W. L. Gore & Associates' Comments on Dossier Submitters' Draft EU REACH restriction on PFAS

Public consultation

Request for Derogation:
Pollution Control and Dust Collection

June 2023

Gore appreciates the opportunity offered by the public consultation process to provide comments on the Proposal for a Restriction of Per- and polyfluoroalkyl substances (PFAS) (hereinafter **'Restriction Proposal'**).

With this submission, we would like to explain why we believe that a derogation for **pollution control and dust collection equipment and in particular filters**, which are not covered by the derogations in the Restriction Proposal, is needed and justified. Further, we would like to explain why this derogation should be time-unlimited for applications requiring resistance to corrosive and chemically aggressive compounds and high temperatures, and why for other applications a derogation with a transitional period of 13,5 years is required.

The conclusions from our statement are summarized as follows:

- Pollution control and dust collection for industrial air emission streams are a critical function for human health and environmental protection. These applications are not sufficiently covered yet in the Restriction Proposal. It would be beneficial to create a sub-use for air pollution control and dust collection equipment to better capture this application.
- **For pollution control and dust collection applications requiring resistance to corrosive and chemically aggressive compounds or high temperature, neither alternative materials nor alternative techniques are available.** For applications in less demanding environments, substitution is likely to be possible, but development and qualifications activities will require a transition period of 13,5 years.
- Without sufficient derogations, significant adverse impacts from increased exposure to fine dust, dioxins, heavy metals and other toxic or carcinogenic pollutants as well as increased CO2 emissions are to be expected.

I. Derogation Request

Considering the arguments and evidence presented below, Gore respectfully requests to include the following application-specific derogations for pollution control and dust collection equipment in Column 2, paragraph 6 of the proposed restriction:

1. *Air filtration media for the purpose of pollution control and dust collection used in industrial or professional settings where flue gases contain corrosive or chemically aggressive compounds or where operation temperature is above 100°C;*
2. *Other [= no corrosive or chemically aggressive compounds and temperature ≤100°C] air filtration media for the purpose of pollution control and dust collection used in industrial or professional settings until 13,5 years after EiF.*

II. Description of the End Use

a) Overview of Industrial Filtration

A wide variety of filters are used to treat air emissions from industrial processes in areas such as chemical and cement manufacturing, metals processing, energy production and many others. The purpose of such filters is to prevent the release of harmful particulates and chemicals to the environment with significant benefits to human health. In some cases, the filters act as a physical barrier to particulates while allowing exhaust air to easily pass through. In other cases, the filters perform an additional function of promoting a chemical reaction on substances in the exhaust air stream to capture or convert those substances into something less harmful. Emissions are often regulated, so use of appropriate emissions controls is required for regulatory compliance.

Industrial processes vary significantly, therefore the operating conditions and substances found in air exhaust are also very different from process to process. Filters must be able to operate in these conditions which can include elevated temperatures and aggressive chemicals. They must also be able to withstand the physical demands of use. These properties along with air flow parameters and the degree to which particulate can be captured are all defined by the inherent properties of the materials used and the ability to create a porous physical form suitable for filtration.

As indicated in the derogation request, these industrial applications can be divided in two groups that are important when considering material options:

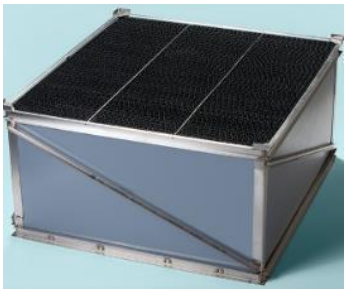
- Uses where flue gases contain corrosive or chemically aggressive compounds or where operation temperature is above 100°C
- Other air filtration uses for pollution control or dust collection

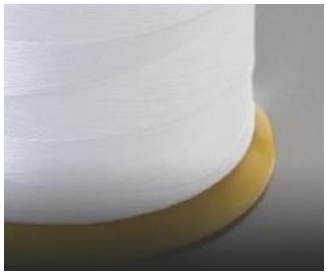
b) Product Examples

To clearly define the proposed new sub-use, detailed description of the type of products and their reliance on PFAS is provided below. The product examples are all Gore products, as details of comparable products manufactured by other companies are not publicly available. We believe that these products are representative of products manufactured and placed on the EU market by other companies.

