24 May 2023

Alliance for Telomer Chemistry Stewardship's Response to the Public Consultation on Restriction Proposal on all PFAS

Part II – Specific Information Requests

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Specific Information Requests

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

In the present document, we wish to complement our previous input by providing information on the supported derogations. Below you find an overview of the uses we will cover per sector and the different questions that we intend to address per use.

Table 1 - Overview of sectors and (sub-)uses

Sector	Use	Sub-use	Derogation Status	Questions
TULAC	Professional apparel (incl. PPE)	Military, police and emergency response, including firefighting activities	Proposed derogation (limited scope) = Missing use	Question 6
		Worker protection	Proposed derogation (limited scope) = Missing use	
		High-visibility clothing	Missing use	
	Technical textiles	Filtration and separation media	Proposed derogation (extension needed)	Question 2
		Medical textiles	Missing use	Question 6
	Other: Textiles used in engine bays		For reconsideration	Question 7
Medical devices	Membranes for venting medical devices		For reconsideration	Question 7
	Wound treatment		For reconsideration	Question 7
Electronics	Semiconductors		For reconsideration	Question 7
	Coating of electronic devices		Other identified uses	Question 8
Metal plating	Hard chrome plating		For reconsideration	Question 7
Lubricants	Lubricants for watchmaking		Other identified uses	Question 8

Question 2: Emissions in the end-of-life phase: The environmental impact assessment does not cover emissions resulting from the end-of-life phase. To get a better understanding of the extent of the resulting underestimation, (sub-)use-specific information is requested on emissions across the different stages of the lifecycle of products, i.e. the manufacture phase, the use phase and the end-of-life phase. Please provide justifications for the representativeness of the provided information. In particular:

Sector: TULAC

a) Please provide, at the (sub-)use level, an indication of the share of emissions (as percentages) attributable to these three different stages. An indication of annual emission volumes in the end-of-life phase at sector or sub-sector level would also be appreciated:

i. Volumes

The EU textile industry, which is the main user of C6 SFP[1], has estimated an annual consumption of 200-300 t/y of C6 SFP (20-30% solids of 10 000 t/y delivered product) for initial textile finishing in EU, and an annual content of impurities of 10 kg/y (PFHxA).

ii. Emissions during production

It is also worth highlighting that significant efforts were conducted by the textile sector over the past years to reduce emissions, including from PFAS substances. The Best Available Techniques (BREF/BATs) for the textile sector have recently been revised under the EU Industrial Emissions Directive. The BATs set requirements regarding emissions that industrial plants must meet in order to be allowed to operate. The revised BREF/BATs for the textile sector provide specific provisions on C6 SFP chemistry.[2] As a result of the existing BATs, current measurements conducted by companies using C6 SFP in textile finishing estimate emissions of 100-300 ng/l in water.

Furthermore, it should be noted that C6 SFP is used to treat technical textiles for professional and industrial uses (e.g., PPE, medical), and the reimpregnation of these articles takes place in closed systems.

[1] Please note that this is due to the restricted use of C6 SFP in paper as a result of the PFHxA restriction.

[2] Roth, Joze, Benoît Zerger, GEETER Damien De, BENAVIDES Jorge Gómez, and Serge Roudier. 2023. "Best Available Techniques (BAT) Reference Document for the Textiles Industry." JRC Publications Repository. January 16, 2023. https://publications.jrc.ec.europa.eu/repository/handle/JRC131874.

iii. Emissions during use

Treated articles are expected to be in contact with water (e.g., rain, laundry). A certain amount of abrasion during lifetime has been reported resulting in C6 SFPs on textiles separating from the article and ending up being released into the environment.[3] Nonetheless, these emissions have been shown to be minimal. In a study focusing on PFOA and conducted by the German Environmental Agency, it was estimated that 80 million outdoor jackets sold in Germany represent 0,27 kg of emissions of PFOA.[4]

iv. Emissions at end of life

C6 SFP-treated textiles are used either to manufacturer PPE or technical textile applications. To the best of our knowledge, these are subject to treatment in modern high-temperature incineration plants.[5]

b) If possible, please provide for each (sub-)use what share of the waste (as percentages) is treated through incineration, landfilling and recycling. Please provide information to justify the estimates as well as information on the form of recycling referred to.

Sector: TULAC

High-temperature incineration is the most efficient and widely accepted method to handle PFAS waste, ensuring there are no releases into the environment. According to existing EU legislation, waste is pre-treated and sent into high-temperature incineration:

- 850ºC or higher for at least two seconds for non-hazardous waste;

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[3] Gremmel, Christoph, Tobias Frömel, and Thomas P. Knepper. 2016. "Systematic Determination of Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs) in Outdoor Jackets." *Chemosphere* 160 (October): 173–80. https://doi.org/10.1016/j.chemosphere.2016.06.043.; Thomas P. Knepper, Tobias Frömel, Gremmel, Christoph, Inge Van Driezum, Heike Weil, Robin Vestergren, Ian Cousins. 2014. "Understanding the exposure pathways of per- and polyfluoralkyl substances (PFASs) via use of PFASs-containing products - risk estimation for man and the environment." Umwelt Bundes amt: Dessau-Roßlau.

[4] Thomas P. Knepper, Tobias Frömel, Gremmel, Christoph, Inge Van Driezum, Heike Weil, Robin Vestergren, Ian Cousins. 2014. "Understanding the exposure pathways of per- and polyfluoralkyl substances (PFASs) via use of PFASs-containing products - risk estimation for man and the environment." Umwelt Bundes amt: Dessau-Roßlau. https://www.waterresources.at/fileadmin/user_uploads/Publications/van_Driezum_UBA_report_2014.pdf

[5] For instance, protective clothing is handled according to the Waste Code 15 02 02* or 15 02 03, Consolidated TEXT: 32000D0532 — EN — 01.06.2015 (europa.eu).

- 1100ºC or higher for at least two seconds in case of hazardous waste or co-incineration.[6]

Incineration plants are equipped with flue gas cleaning technology that includes multistage wet scrubber using calcium hydroxide (Ca(OH)2). Hydrogen fluoride will be transformed to calcium fluoride (CaF2), the principal source of hydrogen fluoride, a commodity chemical used to produce a wide range of materials.

Disclaimer: The information provided is based on the knowledge of the ATCS at the time of writing. The ATCS does not assume responsibility or liability in cases of inappropriate waste handling due to national specificities or changes beyond its control.

[6] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control), https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32010L0075&from=EN.

Question 3: Emissions in the end-of-life phase: With respect to waste management options, additional information is requested on the effectiveness of incineration under normal operational conditions (for different waste types, e.g. hazardous, municipal) with respect to the destruction of PFAS and the prevention of PFAS emissions.

Research has found that the incineration of PTFE, a very stable substance whose bonds are more difficult to break, at between 870 and 1020ºC and with a residence time of between 4.0 and 2.7 seconds, respectively, while using BATs, ensures a complete mineralization of the carbon bonds.[7]

Therefore, we can assume that high-temperature incineration of C6 SFP-treated articles, coupled with high-efficiency incinerator effluent gas scrubbing, also provides a complete mineralization of the carbon-fluorine bonds, ensuring no emissions are released into the environment.

In addition, we know of several combustion/incineration studies on PFAS compounds that are currently ongoing and expected to produce results in 2023. These results will be shared when the data becomes available. The current studies include small PFAS molecules (C2-C6), Aqueous Film Forming Foam (AFFF) systems and fluoropolymers.

Finally, we would like to share the results of a survey conducted on 2021 on combustion operating conditions across municipal waste-to-energy facilities in the US. The survey results show that typical municipal waste-to-energy combustion operating conditions in the U.S. are (1) furnace temperature above 1160 ˚C, (2) gas residence time above 2.4s, (3) exit gas concentrations of nearly 10% for oxygen (dry basis), and (4) over 16% for moisture. Waste-to-energy operators in the US and the EU put a strong emphasis on compliance with environmental regulations; this translates in practice to running their plants at higher than minimum operating standards to cope with variations in waste feedstock and to ensure strict compliance with emission standards.[8]

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[7] K. Aleksandrov et al., "Waste incineration of Polytetrafluoroethylene (PTFE) to evaluate potential formation of per- and Poly-Fluorinated Alkyl Substances (PFAS) in flue gas," *Chemosphere* 226, Issue No. (2019): 898-906. https://doi.org/10.1016/j.chemosphere.2019.03.191.

[8] Robert J. Giraud, Philip H. Taylor, Chin-pao Huang, 'Combustion operating conditions for municipal Waste-to-Energy facilities in the U.S.', *Waste Management* 132: 124-132.

Question 5: Proposed derogations – Tonnage and emissions: Paragraphs 5 and 6 of the proposed restriction entry text (see table starting on page 4 of the summary of the Annex XV restriction report) include several proposed derogations. For these proposed derogations, information is requested on the tonnage of PFAS used per year and the resulting emissions to the environment for the relevant use. Please provide justifications for the representativeness of the provided information:

Sector: TULAC

Sub-use: Technical textiles – Filtration and separation media under paragraph 5(e)

According to the filtration and separation industry, the average estimate of the volumes of C6 SFPs used for the filtration and separation media placed on the EU market is approximately 67 t/y.[9]

Measurements from wastewater conducted by media manufacturers show very limited emissions, either non detectable or close to the detection limit. Test results were shared during the public consultation on the PFHxA restriction proposal and as part of the calls for evidence.

