFAS-containing mixtures and articles

Information on alternatives (by PFAS sector) *

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I have information

I have no

information

40. Would it be possible for the use referred to in question 7 (different use areas) to substitute it with a different technical solution without environmental emissions?

Even when used in small amounts, fluoropolymers offer key attributes: non-wetting, high dielectric, non-stick, fire resistant, temperature resistant, weather resistant, and with near universal resistance to chemicals. It is their specific combinations of properties that are not matched by any other alternative and which thus make them so valuable (see the attached socio-economic report, p.3).

For each of the key sectors and applications in the previous chapters, we considered the possible alternatives to fluoropolymers, whether these were used historically, before the transition to fluoropolymers, or are used in other similar applications today. This is a high-level assessment based on a consultation which industry conducted in 2016, alongside desktop research. The consultation was conducted amongst five manufacturers of fluoropolymers and 17 downstream users which operate in all the sectors covered by this study (see SE, Appendix C). It is recognised that R&D activities within the companies consulted, and amongst the large number of downstream users are confidential. Alternatives are potentially viable in specific applications and contexts, not all of which can be detailed in this response. Conclusions are drawn at sector and/or application level. Further information is contained in Appendix C of the attached socio-economic report. In considering the implications of alternatives, the criteria considered are as follows:

- **Technical feasibility:** Could the alternative provide an equivalent technical function to fluoropolymers in the application concerned? Would the alternative provide the final products with the same/similar technical functionality?
- **Economic feasibility:** Would adoption of the alternative incur additional costs to manufacturers, downstream users or consumers? This may arise from higher unit costs, process or production changes requiring new or altered machinery or loss of functionality to the end user, which might impose additional costs.
- **Availability:** Is the alternative likely to be available? Are they likely to be available in the required quantities and without undue delay?
- **Hazards and risks of the alternative:** Would the overall risks to human health and the environment from the use of the alternative increase or decrease? The information on alternatives contained in Appendix C is based on general feedback on alternatives and on specific examples. As a result, it does not necessarily cover all applications and/or all products. The alternatives mentioned as part of the consultation include steel and other metals; high nickel alloys, polypropylene, PVC, glass, ceramics, mica, polyether sulfone, polyimide, ethylene propylene diene monomer (M-class) rubber (known as EPDM rubber), nitrile rubber (NBR), hydrogenated nitrile rubber (HNBR), acrylic rubber (ACM), Ethylene-acrylic rubber (AEM rubber), fluorosilicone (FVMQ), graphite, aramid, slip agents. Each would only be a possible alternative for some of the applications of fluoropolymers.
- Fluoropolymers are widely used in various specific components; each serves a slightly different purpose and hence each requires different characteristics. Overall, whilst some alternatives might have a similar performance to fluoropolymers for a particular parameter or property, it is the combination or range of properties required for the applications where fluoropolymers are used

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that is the key characteristic. In sectors such as chemical & power, pharmaceuticals or transport, fluoropolymers provide resistance to a wide range of low and high temperatures and universal chemical resistance. This “universal” resistance to chemicals is a crucial characteristic of fluoropolymers that is not present in any of the alternatives, according to consultation feedback. There are alternatives that are more or less resistant to specific chemicals, but there is not one that is universally suitable.

In summary, whilst the implications differ across specific applications, they include:

- Technical implications: Various implications which include lower performance, increased weight (with associated effects on fuel consumption and fuel efficiency), and reduced durability less compatibility and versatility, hence increased challenges associated with component redesign and operating condition requirements.
- Economic implications: Various which would include efficiency losses, higher initial (investment) costs and higher maintenance costs. The diversity of specific applications would pose major product qualification issues alongside design implications.
- Environmental / health implications: Potential for higher risk of exposure of staff to hazardous substances, higher safety risks (vehicle or aircraft failure), higher emissions arising from weight increases, e.g. in transport.

Please see Annex C of the attached socio-economic report for more details (pages 67-73)

Overall, while some alternatives might have a similar performance to fluoropolymers for a parameter or property, it is the combination of properties required for the applications that sets fluoropolymers apart from the alternatives. Implications of a transition could include lower performance, lower durability and reliability, and increased weight (with associated effects on fuel consumption and fuel efficiency). Economic implications include regression of advanced technologies and the reduced ability of Europe to attract high and medium technology manufacturing investment, efficiency losses, higher capital and maintenance costs. The diversity of fluoropolymer applications would pose major product qualification issues, in addition to design implications. Environmental / health and safety implications include potential higher safety risks to medical patients and consumers, alongside increases in emissions from technical regression.