Based on the current proposal the following pollution control products perform necessary functions, but would not be covered by the derogation proposed in Paragraph 5e:

Table 1. Pollution Control and Dust Collection Products

Product	Illustrations	Description
GORE® Catalytic Filter Bags		Filter bags that are used in baghouses to convert toxic or hazardous components such as gaseous dioxins and furans or nitrous oxides from aggressive and corrosive gas streams into harmless substances (i.e., to levels below regulatory limits). The filter's surface captures fine particles and releases these particles to be collected in the bottom of the baghouse hopper. Then, the filter lets the gaseous pollutants pass through into the catalytic felt where the catalyst reacts with the dioxin, furan or nitrous oxides (NOx) molecules to convert them into insignificant amounts of carbon dioxide (CO_2), water (H_2O), nitrogen (N_2) and hydrogen chloride (HCl). In most of the cases the catalytic conversion takes place at temperatures above 200 degrees Celsius; the minimum temperature is 180 degrees Celsius. These filters are typically applied in waste incineration, chemical processes, metallurgical processes, and cement manufacturing to help meet regulatory requirements for limiting air emissions.
GORE® Industrial Dry Filtration Products		These filter products are used to separate particulate from predominantly chemically aggressive and corrosive gas streams. The dust often consists of toxic, fine (sub-micron, sometimes nanoparticles), non-agglomerative, abrasive and/or sticky particulate such as heavy metals or dioxin containing fly ash. In operation, the filters are cleaned by a high-pressure pulse jet blast, or a reversed air flow, often combined with mechanical vibration. Typically used in waste incineration, chemical processes, metallurgical processes, and cement manufacturing at temperatures above 200 degrees Celsius to help meet regulatory requirements for limiting air emissions.
GORE® Mercury and SO_2 Control Modules		These modules are used to separate mercury from aggressive and corrosive gas streams and convert SO_2 into a dilute sulphuric acid. The modules consist of a metal frame which houses a PTFE based composite that contains adsorptive and catalytically active components. While PTFE is the functional material, PVDF is used as a mechanical stabilizer. Typically used in waste incineration, coal fired power generation, metallurgical processes and cement manufacturing to help meet regulatory requirements for limiting air emissions.

Product	Illustrations	Description
Rastex® / Gore industrial fibre		A sewing thread engineered specifically for the demands of filtration applications – it withstands exposure to chemicals, high temperatures, abrasives, and moist environments. The fibre can also be processed as a "staple fibre" used to create non-woven filter media.

All these products are made of fluoropolymers; other polymers are not used. The fluoropolymers meet the criteria for Polymers of Low Concern (PLCs), under the definition provided by the OECD Expert Group on Polymers. The fluoropolymers used for each product are listed below in Table 2.

Table 2. PFAS used in Pollution Control and Dust Collection Products

Example product	Type of PFAS	CAS number
GORE® Catalytic Filter Bags	PTFE	9002-84-0
GORE® Industrial Dry Filtration Products	PTFE	9002-84-0
GORE® Mercury and SO_2 Control Modules	PTFE	9002-84-0
	PVDF	24937-79-9
Rastex® / Gore industrial fibre	PTFE	9002-84-0

III. Reference in Restriction Proposal

a) Many industrial air filtration uses are not addressed in the Restriction Proposal

In the Restriction Proposal pollution control and dust collection products are discussed under the application TULAC and the sub-use technical fibers under the broad category of filtration and separation media. For certain products needed for high performance air and liquid filtration applications in industrial or professional settings that require a combination of water and oil repellence, a derogation is proposed in Paragraph 5e of the Restriction Proposal.

However, after carefully reviewing the Restriction Proposal, we have identified that filtration media for pollution control and dust collection are not covered by the proposed derogation yet. This omission translates into gaps in the justification, which seem to be closely related to the high number of products falling under the broad category of filtration and separation media.

In the Restriction Proposal it is acknowledged that there are various applications of filtration and separation media and that not all these applications are captured. It only refers to a few examples like gas turbines, hydraulic applications, nuclear industry, respiratory applications and air pollution control and dust collection as well as it refers to high performance membranes.