Regarding air emissions, no releases are expected since the temperature remains below degradation possibility. Moreover, solid residuals from the process are fully captured and then disposed according to waste codes 150202* or 150203.[10]

Furthermore, the majority of C6 SFP-based filters stem from professional and industrial applications. These filters are, therefore, collected separately and incinerated in line with waste codes 150202* and 150203.[11]

Finally, we would like to add a few comments on the proposed wording. Firstly, we wanted to note that due to the absence of alternatives to provide a combination of water- and oil-repellence, a longer transition period under paragraph 5(e) may need to be reconsidered, especially for applications relying on oil-repellence (e.g., gas turbines, fuel

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[9] Comment #961, Comments on SEAC Draft Opinion on REACH restriction proposal on PFHxA, its salts and related substances, p. 10-11, https://echa.europa.eu/documents/10162/f1a33a2f-e008-b3d0-1c46-96d1c9eadf10.

[10] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02000D0532-20150601&from=EN; Commission Decision 2000/532/EC replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098.

[11] *Ibid.*

filtration, air-oil separation). In addition, the term ‘textiles’ should be removed, as filtration media does not only cover woven materials but also nonwovens and cellulose-based media, which are not covered under the current wording.

Further information on this application, beyond the specific information requests included in the questionnaire, will be submitted in our next response to the public consultation.

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

Sector: TULAC

Sub-use: Professional apparel – Personal Protective Equipment (beyond applications covered under paragraph 5b)

A broader derogation for PPE, at minimum in line with the PFHxA restriction proposal, needs to be included under paragraph 5.

a) The annual tonnage and emissions (at sub-sector level) and type of PFAS associated with the relevant use.

Please refer to contributions of ESF and EURATEX.

c) The key functionalities provided by PFAS for the relevant use.

C6 SFP-treated PPE protects workers against water, oil-based dirt, abrasions, electric hazards, as well as hazardous, acidic or caustic liquids, gases or vapors.[12]

The technical functions provided by C6 SFP to personal protective equipment as well as the relevant industry standards are listed below:

Table 2 – List of standards for high performance personal protective equipment

Property	Standard Description	EN / ISO / AATCC Standard
Water repellency	Water Repellency: Spray Test	ISO 4920 / AATCC 22
	Protective clothing - Protection against rain	EN ISO 343
	Textiles - Determination of resistance to water penetration - Hydrostatic pressure test	EN 20811

[12] Steffen Schellenberger, et al., "Highly fluorinated chemicals in functional textiles can be replaced by re-evaluating liquid repellency and end-user requirements," *Journal of Cleaner Production, 217,* (2019): 134–143. doi: 10.1016/j.jclepro.2019.01.160.

Property	Standard Description	EN / ISO / AATCC Standard
	Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test)	EN 31092
	Determination of tear resistance	ISO 4674
	Textiles — Determination of dimensional change in washing and drying	ISO 5077
	Rubber- or plastics-coated fabrics — Determination of tensile strength and elongation at break	ISO 1421 / EN 13934-1
Alcohol repellency	Test Method for Aqueous Liquid Repellency: Water/Alcohol Solution Resistance	ISO 23232 AATCC 193
Oil-repellency	Test Method for Oil Repellency: Hydrocarbon Resistance	ISO 14419 AATCC 118
Stain resistance/ soil protection	Soil Release: Oily Stain Release Method	AATCC-130
Repellency against (solid, liquid and gaseous) chemicals	Protection against liquid chemicals — Test method for resistance of materials to penetration by liquids	ISO 6529 / ISO 6530:2005
	Protective clothing against hazardous solid, liquid and gaseous chemicals, including liquid aerosols and solid particles - Part 1: Performance requirements for Type 1 (gas-tight)	EN 943-1
	Protective clothing against liquid chemicals - Performance requirements for chemical protective suits with liquid-tight (type 3) or spray-tight (type 4) connections between the parts of the garment, including garments providing protection to parts of the body only (types PB [3] and PB [4])	EN 14605
	Protective clothing against chemicals - Test methods and performance classification of chemical protective clothing materials, seams, joins and assemblages	ISO 14325
(Compatibility with) flame retardancy	Protective clothing — Clothing to protect against heat and flame — Minimum performance requirements	ISO 11612

d) The number of companies in the sector estimated to be affected by the restriction.

Please refer to contributions of ESF and EURATEX.

e) The availability, technical and economic feasibility, hazards and risks of alternatives for the relevant use, including information on the extent (in terms of market shares) to which alternative-based products are already offered on the EU market and whether any shortages in the supply of relevant alternatives are expected.

Decreased liquid repellency of non-fluorinated durable water repellents (DWRs) constitutes an issue for occupational protective clothing (e.g., military uniforms, firefighting garments, protective clothing used in the oil and gas industry), which need repellency towards non-polar stains as part of the hazard management. The use of non-fluorinated alternatives could lead to serious injuries.

Recent studies have observed a decreasing stain repellency with decreasing chain length of the fluorinated chains in side-chain fluorinated DWR. This indicates that an increased concentration of the DWRs-based on short-chain side-chain fluorinated polymers (SFPs) might need to be applied to fulfil protection requirements. Therefore, substitution of fluorine based DWRs cannot be considered an option.[13]

This statement is also supported by the report on the use of PFAS in TULAC, which concludes that for applications requiring repellency against blood, solvents, fuels (e.g., petrol, kerosene, diesel, gasoline) and liquid chemicals, fluorine-free finishing agents are not currently able to meet the same levels of performance.[14]

For these applications, transitioning to fluorine-free alternatives could lead to functional losses, resulting in decreased safety and increased human health costs.

f) For cases in which alternatives are not yet available, information on the status of R&D processes for finding suitable alternatives, including the extent of R&D initiatives in terms of time and/or financial investments, the likelihood of successful completion, the time expected to be required for substitution (including any relevant certification or regulatory approvals) and the major challenges encountered with alternatives which were considered but subsequently disregarded.

As alternatives are not yet available, we support a permanent derogation for this use or, at least, a minimum transition period of 13,5 years after EiF.

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[13] Steffen Schellenberger, et al., "Highly fluorinated chemicals in functional textiles can be replaced by re-evaluating liquid repellency and end-user requirements," *Journal of Cleaner Production, 217,* (2019): 134–143. doi: 10.1016/j.jclepro.2019.01.160.

[14] European Commission, Directorate-General for the Environment, Directorate B. Circular Economy, Unit B.2 Safe & Sustainable Chemicals, *The use of PFAS and fluorine-free alternatives in textiles, upholstery, carpets, leather and apparel*, October 22, 2020, Doc Ref. 42054-WOOD-XX-XX-RP-OP-0004_S4_P01.3, p.95, https://echa.europa.eu/documents/10162/13641/pfas_in_textiles_final_report_en.pdf/0a3b1c60-3427-5327-4a19-4d98ee06f041.

g) For cases in which substitution is technically and economically feasible but more time is required to substitute.

Not relevant, as we understand that alternatives are not yet available.

h) For cases in which substitution is not technically or economically feasible, information on what the socio-economic impacts would be for companies, consumers, and other affected actors. If available, please provide the annual value of EU sales and profits of the relevant sector, and employment numbers for the sector

Please refer to the contributions of EURATEX and ESF.

Sub-use: Professional apparel – Protective equipment and clothing for military, police and emergency response workers, including firefighters (beyond applications covered under paragraph 5c)

A derogation for protective equipment and clothing used for military, police, and other emergency response workers, in line with the PFHxA restriction proposal, needs to be included under paragraph 5.

a) The annual tonnage and emissions (at sub-sector level) and type of PFAS associated with the relevant use.

Please refer to contributions of ESF and EURATEX.

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

C6 SFP is used in these applications to ensure maximum water- and oil-repellency, protection against liquid chemicals, and high durability against repeated laundry/dry cleaning fastness to repeated washing cycles.

Water-repellent properties help prevent hypothermia and cold injuries. They also avoid the enlargement of uniforms in case of contact with water and it allows ‘quick redry’.

Moreover, ballistic properties of PPE are rendered inoperative by absorption of liquids and, therefore, require full combined water and oil repellency to maintain their function. C6 SFP-based coating is absolutely critical to assure the bullet proof required performance.

Moreover, oil-repellent properties offer protection towards radioactive, biological and chemical particles, and non-polar stains[15], which could lead to serious injuries.

C6 SFP 's chemical stability also ensures increased durability and heat resistance.

c) The number of companies in the sector estimated to be affected by the restriction.

Please refer to contributions of ESF and EURATEX.

d) The availability, technical and economic feasibility, hazards and risks of alternatives for the relevant use, including information on the extent (in terms of market shares) to which alternative-based products are already offered on the EU market and whether any shortages in the supply of relevant alternatives are expected.

According to the report by Ramboll and Wood, in situations where a high-performance level is required, the lack of adequate performance by any of the alternatives examined suggests that removal of PFAS could lead to increased risks, with potential high societal costs.[16]

Protective clothing without effective oleophobic protection will lead to early failure of water beading performance, leading to loss of breathability, heaviness and, most importantly, risk of cold-related injury.[17]

Moreover, non-fluorinated alternatives that do not ensure adequate performance are not compatible with flame-retardant products. Substitution could, therefore, lead to increased health and safety-related risks.