41. Please describe alternative substances or alternative technologies for your uses of PFAS and mixtures containing PFAS.

Please see Annex C of the attached socio-economic report for more details (pages 67-73)

42. In your view, using the alternative substance(s)/technology would it be possible i) to manufacture comparable products and ii) what alternative ingredient could be used to maintain comparable product properties as compared to the same product containing PFAS.

See Annex C of the attached socio-economic report for more details (pages 67-73)

43. Do you use the alternative substance(s)/technology yourself or are you planning to use alternative substances and/or technologies?

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N/A

44. What would be the technical and economic implications for you and your customers if you used the alternative substance/technology? Please consider a level playing field where no PFAS are used. In general, is a deterioration of consumer product performance or durability expected?

Overall, while some alternatives might have a similar, or even superior performance to fluoropolymers for a particular parameter or property: the key characteristic of fluoropolymers is the combination of properties required for the applications where fluoropolymers are used. Implications of a transition could include lower performance, lower durability and reliability, and increased weight (with associated effects on fuel consumption and fuel efficiency). Some applications, like semiconductor manufacturing would be severely impaired, based on current technical knowledge. Economic implications include regression of advanced technologies and the reduced ability of the European Union to attract high and medium technology manufacturing investment, efficiency losses, higher capital and maintenance costs. The diversity of fluoropolymer applications would pose major product qualification issues, in addition to design implications. Environmental / health and safety implications include potential higher safety risks to medical patients and consumers, alongside increases in emissions from technical regression.

See Annex C of the attached socio-economic report for more details (pages 67-73).

45. What time frame would the adaptation to alternative substance(s)/technology require? In which time frame could the substitution be completed? Please specify individual time frames for all necessary steps in your substitution plan.

N/A

46. What would be the cost of the adaptation to an alternative substance(s)/technologies?

See Annex C of the attached socio-economic report for more details (pages 67-73)

47. Are there use(s) where it is not possible to adapt to alternative substance(s) or technologies? What would be needed to make this adaption possible? What measures are you taking to achieve this feasibility? How long will it take for those measures to be in place?

Please differentiate between economical and technical reasons.

Overall, while some alternatives might have a similar, or even superior performance to fluoropolymers for a particular parameter or property: the key characteristic of fluoropolymers is the combination of properties required for the applications where fluoropolymers are used. Implications of a transition could include lower performance, lower durability and reliability, and increased weight (with associated effects on fuel consumption and fuel efficiency). Some applications, like semiconductor manufacturing would be severely impaired, based on current technical knowledge. Economic implications include regression of advanced technologies and the reduced ability of the European Union to attract high and medium technology manufacturing investment, efficiency losses, higher capital and maintenance costs. The diversity of fluoropolymer applications would pose major product qualification issues in addition to design implications.

Environmental / health and safety implications include potential higher safety risks to medical patients and consumers and increases in emissions from technical regression.

48. What are the different areas your product is used in? Do you think that the use of PFASs in this area is necessary for health or safety or other highly important purposes? If yes, please describe why and what will be the consequences if this use is no longer available.

N/A

V. Questions - Section B - ALTERNATIVES to PFAS

2. Are you a manufacturer, importer and/or downstream user of an alternative that can replace the use of any substance of the PFAS group (see Section II for definition)?

- ☐ Manufacturer
- ☐ Importer
- ☐ Downstream user

3. Is/Are your alternative(s) a chemical or non-chemical/technical or functional replacement to PFAS? In case of more than one alternative please indicate the alternative(s) behind each category below.

- ☐ Chemical replacement
- ☐ Non-chemical/technical replacement
- ☐ functional replacement

4. Please name the PFAS-substance(s) intended to be replaced with CAS- and EC-numbers. Please link this information to your alternative(s).

N/A

5. Besides persistence, is there any other relevant hazard for human health and the environment known to you for the PFAS named under question 4 to be replaced by your alternative(s)? The text field below can be used for further descriptions.