Even though air pollution control and dust collection were identified in the Restriction Proposal as a use within the sub-use category, the full range of necessary products covered by the use are not sufficiently captured. The use of PTFE in filtration applications is described in Section A.3.3.1.1./page 28f of Annex A, where it is pointed out that PTFE membranes are *"laminated to a wide variety of substrate materials such as polyester needlefelts and woven glass fibers to be made into filter bags [...]"*. **This only captures a very limited number of pollution control and dust collection products. For many of the products, PTFE or other fluoropolymers need to be used for membranes as well as substrates, since other materials would not withstand the harsh operating conditions (further explained below).** We would therefore like to take this opportunity to explain which other types of products fall under the category pollution control and dust collection.

b) Data Submitted to the PFHxA Restriction does not represent most Industrial Air Filtration Uses

In the Restriction Proposal it is recognized that there are filtration products requiring both water and oil repellence, and some that do not need oil repellence. The former being based on PFHxA and related substances, and the latter purely based on fluoropolymers (only PTFE is referenced). However, a derogation is only proposed for filtration products requiring a combination of water and oil repellence (Paragraph 5e), which is based on information provided in the PFHxA restriction process. **Because many filtration applications require the use of fluoropolymers, but not PFHxA-related substances, the information submitted for the PFHxA restriction proposal is not representative of all the PFAS use in this category.**

Even though the availability of suitable alternatives for filtration products made from PTFE are not apparent from the Restriction Proposal, a derogation is not proposed. The reasons for this remain unclear. It is stated on page 112 of Annex E that alternatives are available, however, the underlying evidence (Section E.2.2.4.2 and E.2.2.2.1) support the conclusion that alternatives are not available for the applications addressed herein. Polyester and polyurethane are mentioned as alternative substances in the Restriction Proposal, but it is not identified for which of the many products that fall under the category of filtration and separation media these alternatives would be technically feasible (see Section E.2.2.5.4., page 120 of Annex E). Also, Appendix E.2. does not provide information on alternatives for pollution control and dust collection products; no alternative for this sub-use is identified.

Overall, we believe that the assessment of alternatives in the Restriction Proposal has not been completed at a sufficient level of detail to allow for a conclusion on availability of suitable alternatives for all the products within the broad category of filtration and separation media.

IV. Need and Justification for Derogation Request

A derogation for pollution control and dust collection equipment and in particular filters is needed and justified. **Without a derogation significant increase of fine dust carrying dioxins, heavy metals and other toxic or carcinogenic pollutants as well as increase in CO_2 emissions is expected.** We propose that a derogation is justified based on the following points:

- The **performance requirements** for industrial air filtration applications
- The **lack of current alternatives** that would provide a sufficient level of performance
- The **time required** to develop, test, and commercialize new air filtration products, once a feasible material option is identified
- The **large socio-economic cost** of restricting the use

a) Performance Requirements

Detailed performance requirements for various industrial air filtration applications are listed in Annex I. Requirements vary based on the specific process and emissions being controlled and typically include combinations of the following:

- Filtration efficiency

  Filtration efficiency is a measure of the % of specified emissions captured by a filter. This is typically a primary indicator of the functional performance of a filter. To meet this requirement, a filter material needs a controlled pore size to allow air flow through while not allowing particulates to pass. It must also be able to maintain performance as particulate builds up inside the filter. Often efficiency is expressed as a percentage (like 99.99%) for a specific particle size. **While to readers unfamiliar with filtration technology, it may seem like the difference between 99% and 99.99% filtration efficiency is insignificant but in reality, such a difference indicated by the lower value can lead to enormous amounts of additional pollutants being released from a given process and failure to meet regulatory requirements.**

  As an example of regulatory requirements, the EU BAT Conclusions for Waste Incinerators sets dust emissions limits of ≤ 2-5 mg/Nm³, for certain Heavy Metals (Cd, Tl) ≤ 0.005 – 0.02 mg/Nm³ and for Dioxin ≤ 0.01 – 0.08 ng/Nm³. The dust content in the raw gas, together with the purposely injected additives, typically is on the order of 10-1000 g/Nm³. Hence the overall filtration efficiency needs to be at least (10,000 mg – 5 mg)/10,000 mg = 99.95 %. Dioxins need to be reduced from typically 2-3 ng/Nm³ in the unfiltered flue gas; hence the destruction removal efficiency needs to be at least (2 ng-0.08 ng)/2 ng = 96 %. Besides the minimum requirements of EU wide regulations, often there are stricter local or regional regulation.