In addition, the report by Ramboll and Wood concludes that alternatives do not provide resistance against oil, chemicals and biological hazards, and undermine the durability of

[15] Schellenberger, et al., "*Highly fluorinated chemicals in functional textiles can be replaced by re-evaluating liquid repellency and end-user requirements*".

[16] Ramboll and Wood, (October 2020), 'The Role of PFAS and Fluorine-free alternatives in Textiles, Upholstery, Carpets, Leather and Apparel', European Commission, https://echa.europa.eu/documents/10162/13641/pfas_in_textiles_final_report_en.pdf/0a3b1c60-3427-5327-4a19-4d98ee06f041, p. 95.

[17] Comment #3015, Comments on REACH restriction proposal on PFHxA, its salts and related substances, p. 114-116, https://echa.europa.eu/documents/10162/2b03c56b-8d05-d471-cca3-bd84efc4de79.

the equipment, which is essential for the protection against extreme weather conditions.[18]

e) For cases in which alternatives are not yet available, information on the status of R&D processes for finding suitable alternatives, including the extent of R&D initiatives in terms of time and/or financial investments, the likelihood of successful completion, the time expected to be required for substitution (including any relevant certification or regulatory approvals) and the major challenges encountered with alternatives which were considered but subsequently disregarded.

As alternatives are not yet available, we support a permanent derogation for this use or, at least, a minimum transition period of 13,5 years after EiF.

f) For cases in which substitution is technically and economically feasible but more time is required to substitute.

Not relevant, as we understand that alternatives are not yet available.

g) For cases in which substitution is not technically or economically feasible, information on what the socio-economic impacts would be for companies, consumers, and other affected actors. If available, please provide the annual value of EU sales and profits of the relevant sector, and employment numbers for the sector

Please refer to contributions of ESF and EURATEX.

Sub-use: Protective apparel – High visibility clothing

a) The annual tonnage and emissions (at sub-sector level) and type of PFAS associated with the relevant use.

For information on questions a) and c) to g), please refer to the sections on PPE and the contribution of EURATEX.

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

C6 is used in high visibility equipment to prevent soiling and ensure compliance with EN ISO 20471. The use of C6 soil release finish means, on average, a doubling of service

[18] Ramboll and Wood, October 2020, 'The Role of PFAS and Fluorine-free alternatives in Textiles, Upholstery, Carpets, Leather and Apparel'.

life and is thus not only an essential aspect of protecting the health and safety of wearers but also an essential aspect of sustainability.

This was acknowledged by the Dossier Submitter in the context of the PFHxA restriction proposal, which provides a permanent derogation for this use.[19]

Sub-use: Technical textiles – Medical textiles

A derogation for medical textiles, in line with the PFHxA restriction proposal, needs to be included under paragraph 5.

a) The annual tonnage and emissions (at sub-sector level) and type of PFAS associated with the relevant use.

All products have a C6 SFP concentration of approx. <0.5%, as indicated by the report on PFAS in TULAC applications.[20]

Based on information from the textile sector, we understand that emissions during manufacture are estimated at 10 kg/y of PFHxA for all C6 SFP-treated textiles by using the BATs, and production scraps are incinerated in line with the European Waste Catalogue (CER 04 02 22).

Regarding the use phase, C6 SFP side-chain fluorinated polymers (C6 SFPs) are well embedded in the fabric matrix and there are, therefore, no expected emissions under the correct conditions of use.[21]

Disposal is done according to the procedures established by hospitals, clinics and laboratories. Protective clothing and barrier fabrics are handled in line with CER 04 02 22, 15 02 02* or 15 02 03, and eventually incinerated.[22]

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

C6 SFP fluorotelomer chemistry is used in surgical textiles – including drapes, gowns, and clean air suits – that require a combination of durable water-, oil- and stain-

[19] European Chemicals Agency (ECHA), Committee for Risk Assessment (RAC) & Committee for Socio-economic Analysis (SEAC), *Background Document to the Opinion on the Annex XV dossier proposing restrictions on Undecafluorohexanoic acid (PFHxA), its salts and related substances*, June 9, 2021, https://echa.europa.eu/documents/10162/5c011606-5891-d26a-03e7-ceba0a35126f.

[20] Ramboll and Wood, (October 2020).

[21] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02000D0532-20150601&from=EN.

[22] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32010L0075&from=EN.

repellence to prevent occupational exposure and equipment contamination. In particular, repellence towards non-polar liquids is part of the hazard management, such as preventing transmission of infectious agents.

c) The **number** of companies in the sector estimated to be affected by the restriction.

Please refer to the contribution of EURATEX.

d) The availability, technical and economic feasibility, hazards and risks of alternatives for the relevant use, including information on the extent (in terms of market shares) to which alternative-based products are already offered on the EU market and whether any shortages in the supply of relevant alternatives are expected.

For professional textile applications, studies have concluded that there is an absence of suitable non-fluorinated alternatives.[23] Medical garments – including white coats, surgical clothing gowns or surgical covers – and devices need a combination of durable water, oil and stain repellence to protect healthcare personnel and ensure patients' safety. In particular, repellence towards non-polar liquids (such as body fluids) is part of the hazard management, such as preventing transmission of infectious agents. As discussed above, dirt, oil, grease and water repellence properties cannot be reached by existing non-fluorinated alternatives – i.e., wax-based repellents consisting of paraffin-metal salt formulations, silicone repellents, resin-based repellents consisting of fatty modified melamine resins, and hydrophobic modified polyurethanes.[24]

Another important property is the breathability of the fabric. It is possible to create a non-fluorinated barrier with repellence, but then the fabric will lose all breathability, which for some work environments may result in an unacceptable level of worker discomfort. Furthermore, a barrier type effect will result in large quantities of unwanted substances adhering to the textile or nonwoven, which may create more risks for workers.[25]

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[23] Hill, P. J., Taylor, M., Goswami, P., and Blackburn, R. S. (2017). Substitution of PFAS chemistry in outdoor apparel and the impact on repellency performance. *Chemosphere, 181,* 500–507. doi: 10.1016/j.chemosphere.2017.04.122.

[24] Philippa J. Hill et al., "Substitution of PFAS chemistry in outdoor apparel and the impact on repellency performance," *Chemosphere 181*, (2017): 500-507. https://doi.org/10.1016/j.chemosphere.2017.04.122; Danish Ministry of the Environment, Environmental Protection Agency, *Alternatives to perfluoroalkyl and polyfluoroalkyl substances (PFAS) in textiles, Survey of chemical substances in consumer products No.137*, 2015, 978-87-93352-16-2. https://www2.mst.dk/Udgiv/publications/2015/05/978-87-93352-16-2.pdf.

[25] Schellenberger et al., "Highly fluorinated chemicals in functional textiles can be replaced by re-evaluating liquid repellency and end-user requirements.

It is also relevant to consider that the mentioned products have to meet higher requirements due to legal normative regulations. Please, find below some of the most relevant standards and test methods:

Table 3 – Standards and analytical methods for medical garments

Standard/Test	Scope
DIN EN 13795 (39/42/EEC)	Medical-product legislation.
EN 14216	Protective textiles against infection.
DIN EN 14126	Protective clothing – performance requirements and test methods for protective clothing against infective agents.
DIN EN 14786	Protective clothing – determination of resistance to penetration by sprayed liquid chemicals, emulsions and dispersions –Atomizer test.

Medical textiles necessitate, in addition to the abovementioned requirements, high resistance to extreme cleaning since they undergo hot steam disinfection (130°C) and often repeated laundry. The performance of these products is also covered by specific regulations. Please, find below some of the most relevant standards and test methods:

Table 4 – Standards and analytical methods for medical devices

Standard/Test	Scope
EN 943 Protective clothing against liquid and gaseous chemicals, including liquid aerosols and solid particles – Part 1 and 2.	Part 1: Performance requirements for ventilated and non-ventilated 'gas-tight' (Type 1) and 'non-gas-tight' (Type 2) chemical protective suits Part 2: Protective clothing against liquid and gaseous chemicals, including liquid aerosols and solid particles – Part 2: Performance requirements for "gas-tight" (Type 1) chemical protective suits for emergency teams (ET)
EN14605 Protective clothing against liquid chemicals	Performance requirements for clothing with liquid-tight (Type 3) or spray-tight (Type 4) connections, including items providing protection to parts of the body only (Types PB [3] and PB [4])
EN 13982 Protective clothing for use against solid particulates – Part 1	Performance requirements for chemical protective clothing providing protection to the full body against airborne solid particulates (type 5 clothing)
EN 13034 Protective clothing against liquid chemicals	Performance requirements for chemical protective suits offering limited protective performance against liquid chemicals (Type 6 equipment)

e) For cases in which alternatives are not yet available, information on the status of R&D processes for finding suitable alternatives, including the extent of R&D initiatives in terms of time and/or financial investments, the likelihood of successful completion, the time expected to be required for substitution (including any relevant certification or regulatory approvals) and the major challenges encountered with alternatives which were considered but subsequently disregarded.

As alternatives are not yet available, we support a minimum transition period of 13,5 years after EiF.

For further information on questions e) to g), please refer to the contribution of EURATEX.