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- ☐ Cancerogenic, Mutagenic, Toxic to Reproduction (CMR)
- ☐ Neurotoxic
- ☐ Skin/respiratory sensitizing
- ☐ Other toxic effects

N/A

6. Please list your chemical alternative(s) i.e. the substance(s), with trade names, CAS- and EC-numbers, which you manufacture, import and/or use?

This can be done using an Excel file, which can be downloaded and expanded according to your needs via the following link: [Chemical Alternatives.xlsx](#)

N/A

Here, the Excel file "Chemical Alternatives.xlsx" can be attached to the questionnaire:

7. Please list your non-chemical alternative(s) e.g. technical solution(s) etc. and provide further description, if possible.

N/A

8. Which quantities of each alternative do you produce/import/use per year?

N/A

9. Please describe the state of implementation of your alternative(s) e.g. technical readiness level (TRL 1-9)? Is/Are the alternative(s) already available on the market?

N/A

10. Please list your self-classification and any hazards relevant for human health and the environment known for each alternative (substance) that you manufacture, import and/or use. Please link with corresponding CAS-number. What risk measurement measures are in place, if necessary?

This can be done using the above mentioned (Question 6) an Excel file which can be downloaded and expanded according to your needs via the following link: [Chemical Alternatives.xlsx](#)

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N/A

Here, the Excel file "Chemical Alternatives.xlsx" can be attached to the questionnaire:

11. With respect to which function(s) can your alternative(s) be used as a replacement for PFAS or PFAS in mixtures and/or articles?

- ☐ Water repellence
- ☐ Grease repellence
- ☐ Film forming
- ☐ Thermal stability
- ☐ Electric stability
- ☐ Other(s)

Which are the use(s) and area(s) of applications of your alternative(s)? In which use(s) can your alternative(s) replace PFAS(s)?

Please tick - Use of alternatives

Please tick - Replacement of PFAS in that use

Firefighting foams	☐	☐
Textiles, leather and apparel, and textile related products	☐	☐
Cosmetic products	☐	☐
Food contact materials and non-stick kitchenware	☐	☐
Paper and packaging	☐	☐
Household articles/Consumer mixtures (e.g. non-sticking coating, impregnation agents, polishes etc.)	☐	☐
Construction products (e.g. surface treatments (paints, coatings)	☐	☐
Lubricants and greases		

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	☐	☐
Chrome plating (including mist suppressing agents)	☐	☐
Ski waxes	☐	☐
Medical devices and applications	☐	☐
F-gases e.g. (PFC, HFC, HCFC, HFE, HFO) in air-conditioning, heat-pump equipment, aerosol cans, foams etc.	☐	☐
Uses of C1 perfluorinated carboxylic and sulfonic acids (trifluoroacetic acid (TFA) or trifluoromethanesulfonic acid (triflic acid, TfOH))	☐	☐
Semiconductors	☐	☐
Transportation (automotive, aviation etc.) other than listed above (e.g. greases)	☐	☐
Photographic surface layers	☐	☐
Applications within oil, gas, mining industry (apart from firefighting foam)	☐	☐
Other	☐	☐

12. You have ticked other(s), please specify this/these use(s) and/or area(s) of application of your alternative(s).

N/A

13. Do you have data on the performance of your alternative in an application for which normally PFAS are used? Please indicate here and submit further data at the end of this questionnaire.

N/A

14. Do users need to consider obstacles when planning to substitute with your alternative (e.g. availability,

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testing, costs etc.)?

N/A

15. Are releases to the environment expected from your alternative(s)? What are the environmental properties of the alternative(s) to be expected?

N/A

16. Is relevant worker and/or consumer exposure expected from your alternative(s)?

N/A

VI. Additional Information

Please attach additional information below. Data labelled as confidential will be treated as confidential business information. All data will be transmitted encrypted and saved on an external server. In case you prefer not to transmit data electronically, you may send them to the Federal Office for Chemicals at the BAuA per postal mail (see below).

Attachment

You can attach one or more files from your computer to your response. To attach a document, click the button below and browse for the file. Select the file and click "Open". To delete a file, click on the recycle bin icon. The attachment must be type of doc, docx, pdf, xls, xlsx.

[Further information and attachments](#)

Postal Address

In case you intend to submit confidential information by postal mail please use the following address:

Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA)
 Bundesstelle für Chemikalien
 Friedrich-Henkel-Weg 1-25

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Thank you very much for your contribution.

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