- Temperature Resistance

  The temperature of flue gas streams varies by industrial process. Many require filtration of exhaust at temperatures up to 240°C. Filters need to withstand

continuous operation at these temperatures without degradation in strength or performance.

- Chemical Resistance

  Flue gas streams may contain acids, organic solvents, or other aggressive chemicals, including but not limited to HCl, HF, SO_2, NOx, and NH_3. Filters need to resist being damaged or degraded by constant exposure to these chemicals.

- Physical Strength

  Filters must be able to withstand the physical stresses experienced during use which can include high pulses as part of a periodic cleaning process. If filters tear or seams fail during use, particulates and other substances will be emitted to the atmosphere instead of being captured.

- Catalytic or Sorbent Function

  In addition to physical capture of particulates, some flue gas streams contain gaseous chemicals that need to be captured or destroyed. Filters need to contain embedded catalysts or sorbent that are retained in the filter yet come in direct contact with the flue gas to control emissions. End uses typically have % capture specifications which indicate the required effectiveness of the catalytic or sorbent activity.

b) Assessment of Alternatives

In September 2022 we provided a full Socio-Economic Assessment (SEA) prepared by eftec. The SEA has been submitted to all 5 Dossier Submitters. Since this information was provided after the end of the Call for Evidence in September 2021, the SEA is attached as **Annex II** to this derogation request. The SEA contains a comprehensive assessment of alternatives (see Section 3 (pages 36-42)).

To make the information more easily available and to take into account the information provided in the Restriction Proposal, we have summarized all information on alternatives in **Annex I** of this document, which also contains updated and supplementary information obtained after the SEA was submitted. The information on alternatives is provided at a 'product-type' level, referring to the products described in the Table 1 above.

The conclusions from Annex I are summarized as follows:

Catalytic Filter Bags: Destruction of certain toxins	**There are no alternative materials known which would work under the harsh operating conditions where the flue gases contain corrosive and chemically aggressive compounds or temperature is above 180°C.** Other materials cannot resist either the corrosive/chemically aggressive compounds (e.g., fiberglass) or the temperature (e.g., PET, PU, PI). Other techniques (solid catalysts or absorbent systems) are not considered a viable alternative since they are not able to remove dust without being combined with dust filters. There are no dust filters that do not require fluorinated materials with a sufficient filtration performance that can be used at the required temperature of above 180°C.

Industrial Dry Filtration: Dust filtration	For most (around 90%) of the applications of industrial dry filters there are no known alternative materials which would work due to the harsh operating conditions where the flue gases contain corrosive and chemically aggressive compounds or temperature exceeding 200°C. For applications without contact to harsh chemicals and at ambient/medium temperatures, other material could be used but would provide a much poorer filtration performance (75 – 99 % compared to ›99.9% for expanded PTFE). **An efficiency of 99% is not sufficient to comply with all requirements under the EU BAT Conclusions for Waste Incinerators,** therefore, they are not considered viable alternatives. Based on current knowledge, we believe that recently tested [redacted] could potentially be modified to provide sufficient performance in the future [redacted] for ambient/medium temperature applications (‹100°C).
Mercury and SO_2 Control	There are no known alternative materials which would work under the harsh operating conditions of applications where mercury and SO_2 control is needed. In addition, other materials lack a sufficient hydrophobicity to withstand flue gas which is typically saturated with water vapor. Other techniques (such as adsorption systems, limestone based wet scrubbing) are not considered viable alternatives since these techniques either cannot remove SO_2 from flue gas (adsorption system) or cannot remove mercury (limestone based wet scrubbing), both of which are needed to meet emission limitations in power plant and incinerators. Therefore, instead of a module combining both, an adsorption system as well as a limestone based wet scrubbing systems would need to be installed to fulfil the same function. In addition, there are severe disadvantages, in particular, a much higher carbon footprint (up to 100 times higher).
Industrial fibre for filtration: Thread and Staple	Except for asbestos, there is no known alternative material that would work under the harsh operating conditions of applications where industrial fibres are used (see section on Industrial Dry Filtration above).

c) Timeline

For highly technical, demanding and complex uses with strict performance requirements, such as pollution control and dust collection equipment, the in-depth identification and assessment of alternatives included in this document indicates that a general application of a 13,5 years derogation period is not sufficient to cover the needs of such uses.