Question 7: Potential derogations marked for reconsideration – Analysis of alternatives and socio-economic analysis: Paragraphs 5 and 6 of the proposed restriction entry text (see table starting on page 4 of the summary of the Annex XV restriction report) include several potential derogations for reconsideration after the consultation. These are uses of PFAS where the evidence underlying the assessment of the substitution potential was weak. The substitution potential is determined on the basis of i) whether technically and economically feasible alternatives have already been identified or alternative-based products are available on the market at the assumed entry into force of the proposed restriction, ii) whether known alternatives can be implemented before the transition period ends (taking into account time requirements for substitution and certification or regulatory approval), and iii) whether known alternatives are available in sufficient quantities on the market at the assumed entry into force to allow affected companies to substitute.

Sector: TULAC

Sub-sector: Other – Textiles used in engine bays (5u)

The ATCS would like to propose a series of modifications to the derogation recommended for reconsideration by the Dossier Submitters.

Firstly, we would like to point out that the term 'automotive' covers only certain categories of vehicles (e.g., passenger cars), but not motorcycles nor non-road mobile machinery that are used for construction or agriculture. In our view, **the term 'automotive' should be reconsidered**, as done by the SEAC Committee in the context of the PFHxA restriction proposal.[26]

In addition, we believe that **referring to the functions of the textiles and not to their location in the vehicle** allows to set an effective and enforceable limitation to the scope, while covering all the relevant applications.[27] This will also leave out textiles used in the passenger compartment, for which C6 SFP might not be considered necessary.

[26] RAC & SEAC, *Opinion on the Annex XV dossier proposing restrictions on Undecafluorohexanoic acid (PFHxA), its salts and related substances*, June 9, 2021.

[27] It is our understanding that filtration and separation applications in transport would be covered by the separate derogation for filtration and separation media. As long as a derogation for filtration and separation media is granted and extended to 13,5 years, a reference to filtration will not be needed.

a) The annual tonnage and emissions (at sub-sector level) and type of PFAS associated with the relevant use.

Based on information from the textile sector, we understand that emissions during manufacture are estimated at 10 kg/y of PFHxA for all technical textiles based on the use of the BATs. Production scraps are incinerated in line with the European Waste Catalogue (CER 04 02 22).[28]

Regarding products, technical textiles have an estimated C6 SFP concentration of 0.2-0.5%, as identified in the report by Ramboll and Wood on the use of PFAS in textiles.[29] C6 SFPs are well embedded in the fabric matrix and there are, therefore, no expected emissions under foreseeable conditions of use. The end-of-life, removal and disposal are covered by the End of Life Vehicles (ELV) Directive (2000/53/EC), which ensures proper handling and treatment.[30]

For further information, please refer to Question 2.

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

Although the performance requirements may depend on the final applications, C6 SFPs provide several combined performance benefits to the sector. They qualify as being high-performance materials, as defined in the *Report on the use of PFAS in TULAC*, as they offer multiple **technical benefits**, specifically:

- water repellence;
- oil repellence;
- stain-resistance/soil protection; and
- flame retardancy[31].

Based on our knowledge, these properties can be measured according to the following list of standards:

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[28] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32008L0098&from=EN.

[29] Ramboll and Wood, (October 2020).

[30] Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of life vehicles, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32000L0053&from=EN.

[31] We would like to stress that C6 SFP does not provide flame retardancy but, unlike other chemicals, it is compatible with flame retardant products.

Table 5 – List of standards for high performance technical textiles

Property	Standard
Water-repellency[32]	ISO 4920 / AATCC 22
	ISO 811 / AATCC 127
Oil-repellency	ISO 14419 / AATCC 118
Stain resistance/ soil protection	AATCC 130

c) The number of companies in the sector estimated to be affected by the restriction.

Please find below information on the main downstream sectors associated with this derogation:

- Automotive: Approximately 300 automobile assembly and engine production plants operate in Europe today, according to freshly-updated data from the European Automobile Manufacturers Association (ACEA).
- Aerospace: Over 3,000 companies of all sizes, based on data from Aerospace and Defence Industries Association of Europe (ASD).
- NRMM: The production of non-road mobile machinery in the EU is carried out by both large and small manufacturers. Like in other segments of the machinery industry, a small number of large companies control large shares of the market, while SMEs tend to be more specialised in niche markets. An estimation of size distribution points to SMEs accounting for 98% of all companies registered. Nevertheless, large enterprises contribute 82% of the sector's revenues and 70% of employment.[33]

d) The availability, technical and economic feasibility, hazards and risks of alternatives for the relevant use, including information on the extent (in terms of market shares) to which alternative-based products are already offered on the EU market and whether any shortages in the supply of relevant alternatives are expected.

[32] Although there may be alternatives available to provide water-repellency and comply with these standards, they are not able to provide it in combination of the properties listed hereinbelow.

[33] ESTAT 2018: Annual enterprise statistics by size class for special aggregates of activities (NACE Rev. 2), C283 and C289 [SBS_SC_SCA_R2__custom_1485219].

Side-chain fluorinated polymers' properties include a combination of stain, oil, grease and water repellence, which are imperative to manufacture the high-performance technical textile in these applications.

The Danish Environmental Protection Agency reported that many different agents providing water repellence are marketed – including wax-based repellents consisting of paraffin-metal salt formulations, resin-based repellents consisting of fatty modified melamine resins, and hydrophobic modified polyurethanes. None of the identified agents provide efficient repellence against oil, alcohol and oil-based stains. Therefore, these agents cannot be considered as suitable candidates.[34]

e) For cases in which alternatives are not yet available, information on the status of R&D processes for finding suitable alternatives, including the extent of R&D initiatives in terms of time and/or financial investments, the likelihood of successful completion, the time expected to be required for substitution (including any relevant certification or regulatory approvals) and the major challenges encountered with alternatives which were considered but subsequently disregarded.

Complex products, such as cars or non-road mobile machinery, follow a lengthy and rigorous qualification period that generally takes at least 5 years from the first sketches to the placing on the market (see Figure 1[35]) and can take even longer for other means of transport.

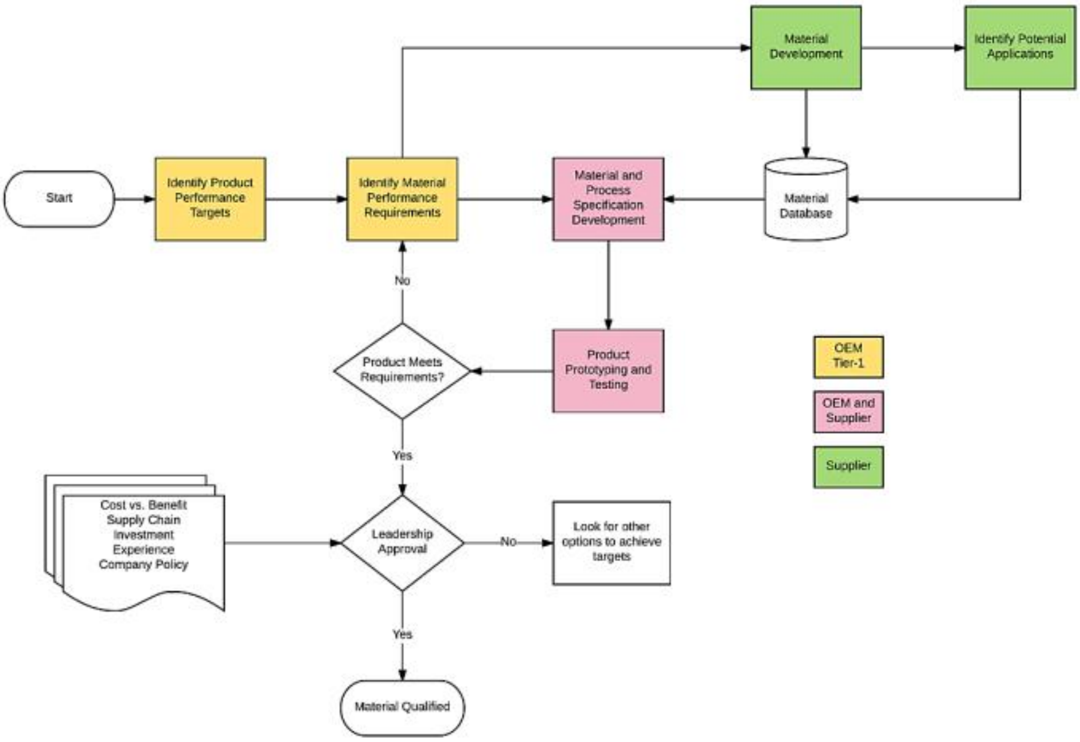
While suppliers conduct testing to develop material specifications, the OEMs also perform some critical tests for verification. For new materials, third party independent laboratory testing and certification may also be requested by the customer to increase confidence in the material behaviour.

As alternatives are not yet available, we support a minimum transition period of 13,5 years after EiF, which would allow sufficient time to identify potential candidates, test, approve, and implement them and place them on the market in new articles.

[34] Lassen C. et al, (2015), Alternatives to perfluoroalkyl and polyfluoroalkyl substances (PFAS) in textiles, *Survey of chemical substances in consumer products*, p. 137, https://www2.mst.dk/Udgiv/publications/2015/05/978-87-93352-16-2.pdf.

[35] Shashank, Modi. n.d. Review of Material Qualification in the Automotive Industry. Ann Arbor, MI.: Center for Automotive Research, accessed November 2016, https://www.cargroup.org/wp-content/uploads/2017/02/Material-Qualification.pdf.

Figure 1 – Requalification process for materials in the automotive industry



f) For cases in which substitution is technically and economically feasible but more time is required to substitute.

We understand that no suitable candidates have been identified and substitution is, therefore, not possible.

g) For cases in which substitution is not technically or economically feasible, information on what the socio-economic impacts would be for companies, consumers, and other affected actors. If available, please provide the annual value of EU sales and profits of the relevant sector, and employment numbers for the sector.

Please find below information on the main downstream sectors associated with this derogation:

- Automotive sector: The automotive sector provides direct and indirect jobs to 13.8 million Europeans, representing 6.1% of total EU employment. 2.6 million people work in direct manufacturing of motor vehicles, representing 8.5 % of EU employment in manufacturing.
- Aerospace sector: The European industry is the world leader in the production of civil aircraft, including helicopters, aircraft engines, parts and components. It provides

405,000 jobs, generates €130 billion revenues and plays a leading role in exports, amounting to €109 billion in 2019.

- NRMM sector: The overall non-road mobile machinery EU production value can be estimated at €12.5 billion per year and is manufactured by both large and small companies. It is estimated that SMEs account for 98% of all companies registered and contribute up to 18% of the sector's revenues and 30% of the sector's employment.

For more information on socio-economic implications, please refer to the contribution of ACEA.

Sector: Medical devices

Sub-use: Membranes used for venting of medical devices (5cc)

The ATCS supports the proposed derogation. Nonetheless, if the proposed transition period for filtration and separation media under paragraph 5(e) is not extended, we would recommend replacing the term ‘membranes’ by ‘membranes and media’ to ensure that the derogation does not only cover fluoropolymers but also other types of materials. We understand that this was the intention of the Dossier Submitters, who included the derogation under paragraph 5 and not under paragraph 6.

a) The annual tonnage and emissions (at sub-sector level) and type of PFAS associated with the relevant use.

Based on industry information, understand that the total consumption of C6 SFP for the manufacturing of media for medical respiratory devices is 12-18 t/y. During manufacture, the emissions of C6 SFP and PFHxA are effectively zero based on the use of the BATs, while at end of life the venting devices are incinerated as hazardous waste.

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

C6 SFP provides excellent barrier properties to airborne microbial contaminants and microbiological growth, helps preventing clogging of filter media from humidity, and enables heat and moisture exchange properties in respiratory circuits. At present, no alternatives have been identified as they retain microbiological pollutants.

In addition, nonwoven filtration media used in medical respiratory equipment, including intensive-care ventilators and anaesthesia breathing systems, require the use of C6 SFP to comply with existing applications standards, some of which are included in Table x.

Table 6 – List of standards specific to respiratory devices[36]

Standard	Application
ISO 14971:2019	Medical devices — Application of risk management to medical devices
EN 794-3:1998+A2:2009	Lung ventilators - Part 3: Particular requirements for emergency and transport ventilators
EN ISO 8835-5:2009	Inhalational anaesthesia systems - Part 5: Anaesthetic ventilators (ISO 8835-5:2004)
EN ISO 10651-2:2009	Lung ventilators for medical use - Particular requirements for basic safety and essential performance - Part 2: Home care ventilators for ventilator-dependent patients (ISO 10651- 2:2004)
EN ISO 10651-6:2009	Lung ventilators for medical use - Particular requirements for basic safety and essential performance - Part 6: Home-care ventilatory support devices (ISO 10651-6:2004)
EN ISO 23328-1:2008	Breathing system filters for anaesthetic and respiratory use - Part 1: Salt test method to assess filtration performance (ISO 23328- 1:2003)
EN ISO 23328-2:2009	Breathing system filters for anaesthetic and respiratory use - Part 2: Non-filtration aspects (ISO 23328-2:2002)

c) The **number** of companies in the sector estimated to be affected by the restriction.

This is out of the scope of our competence.

d) The availability, technical and economic feasibility, hazards and risks of alternatives for the relevant use, including information on the extent (in terms of market shares) to which alternative-based products are already offered on the EU market and whether any shortages in the supply of relevant alternatives are expected.

The absence of a derogation for these applications would result in lower barrier properties against airborne droplets carrying over microbial contaminants exhaled by

[36] European Union. 2020. *Commission Implementing Decision (EU) 2020/437 of 24 March 2020 on the Harmonised Standards for Medical Devices Drafted in Support of Council Directive 93/42/EEC, Commission Implementing Decision (EU) 2020/438 of 24 March 2020 on the Harmonised Standards for Active Implantable Medical Devices Drafted in Support of Council Directive 90/385/EEC, Commission Implementing Decision (EU) 2020/439 of 24 March 2020 on the Harmonised Standards for in Vitro Diagnostic Medical Devices Drafted in Support of Directive 98/79/EC of the European Parliament and of the Council.* L 090I, Vol. 63. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:L:2020:090I:FULL&from=EN.

patients. This would provoke an increased risk of contamination to medical staff, other patients and of the medical equipment.

For question e) to g), please refer to the contribution of EURATEX.

Sub-use: Wound treatment (6i)

The ATCS supports the proposed derogation but notes that it should be included under paragraph 5, to address the use of C6 SFP, and not in paragraph 6, which is limited to fluoropolymer uses.

a) The annual tonnage and emissions (at sub-sector level) and type of PFAS associated with the relevant use.

While the proposed derogation is limited to fluoropolymers, C6 SFPs are also used in professional medical adhesive tapes, also known as surgical adhesive tapes. These are used to hold a gaping wound closed while it waits to be stitched shut, or to keep the wound closed while it heals.

During manufacturing the emissions are effectively zero based on the use of the BATs, while at end of life the articles are incinerated.

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

Professional medical tapes must be repellent to water and other liquids with a lower surface tension. By using repellent tape for bandaging, liquids will not be able to penetrate the bandage and infect a wound. This type of tape can act as an insulator to prevent bodily secretions and blood from getting out of the bandage. They are commonly found in clinics, doctor’s offices, and hospitals in a variety of sizes.

Medical tapes must also be breathable to allow air to circulate around the wound. It has been found that healing time tends to be reduced when wounds are kept ventilated as well as being cleaned, so the tape promotes a healthy flow of air rather than suffocating the wound surface.

c) The **number** of companies in the sector estimated to be affected by the restriction.

This is out of the scope of our competence.

d) The availability, technical and economic feasibility, hazards and risks of alternatives for the relevant use, including information on the extent (in terms of market shares) to which alternative-based products are already offered on the EU market and whether any shortages in the supply of relevant alternatives are expected.

Please see information on surgical textiles.

For question e) to g), please refer to the contribution of EURATEX.

Sector: Electronics

Sub-use: Semiconductors (5cc)

The ATCS supports the proposed derogation for semiconductors.

a) The annual tonnage and emissions (at sub-sector level) and type of PFAS associated with the relevant use.

Already in the context of the PFHxA restriction proposal, the annual release of C6 SFP from the semiconductor industry was assumed to be "very low". C6 SFP are becoming part of the final product (the microchip) in very small quantities, estimated to be <10 t/a.[37]

Emissions are negligible due to the strictly controlled environment in production facilities. As described above, the application levels are very small, and the manufacturing process ensures that emissions during manufacturing are effectively zero. The main application used is photolithography, assumed to account for zero emissions during the product lifetime and zero breakdown emissions at the waste management phase due to the incineration process used.

The European Court of Auditors (ECA) reports that the collection and recovery of e-waste in the EU have improved steadily with the recycling rate of the collected e-waste currently around 80%. It is expected that this rate will increase in the coming years as the EU will set higher binding targets.[38]

For further information, please refer to the contributions of ESIA and SEMI.

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

Only C6 fluorosurfactants can withstand the harsh acidic and alkaline processes used in semiconductors' wet chemical processes. C6 fluorosurfactants are used in the etching agents in the manufacturing of semiconductors, which are a foundational technology for numerous electronic devices (e.g., PCs, automobiles, game machines, various home

[37] European Chemicals Agency (ECHA), Committee for Risk Assessment (RAC) & Committee for Socio-economic Analysis (SEAC), *Background Document to the Opinion on the Annex XV dossier proposing restrictions on Undecafluorohexanoic acid (PFHxA), its salts and related substances*, 8 December 2021, https://echa.europa.eu/documents/10162/c41acb41-9ed0-3a35-504f-255292abdc1f.

[38] The European Court of Auditors (ECA), "EU e-waste targets difficult to achieve," *Press Release*, 20 May, 2021, https://www.eca.europa.eu/Lists/News/NEWS2105_20/INRW_Electronic_Waste_EN.pdf. (Accessed 12 April 2023).

appliances, watches, audio equipment and industrial machines). The ability to wet/penetrate high aspect microelectronic structures is facilitated by the use of fluorosurfactants.

They are also a critical process chemical in photolithography, where small patterns are transferred onto a thin film (“wafer”). When used in the intended applications, C6 fluorosurfactants provide improved permeability and reduces particle adhesion onto silicon wafers. In imaging semiconductor applications, C6 fluorosurfactants provide an additional function of improving the sensor’s resolution and accuracy.

c) The number of companies in the sector estimated to be affected by the restriction.