The Restriction Proposal only advises transitional periods of 13,5 years or below, even in cases where no alternative exists or is likely to be found within the transition period. As pointed out on page 77 of the Restriction Dossier, this is based on the understanding of the Dossier Submitter that 13,5 years are *'normally sufficient for industry to take benefit from technical progress and to carry out scientific R&D activities to find and deploy technically and economically feasible alternatives'*. **This assumption does not accurately take into account the time needed to identify alternative materials, nor the time to develop, test, and commercialize products once an alternative material is identified.**

As explained above and in the SEA for Filters, so far, no alternative materials, techniques or products are available as potential substitutes for pollution control and dust collections products. Only for some (dry) dust filtration applications without contact to harsh chemicals and at ambient/medium temperatures (‹100°C), [redacted] has the potential to be modified to receive a sufficient performance in the future [redacted]. Timelines for each of these categories are described below.

(i) Need for time-unlimited Derogation for applications in harsh environments

Since an alternative material is not available for pollution control and dust collection applications in harsh environments, a new material would need to be found or invented. Thus, the development process needs to begin with creating a new material, potentially a non-fluorinated polymer that can still meet the temperature, chemical resistance, and porous structure requirements. The time needed for this is not known and very difficult to predict.

Examples from the past, show that the time span to develop new materials can vary significantly. For example, the development of acrylic polymer took several decades. The process from the first synthesis of acrylic acid to the introduction of the commercial polymer, was an 85-year journey.[1] While the development of PTFE from the "accidental" discovery to a commercial product took about 10 years, from 1938 to 1948[2], and then decades more to mature that technology into the materials used today. Development advances over this time have had to occur in polymerization, finishing, lubrication and blending, pelletization, extrusion, etc. In absence of such an initial unexpected discovery, we can only speculate that developing a new polymer until commercial availability will take **more than 20 years**.

After identifying a material, several steps would need to follow (see table 3).

Table 3: Substitution steps for developing an alternative to fluoromaterials in pollution control and dust collection products

Steps for substitution	**What activities does this step entail?**	**Time required for step**	**Minimum one-off cost for this step**
1. Identification and development of new material	Developing a new polymer	**Unknown** Estimate > 20 years	Approximately €> [redacted] million
2. Polymer process development – converting a polymer with sufficient inherent properties into a physical form suitable for filtration	Understanding how polymer can be processed into a strong porous membrane and embedded with catalyst or sorbent materials.	3 years	Approximately € [redacted] million

[1] See https://www.ptonline.com/articles/tracing-the-history-of-polymeric-materials-part-20.
[2] https://www.teflon.com/en/news-events/history#:~:text=An%20Accidental%20Discovery&text=Roy%20J.,to%20form%20polytetrafluoroethylene%20(PTFE).

3. Product development an iterative stage of R&D, (re)formulation and lab testing	Development of filters for specific end uses. Product Development from Technology Readiness Level 1 to 9, testing in lab, and pilot scale, including modification of polymer to ensure performance needs.	5 years	Approximately [redacted] million
4. Qualification and/or Validation - testing and validation with customers and/or external testers	Validation by end users, OEM and EPC to be applicable.	3 years	Approximately [redacted] million
5. Certification - review and testing by standard setters and/or regulators	Certification by test institutes to national and international standards. Other certifications and/or standards that need to be met by filters are EN 1822, ZH 1/487, VDI 3926.	1 year	Approximately [redacted] million
6. Production - implementing the manufacturing plan for the alternative, including a possible pilot phase, regulatory approval, and modifications to the production line.	Set up production, manufacturing capabilities, supply chains.	5 years	Over [redacted] million
Total	All steps	>37 years	> [redacted]