Please refer to the contributions of ESIA and SEMI.

d) The availability, technical and economic feasibility, hazards and risks of alternatives for the relevant use, including information on the extent (in terms of market shares) to which alternative-based products are already offered on the EU market and whether any shortages in the supply of relevant alternatives are expected.

C6 is much preferred to available alternatives because the known alternatives all contain silicon. Etching and washing photoresist, the subsequent steps in production of semiconductor wafers, convert the silicon into silicon dioxide, which is a difficult residue to remove and interferes with product quality.

In addition, no single drop-in replacement is possible for all semiconductor applications where substitutes exist. Every use has to be re-engineered to see if a replacement material will meet the technology requirements.

Substitution processes also take time, with feasibility testing only being initiated once the well-defined chemical structure of the alternative has been identified.

e) For cases in which alternatives are not yet available, information on the status of R&D processes for finding suitable alternatives, including the extent of R&D initiatives in terms of time and/or financial investments, the likelihood of successful completion, the time expected to be required for substitution (including any relevant certification or regulatory approvals) and the major challenges encountered with alternatives which were considered but subsequently disregarded.

Continuous technological development changes in production processes of semiconductors are inevitable and fluorine-free alternative technologies are being developed and assessed. A restriction with a 13,5-year derogation after EiF could promote the development and refinement of PFAS-free semiconductor production processes.

f) For cases in which substitution is technically and economically feasible but more time is required to substitute.

Not relevant, as a suitable technology is not known at the moment.

g) For cases in which substitution is not technically or economically feasible, information on what the socio-economic impacts would be for companies, consumers, and other affected actors. If available, please provide the annual value of EU sales and profits of the relevant sector, and employment numbers for the sector

Please refer to the contributions of ESIA and SEMI.

Sector: Metal plating

Sub-use: Hard Chrome Plating (5v)

The ATCS supports a derogation for hard chrome plating in line with the timeline of the authorisation process for Chromium (III).

a) The annual tonnage and emissions (at sub-sector level) and type of PFAS associated with the relevant use.

We understand only 6:2 FTS, as an example of a fluorotelomer-based mist suppressant agent, is used in electroplating. The sector uses a total amount of 5-11 tonnes of 6:2 FTS per year.

In addition, based on emission tests conducted in the context of the PFHxA restriction proposal, we can conclude that on-site measurements of 6:2 FTS concentrations in outlet waters from electroplating facilities show negligible emissions, in the grams range.

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

Following the listing of perfluorooctane sulfonic acid (PFOS) in Annex B to the Stockholm Convention (decision SC-4/17), the electroplating sector switched from PFOS to 6:2 fluorotelomer sulfonate (6:2 FTS).

This substance is used as a mist suppressing agent to lower the surface tension of the plating solution and create a protective foam that prevents the formation of chromium-VI aerosols, limiting workers' exposure to this carcinogenic agent.

c) The number of companies in the sector estimated to be affected by the restriction.

Please refer to the information provided by ZVO.

d) The availability, technical and economic feasibility, hazards and risks of alternatives for the relevant use, including information on the extent (in terms of market shares) to which alternative-based products are already offered on the EU market and whether any shortages in the supply of relevant alternatives are expected.

Alternative products can be used for decorative chrome plating, for which alternative Chromium-(III) processes already exist. However, the non-fluorinated mist suppressant chemical alternatives are not stable enough in the hard chrome bath and require continuous addition, undermining the usefulness of the alternatives for hard chrome processes. Moreover, it should be noted that the transition from PFOS to 6:2 FTS has already led to a decrease in performance and an increase in the dosage required.

e) For cases in which alternatives are not yet available, information on the status of R&D processes for finding suitable alternatives, including the extent of R&D initiatives in terms of time and/or financial investments, the likelihood of successful completion, the time expected to be required for substitution (including any relevant certification or regulatory approvals) and the major challenges encountered with alternatives which were considered but subsequently disregarded.

We support a transition period in line with the timeline of the authorisation process for chromium (III).

f) For cases in which substitution is technically and economically feasible but more time is required to substitute.

Please refer to the information provided by ZVO.

g) For cases in which substitution is not technically or economically feasible, information on what the socio-economic impacts would be for companies, consumers, and other affected actors. If available, please provide the annual value of EU sales and profits of the relevant sector, and employment numbers for the sector

The Danish Ministry of Environment considered the possibility of avoiding air convection to prevent the formation of chromium-VI aerosols. However, they concluded that such method would only be a suitable alternative in mass production systems. Therefore, it is not feasible for plating systems, which generally involve varying productions. It would not be possible to provide the required level of flexibility of such operation and the implementation would involve redesigning the production line.[39]

Chromium trioxide is considered critical for a vast range of industry sectors, the absence of a derogation providing sufficient adaptation time will impact several industries. Examples of the downstream sectors include, among others:

- Aerospace: The usage of the functional chrome plating process within industry includes, amongst others, chrome plating of undercarriage / landing gear and control components, wheel axles or pins or rods of hydraulic actuators or jet turbine engine parts and smaller hardware like fasteners. As indicated in the authorisation dossier:

  > The specific properties of a functional chrome surface are essential to fulfil the high technical requirements posed on components during the lifecycle of aerospace products. The use of Chromium Trioxide in functional chrome plating in the aviation industry is extensive, and often plays a critical role in meeting performance and safety standards, particularly those relating to airworthiness set by EASA (European Aviation Safety Agency). The same is applicable to the **space industry**, which has to comply with ESA requirements (e.g. ECSS requirements), and to the **defence industry** (e.g. BAINBw for German Airforce).

- Automotive: Applications are centred on the moving parts of an engine drive train, transmission, steering and differential components; shock absorbers, piston rings, power train, fuel injection parts, pistons for brakes, engine valves (stems), etc.
- Oil and gas: The usage of the functional chrome plating process includes large heavy-duty hydraulics, pistons, cylinders and rods for pumps and machinery (drills) or digging equipment, oil well equipment (pump shafts, pipeline valves).[40]

We can expect that, if the timeline of the proposed derogation is not aligned with the authorization for the use of chromium trioxide, the electroplating industry will not be able to operate under safe conditions, leading to a disruption of its activities in Europe, and bringing negative consequences for downstream sectors.

Disclaimer: The information provided is based on the knowledge of the ATCS at the time of writing. The ATCS does not assume responsibility or liability due to unforeseen events or changes beyond its control.

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[39] Pia Brunn Poulsen et all, (2011), Substitution of PFOS for use in non-decorative hard chrome plating, *Danish Ministry of the Environment*, https://www2.mst.dk/udgiv/publications/2011/06/978-87-92779-10-6.pdf, p. 10.

[40] European Chemicals Agency, (2020), 'Socio-Economic Analysis (non-confidential report)', https://echa.europa.eu/documents/10162/f33c6bb0-9d53-4a43-9061-08efa8026724, p. 11-14.

Question 8: Other identified uses – Analysis of alternatives and socio-economic analysis: Table 8 in the Annex XV restriction report provides a summary of the identified sectors and (sub-)uses of PFAS, their alternatives and the costs expected from a ban of PFAS. More details on the available evidence are provided in the respective sections in Annex E.

For many of the (sub-)uses, the information on alternatives and socio-economic impacts was generic and mainly qualitative. In particular, evidence on alternatives was inconclusive for some applications falling under the following (sub-)uses: technical textiles, electronics, the energy sector, PTFE thread sealing tape, non-polymeric PFAS processing aids for production of acrylic foam tape, window film manufacturing, and lubricants not used under harsh conditions.

Specific information (if not already included in the Annex XV restriction report or covered in the questions above) is requested on alternatives and socio-economic impacts covering:

Sector: Electronics

Sub-use: Coating of electronic devices

A derogation for coating of electric and electronic devices and the components thereof needs to be included under paragraph 5.

a) The annual tonnage and emissions (at sub-sector level) and type of PFAS associated with the relevant use.

As electronics coatings need to be applied in clean room-type working conditions, the emissions during application are effectively zero. The coatings are designed for durability and are limited to situations with confined conditions, meaning that emissions during the working life of the article are also effectively zero.

The end of life treatment of the components coated with these coatings are covered by the proper waste treatment defined in the Waste from Electrical and Electronic Equipment (WEEE) Directive[41], while the separate collection is defined in the Directive

[41] Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE), https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32012L0019&from=EN.

on the Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS)[42]. This ensures that emissions at the end of life are effectively zero.

It can, therefore, be shown that at all stages of the product's life cycle emissions are effectively zero.

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

- Conformal Coatings

C6 SFP coatings are used to provide liquid and moisture protection of electronic components, used for applications such as switches, connectors, relays, resistors, capacitors, transformers, inductors, integrated circuits, printed circuit boards themselves, display devices, small motors and bearings present in electronic devices like PCs, automobiles, game machines, various home appliances, watches, digital cameras audio equipment, and industrial machines. These represent a wide range of applications, therefore, volumes of SFP as coating agent for the use of electronic components are significant in Europe.

In military applications, conformal coatings are critical to deliver particular specifications, such as ML-B-81744, covering lubricant-migration-deterring barrier coating solution, for which short-chain side-chain fluorinated polymers (SC SFP) are critical. Aerospace applications are covered by RTCA-DO-160G and EUROCAE ED-14G, which ensure protection against 23 different environmental conditions assuring safe use on board aircrafts (DO-160, n.d.).