After an alternative material that has the performance attributes necessary to withstand the operating conditions described in Section 3 has been developed, the most important and time-consuming part would be to understand how the new polymer can be modified to ensure proper functioning as a filter. This requires that:

For catalytic filter bags

- Catalysts and adsorbents can be embedded into the porous structure. Alternatively, a coating technique would need to be developed to bind the catalyst to the polymer reliably for many years of operation
- A porous structure to filter dust particles of different sizes without getting clogged
- Physical strength to withstand cleaning in place while installed
- Conversion into a flat, gas permeable filtration media, that can be used as a filter bag

For dry filtration products

- A porous structure to filter dust particles of different sizes without getting clogged
- Physical strength to cleaning in place while installed
- Conversion into a flat, gas permeable filtration media, that can be used as a filter bag

For mercury and SO_2 control modules (GMCS)

- Catalysts and adsorbents can be embedded into the porous structure. Alternatively, a coating technique would need to be developed to bind the catalyst to the polymer reliably for many years of operation
- Conversion into a pleatable media, that can be used in GMCS modules

For Industrial fiber: thread and staple

- Seam integrity verification when used for filter bag sewing
- Ensure no bypass gaps, loosening at operating temperature, and integrity after back pulse
- In production sewing, confirmability to meet stitching specifications without knotting, kinking, abrading, or breaking.

When Gore developed catalyst filled ePTFE products for catalytic filtration, that process took [redacted] years from filing the patent to providing a commercial product (Steps 3 and 4 of Table 3). An equally long period of time was needed to develop catalyst filled ePTFE products to be used in Mercury and SO_2 Control Modules. This long period of time was necessary although Gore had already considerable know-how in working with and modifying PTFE. When working with a new material/polymer, a considerably longer period of time is expected to be needed.

Overall, **Gore estimates that substitution of all pollution control and dust collection products would take a minimum 17 years and cost at least [redacted] million after an alternative material has been identified**. The time and costs needed to identify a material could not be assessed, as there are no known candidate materials. Based on the examples presented above we can only speculate that this would take more than 20 years resulting in a total development time of more than 37 years.

If at any point during the substitution process a step ends with failure (e.g. a potential alternative substance does not pass a specific standard/certification), then the entire process will need to be restarted which can significantly increase the time and resources required. We believe that this uncertainty and the fact that the time needed to find an alternative material cannot be estimated, justifies the need for a time-unlimited derogation.

We believe that national and European regulatory standards further add to the justification for a time-unlimited derogation. This includes in particular the *EU BAT Conclusions for Waste Incinerators*. As demonstrated in Annex I, the performance requirements set by these regulatory standards cannot be met without the use of fluoropolymers. This situation is comparable to the application of PFAS in refrigerants in HVACR-equipment, which is one of the few uses where a time-unlimited derogation was proposed by the dossier submitters. According to page 150 of the Restriction Proposal, a time-unlimited derogation for refrigerants in HVACR-equipment was proposed since regulatory standards prohibit the use of alternatives substances due to safety concerns.

(ii) Need for transition period of 13,5 years for other applications

[redacted] is the only material identified by Gore as a potential substitute for (dry) dust filtration applications without contact to harsh chemicals and at temperatures below 100°C. As demonstrated in Annex I, filters made from [redacted] currently have a lower dust collection efficiency (99% vs. ›99.9% for PTFE). To increase collection efficiency and improve PE filter performance, which is, in particular, needed to comply with EU BAT Conclusions for Waste Incinerators (see explanation in Annex I below), modification of the [redacted] polymer is needed. As pointed out above, the time estimated to get from product planning to final product is a minimum of 17 years. Since initial R&D work has already been performed, a transition period of 13,5 years after EiF is expected to be sufficient.

V. Additional Information in SEA

Specific information requested in the stakeholder consultation is available in the full SEA which is attached as Annex II to this derogation request. The information provided in the SEA include the following

- Market and sales for filtration products (Section 2.3 and 2.5.2);
- Types and volumes of PFAS used (Section 2.4, 2.5.3 and 2.5.5);
- Material flow, including emission volumes Section (2.4.3 and 2.5.3);
- Further information on alternatives (Chapter 3);
- Economic impacts (Section 4.3);
- Impacts on health and the environment (Section 4.4);
- Social and wider economic impact (Section 4.5); and
- Comparison of impacts and proportionality (Chapter 5).

Please note that the SEA covers a broader variety of filtration products than just pollution control and dust collection, therefore, it also contains information on other filtration categories which fall under different applications/sub-uses.

In the following, we present a high-level summary of parts of the SEA. Gore kindly asks the dossier submitters and the committees to review the entire document:

a) Social and Economic Impacts

The SEA shows that not granting a derogation for filtration products similar to those set out in Table 1 will have large and wide-reaching impacts on the EU. These include significant economic costs throughout the value chain, impacts on employment (lost jobs) as well as adverse impacts on human health and the environment.

The SEA conservatively estimates that the minimum annuity costs, including lost profits and impacts on employment, of restricting the use of PFAS in pollution control and dust collection products amounts to €1.2 billion per year.

b) Impacts on Human Health and the Environmental

It is demonstrated in Section 4.4.3 of the SEA, that a restriction of PFAS in pollution control and dust collection products would have several adverse effects to human health and the environment. This includes that lower performing (non-PTFE membrane) filters would allow more fine dust, dioxins, heavy metals and other toxic or carcinogenic pollutants to be released into the environment, eventually ending up in ambient air and surface water.

c) Emissions

It is demonstrated in Section 2.4.3 of the SEA that emissions from product manufacturing, service life and end of life are negligible. Additional information on responsible manufacturing, processing and disposal of fluoropolymers and products made from fluoropolymers are provided in our derogation request for fluoropolymers.

In addition, an estimate of worst case emissions based on the "investigation report summaries" published by the DS in 2021 (National Institute for Public Health and the Environment (RIVM) et al., 2021) is provided (see section 2.5.3). This information has been compiled in order to create a basis for further consideration within the framework of the SEA. It does not correspond with our knowledge on emissions and in particular our knowledge on emissions from product manufacturing with emission control technologies in place. In our opinion, the emissions from product manufacture estimated in the investigation report summaries are significantly overestimated**. But even when applying highly conservative emission factors, the resulting costs of reducing PFAS through restricting pollution control and dust collection products is very high, with a minimum cost of €4.2 – €6 million per kg PFAS emissions reduced.**

A CE estimate does not in itself, indicate whether benefits of a restriction outweigh the costs. For cases where risks and impacts of reducing exposure to a substance are unknown, it is common to compare the cost-effectiveness estimates with some type of benchmark. A study by Oosterhuis et al. published in 2017 found that for PBTs, vPvBs and substances with similar properties (e.g., lead) emission reduction measures with a cost-effectiveness below €1,100[3] per kg emission reduced were generally not rejected due to costs i.e., the costs were found to be proportionate. Measures with costs above €56,400[4] per kg, on the other hand, were more likely to be rejected, i.e., costs at this level were found to be disproportionate. Cost in between could be either proportionate or disproportionate – a so called 'grey zone' (Oosterhuis et al., 2017). The Oosterhuis benchmarks (BMs) have been used for the assessment of a number of regulations of PBTs and vPvBs, which are substances of very high concern (SVHCs). These BMs are, however, not necessarily applicable to substances of low concern such as PTFE and other PLCs. The reasoning behind this is that the implied willingness to pay (acceptability of costs) would be higher, the higher the perceived risk of a specific substance. If the Oosterhuis BMs are to be used for substances of low concerns, it is reasonable to make some indicative, quantitative or qualitative, adjustments. For example, if the 'grey zone' for a PBT ranges from €1,100 –

[3] €1,000 in original study, uplifted to 2022 prices
[4] €50,000 in original study, uplifted to 2022 prices

€56,400 per kg PBT emission reduced, it is reasonable to assume that upper bound (and likely also the lower bound) would be significantly lower for substances of low concern.