The coatings are described as conformal coatings as they "conform" to the topography of a component or circuit to protect it from the environment and insure reliable performance. Among these environmental challenges are humidity and condensation, temperature cycling, harsh chemicals, vibration and other contaminants. End users include the automotive industry, military and aerospace, medical, industrial and consumer uses (e.g., smart phones).

The two main reasons that SC SFP technology is preferred, is its ability to cope under higher thermal loads and their dielectric properties. Thermal stability arises from electronic systems requiring greater power in ever smaller surface areas. The dielectric properties are required to isolate elements of a circuit or to remove the potential for short circuits to occur. In this way, C6 SFP coatings improve the reliability of parts, extend the service life of the products and their parts, and improve the process efficiency. An additional benefit is anti-corrosion.

[42] Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32011L0065&from=ES.

- Anti-solder coating

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

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

c) The number of companies in the sector estimated to be affected by the restriction.

Please refer to the contributions of DIGITAL EUROPE, ESIA and SEMI.

d) The availability, technical and economic feasibility, hazards and risks of alternatives for the relevant use, including information on the extent (in terms of market shares) to which alternative-based products are already offered on the EU market and whether any shortages in the supply of relevant alternatives are expected.

Except for anti-flux migration coating, there are non-fluorinated alternatives for protective coating (e.g., acrylic type, silicon type, polyurethane type, polyolefin type). However, these substances present several disadvantages:

- Those products are flammable because of their flammable dilution solvents. By contrast, C6 SFPs are non-flammable since the active ingredient can be solved in non-flammable fluorinated solvent. If non-flammable conformal coatings cannot be used, investments need to be done on explosion protection and/or the production line needs to be moved to another area.
- Those products present a slower drying time than C6 SFPs, which means that by using the alternatives, the process time takes longer. In room temperature, those products usually need 24 hours for complete drying. By contrast, C6 SFPs need only 15 minutes for complete drying at room temperature (96 times faster). If fast drying conformal coating is not available, the production time becomes longer, and production cost will increase.
- Those products are thermally unstable, whilst C6 SFPs are highly stable (their decomposition temperature is above 200°C). If thermally stable polymers for protective/conformal coating are not used, cracking film and migration are generated, causing malfunction of customer’s device.
- The film thickness of each product will be much thicker than C6 SFPs.

Therefore, it is considered that no suitable fluorine-free alternatives are available that could meet the requirements of electronics applications

e) For cases in which alternatives are not yet available, information on the status of R&D processes for finding suitable alternatives, including the extent of R&D initiatives in terms of time and/or financial investments, the likelihood of successful completion, the time expected to be required for substitution (including any relevant certification or regulatory approvals) and the major challenges encountered with alternatives which were considered but subsequently disregarded.

We support a minimum transition period of 6,5 years after EiF, in line with the PFHxA restriction proposal.

For further information on questions e) to g), please refer to the contributions of DIGITAL EUROPE under the PFHxA restriction proposal.

Sector: Lubricants

Sub-use (not identified): *Epilame* for watchmaking

A permanent derogation for epilame used in watchmaking and watch servicing processes for mechanical and quartz watches needs to be included under paragraph 5.

a) The annual tonnage and emissions (at sub-sector level) and type of PFAS associated with the relevant use.

The watchmaking industry uses C6 SFPs as coating to lubricate mechanical and quartz watch movement parts (e.g., wheels, pivots, escapements, stones).

As noted in the final opinion on the PFHxA restriction proposal, the overall mass of C6 SFPs used in watchmaking lies within the lower, one-digit kg/y area. Worldwide production takes place at laboratory scale and potential emissions of PFAS are considered negligible. Waste is collected as industrial chemical waste and is properly treated through high temperature incineration. Therefore, emission of PFAS from watchmaking processes can be considered to be low.

The watches only contain a small amount of C6 SFPs (< 1 kg/y on a global scale) and the coated parts are inside the hermetic watch case. Furthermore, mechanical watches usually are expensive products with a long service life. They are not likely to be disposed through household waste, but rather are resold or dismantled for their parts.[43]

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

The coating is required to obtain a low surface tension in order for the lubricant (oil) to stay in place and not spread through the movement of the mechanical watch-parts. Furthermore, the coating must be chemically compatible with the substrate on which it is applied and must also not react with the components of the lubricant.

c) The number of companies in the sector estimated to be affected by the restriction.

This is out of our scope of competence.

d) The availability, technical and economic feasibility, hazards and risks of alternatives for the relevant use, including information on the extent (in terms of market shares) to which alternative-based products are already offered on the EU market and whether any shortages in the supply of relevant alternatives are expected.

We understand that no suitable alternative substance is available for the C6 SFP substance used in the production of lubricant mixtures for watchmaking. Silicone-based coatings have been investigated as potential alternatives, but they do not meet the technical requirements.

In addition, we would like to note that while this derogation applies to mechanical and quartz watches, electronic watches also require the use of PFAS.

e) For cases in which alternatives are not yet available, information on the status of R&D processes for finding suitable alternatives, including the extent of R&D initiatives in terms of time and/or financial investments, the likelihood of successful completion, the time expected to be required for substitution (including any relevant certification or regulatory approvals) and the major challenges encountered with alternatives which were considered but subsequently disregarded.

[43] RAC & SEAC, Background Document to the Opinion on the Annex XV dossier proposing restrictions on Undecafluorohexanoic acid (PFHxA), its salts and related substances, 8 December 2021, p. 352.

A suitable technology is not known at the moment. Given the low environmental impact of this application and the severe impact on the EU and Swiss industries, we support a permanent derogation for this use, in line with the restriction on PFHxA.

f) For cases in which substitution is technically and economically feasible but more time is required to substitute.

We understand that substitution is not yet technically and economically feasible.

g) For cases in which substitution is not technically or economically feasible, information on what the socio-economic impacts would be for companies, consumers, and other affected actors. If available, please provide the annual value of EU sales and profits of the relevant sector, and employment numbers for the sector.

To the best of our knowledge, substitution is not yet technically feasible. In addition to the absence of an identified alternative, it should be noted that the implementation of an entirely new technology to replace the fluorinated chemistry is complex and risky, and it would require many years to evaluate its feasibility and to proceed to its implementation.

For information on the impact on the sector, we can refer to the contribution submitted by the Swiss watch industry to the public consultation on the SEAC Draft Opinion on the PFHxA restriction proposal:

> The analogue watchmaking industry and downstream sectors employ between 150,000 and 200,000 workers in the EU, taking into account production, aftersales services and product distribution. […] Moreover watches generated €2.44 billion in export revenues for the EU in 2020. In addition, €536 million of EU watch components and straps were also exported to Switzerland in 2020, and watches worth CHF 6.2 billion (approximately €5.8 billion) were imported from that country in 2019. Furthermore, according to these figures, the taxes generated in the EU by the analogue watchmaking industry could be estimated as follow: €780 million for VAT, €210 million for direct and indirect taxes on household income, and €70 million for direct and indirect corporate taxes. In addition, the analogue watchmaking industry contribution to social security is estimated at €230 million.[44]

[44] Comment #931, Comments on SEAC Draft Opinion on REACH restriction proposal on PFHxA, its salts and related substances, p. 18-19, https://echa.europa.eu/documents/10162/ba9716b8-3392-3cf8-13ca-f88025921d42.

Question 10: Analytical methods: Annex E of the Annex XV restriction report contains an assessment of the availability of analytical methods for PFAS. Analytical methods are rapidly evolving. Please provide any new or additional information on new developments in analytics not yet considered in the Annex XV restriction report.

There are currently no available analytical methods capable of measuring the total speciated PFAS concentration in products. This is acknowledged in the Restriction Dossier which provides a calculation example for PFASs from Total Organofluorine (TOF) analysis data. The methods in Annex E are either targeted methods or give results for fluorine, which do not translate in PFAS concentrations.[45]

In addition, we would like to note that there are currently no available analytical methods capable of measuring the total speciated PFAS concentration in products. In case the restriction proposal is adopted in its current form, the absence of a harmonised analytical methods and suitable analytical standards would pose serious implementation and enforceability challenges to both industry and regulators. We believe that the availability of harmonized analytical methods should be the prerequisite to any regulatory action, including a restriction.

a) Overview Analytical Methods for Measuring PFAS

Much of the PFAS analysis work has been on PFOS and PFOA,[46] although more recently, analytical methods are starting to be applicable to more PFASs. For example, the US Environmental Protection Agency (EPA) published details of analytical methods for measuring PFAS in water, including the analysis of PFHxA:

- **Method 537.1**: Determination of Selected Per- and Polyfluorinated Alkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS).[47]

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[45] European Chemicals Agency (ECHA), Annex XV Restriction Report on Per- and polyfluoroalkyl substances (PFASs), p. 171, https://echa.europa.eu/documents/10162/1c480180-ece9-1bdd-1eb8-0f3f8e7c0c49.

[46] International Organization for Standardization (ISO), ISO 25101:2009, Water quality — Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) — Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry, 2009, https://www.iso.org/standard/42742.html; National Standards Authority of Ireland, Determination of extractable perfluorooctanesulphonate (PFOS) in coated and impregnated solid articles, liquids and firefighting foams. Method for sampling, extraction and analysis by LCqMS or LC-tandem/MS, 2010, doi: 10.3403/30297120u (accessed 20 April, 2022).

[47] United States Environmental Protection Agency (USA EPA), Method 537.1: Determination of Selected Per- and Polyfluorinated Alkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS), 2018, https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=343042&Lab=NERL (accessed 20 April, 2022).

- **Method 533**: determination of per- and polyfluoroalkyl substances in drinking water by isotope dilution anion exchange solid phase extraction and liquid chromatography/tandem mass spectrometry.[48]
- **Validated Test Method 8327**: Per-and Polyfluoroalkyl Substances (PFAS) Using External Standard Calibration and Multiple Reaction Monitoring (MRM) Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS).[49]

To develop validated and certified methods, the ATCS members are contributing to the development of methods for the analysis of PFAS, including PFHxA, in textiles with CEN.[50]

Table 7 – Comparison of PFAS analytical methods[51]

Method/Technique	Advantages	Limitations/Issues
LC-MS/MS	• Commercially available; extensive QA/QC • Quantifies individual PFAS • UCMR3/Method 537/SW-846 • Differentiates branched/linear (Br/L)	• Expensive equipment • Limited number of PFAS • Generally good for targeted analyses

[48] USA EPA, Method 533: Determination of Per- and Polyfluoroalkyl Substances in Drinking Water by Isotope Dilution Anion Exchange Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry, 2019, https://www.epa.gov/sites/production/files/2019-12/documents/method-533-815b19020.pdf (accessed 20 April, 2022).

[49] USA EPA, Validated Test Method 8327: Per-and Polyfluoroalkyl Substances (PFAS) Using External Standard Calibration and Multiple Reaction Monitoring (MRM) Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS), 2019, https://www.epa.gov/hw-sw846/validated-test-method-8327-and-polyfluoroalkyl-substances-pfas-using-external-standard (accessed 20 April, 2022).

[50] CEN, European Committee for Standarization. (2020). CEN/TC 248 - Textiles and textile products, https://standards.cen.eu/dyn/www/f?p=204:7:0::::FSP_ORG_ID:6229&cs=1CD56AD35AEB8C1A2E7CEE2BB715CAB9F; CEN/TC 289/WG 1 - Chemical test methods, https://standards.iteh.ai/catalog/tc/cen/29df3338-466e-47d1-9d89-023bd6cfd62f/cen-tc-289-wg-1; CEN/TC 309 – Footwear, https://standards.cen.eu/dyn/www/f?p=204:32:0::::FSP_ORG_ID,FSP_LANG_ID:6290,25&cs=1ED79F7259A11E8886AAECA272BFA2193.

[51] Lara Schultes et al., “Total Fluorine Measurements in Food Packaging: How Do Current Methods Perform?,” *Environmental Science & Technology Letters* 6, no. 2 (2019): 73–78. doi: 10.1021/acs.estlett.8b00700; Interstate Technology & Regulation Council, “11 Sampling and Analytical Methods,” *PFAS — Per- and Polyfluoroalkyl Substances*, December 2021, https://pfas-1.itrcweb.org/11-sampling-and-analytical-methods/ (accessed May. 18, 2022).

Method/Technique	Advantages	Limitations/Issues
TOP Assay (LC-MS/MS) Total Oxidizable Precursor	• Commercially available techniques • QA/QC improving • Some chain length and Br/L info	• Twice as expensive (LC-MS/MS - 2X) • No information on individual PFAS or sum of PFAS concentration • Conservative estimate of PFAS presence • Limited comparative data currently • Aggressive lab oxidation: no environmental relevance • TOP is not a validated analytical method
EOF/AOF Extractable / Adsorbable Organic Fluorine	• Quantifies extractable / adsorbable • Organic Fluorine	• No information on individual PFAS or sum of PFAS concentration • Limited comparative data at this time
PIGE Particle Induced Gamma Emission	• Quantifies total fluorine atoms • Faster - quick screening; less expensive • Non-destructive technique	• Not commercially available in us (1 lab - ND). Units being developed for commercial use • Not as sensitive as MS-based methods • Limited comparative data currently Does not speciate - just Fluorine presence • Sample preconcentration needed to increase sensitivity • No information on PFAS or sum of PFAS concentration
LC-QTOF Quadrupole Time of Flight. Can also include HRMS: high resolution mass spec and Orbitrap MS here	• Unlimited number of PFAS – good for non-targeted PFAS analyses • Stored data can be searched in the future	• Instruments but not analysis commercially • Available in US • Expensive; skill; time consuming; lots of data generated which need analyses; • Sample confirmation difficult as no authentic standards in many cases • No information on PFAS or sum of PFAS concentration

Method/Technique	Advantages	Limitations/Issues
CIC Combustion Ion Chromatography	• Used for fluorine mass balance • Determine total fluorine in environmental • Samples and consumer products • Better sensitivity and versatility vs PIGE/INAA	• Possible matrix effects that impact peak separation • CIC does not speciate and give you individual PFAS identification or sum of PFAS concentration
INAA Instrumental Neutron Activation Analysis (Gamma Rays)	• Measurement of fluorine in biological and environmental matrices • Non-destructive technique • Quick screening compared to XRF - often used side-by-side	• Better for solids than liquids • Sensitivity depends on sample matrix • No information on PFAS or sum of PFAS concentration

b) Targeted analytical methods

The Total Oxidizable Precursor Assay (TOPA) technique is mentioned in the Restriction Dossier as a suitable detection technique.[52] Nonetheless, it is worth noting that TOPA, which is performed at lab scale, is not a validated and certified method to measure and speciate PFAS. Moreover, the TOPA presents the following shortcomings:

- TOPA does not quantify nor identify the structures of individual fluorinated compounds and cannot be relied upon to quantify all of the fluorinated mass in a sample.
- TOPA is conducted under excessively harsh oxidative conditions and does not reflect real-world conditions. Therefore, the results of this technique are not indicative of the PFAS mass that is susceptible to oxidation in the natural environment.
- TOPA does not account for PFAA precursors that are resistant to the oxidation method and the precursors that are oxidized to unmonitored PFAAs. As a result, it has very limited value in forensic analyses.[53]

[52] European Chemicals Agency (ECHA), Annex XV Restriction Report on Per- and polyfluoroalkyl substances (PFASs), p. 183, https://echa.europa.eu/documents/10162/1c480180-ece9-1bdd-1eb8-0f3f8e7c0c49.

[53] Dora Chiang, *What Total Oxidizable Precursor Assay Can and Cannot Tell Us about Precursors of Perfluoroalkyl Acids*, January 2019, https://www.semanticscholar.org/paper/What-Total-Oxidizable-Precursor-Assay-Can-and-Tell-Chiang/480762d58de0a62b5d137db7ad59f4be7882c500.

c) Total fluorine methods

We would like to note that while total fluorine detection techniques and methods are useful for general screening, they are not suitable for compliance certification or enforcement unless they are validated and certified methods.[54] Also, as noted above, they do not give an indication of the type of PFAS species that were/are present and their concentration.

Furthermore, as noted in the Restriction Dossier, it is currently not analytically possible to distinguish between PFAS substances (i.e., a molecule containing at least one carbon on which two fluorine atoms are bound) and non-PFAS organofluorine substances (i.e., molecule containing one fluorine atom bound onto one carbon atom) when measuring the total fluorine content of a product,[55] especially in mixtures with such a complex matrix. This would require highly sophisticated procedures, including target and non-target analyses, that would be able to make the distinction which, to the best of our knowledge, are not yet available.

This renders the ancillary requirement under paragraph 2(iii) virtually unusable.

d) Specificities of PFHxA and PFHxA-related substances (C6 fluorotelomers)

With regards to C6 chemistry in particular, it is worth noting that in the SEAC Final Opinion on the restriction proposal on PFHxA, its salts and related substances, the Enforcement Forum of ECHA stressed that it is a common approach to refer to the existing restriction provisions on PFOS and PFOA to claim successful implementation of a PFAS restriction, especially in terms of enforceability and the availability of analytical methods (pp. 146-147). However, the Enforcement Forum noted that this possibility seriously has to be put in question and reiterated the need to develop standard methods for the analytical testing of the content of the substances covered by a proposed restriction, i.e., PFHxA, its salts and C6 fluorotelomers, and explained that some standard methods are only available for water matrices.

In fact, analysis of PFHxA in solid materials is much more challenging due to the sample preparation and extraction stages. Although methods do exist for the extraction and analysis of PFOS and PFOA (ISO 2018), **no standards have yet been published for the extraction of PFHxA**.

Moreover, the Enforcement Forum highlighted the absence of applicable analytical methods addressing precursor compounds (e.g., C6). Measuring C6 is much more difficult than measuring PFHxA, particularly when they are bound to larger molecules, in

[54] E. F. Houtz and D. L. Sedlak, Oxidative Conversion as a Means of Detecting Precursors to Perfluoroalkyl Acids in Urban Runoff, *Environmental Science & Technology 46*(17), 9342-9349, 2012, doi: 10.1021/es302274g.

[55] ECHA, Annex XV Restriction Report on Per- and polyfluoroalkyl substances (PFASs), p. 171.

environmental media, in biota, etc. Precursors are, by definition, significantly more complex than just PFHxA or any PFCA. This leads us to believe that substance specific tests are required.