There are uncertainties associated with all parts of the analysis and a multitude of impacts could not all be quantified and/or monetised. However, due to the consistent conservative approach taken it is believed that the most significant non-quantified impacts are costs of a possible REACH restriction and would therefore further strengthen the conclusions from the quantitative analysis. **It is therefore concluded that restricting the use of PFAS in industrial and professional air filtration end uses will result in highly disproportionate societal costs for the EU.**

Annex I – Comprehensive Alternative Assessment

Alternative Assessment for Catalytic Filter Bags

R&D activities conducted

Our R&D activities focused on an assessment of products made from polyimide which we compared to our fluoropolymer containing catalytic filtration product.

The R&D focus is based on the BREF Document for Waste incineration, as most of the catalytic filters are used in the Waste-to-Energy Industry.[5] In Section 2.5.3.5 of the BREF operational information on the following materials is provided:

Table 2.15: Operational information for different bag filter materials

Fabric	Maximum temperature (°C)	Resistance		
		Acid	Alkali	Physical flexibility
Cotton	80	Poor	Good	Very good
Polypropylene	95	Excellent	Excellent	Very good
Wool	100	Fair	Poor	Very good
Polyester	135	Good	Good	Very good
Nylon	205	Poor to fair	Excellent	Excellent
PTFE	235	Excellent	Excellent	Fair
Polyimide	260	Good	Good	Very good
Fibreglass	260	Fair to good	Fair to good	Fair

NB:
Not all of these materials are commonly used in incineration – see operational data below.
Source: [2, InfoMil 2002] [67, Inspec, 2004]

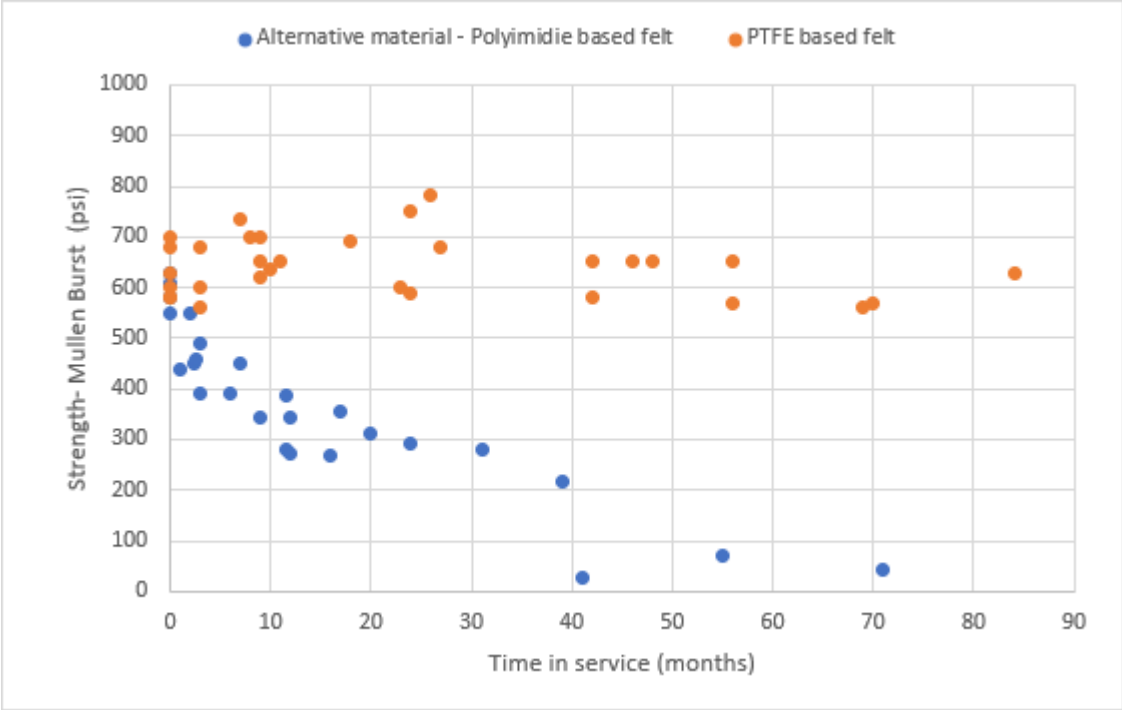
Further it is mentioned that the main media for municipal solid waste incineration (MSWI) plants are polyimide, polyphenylene sulphide (PPS) (rarely), PTFE, and fiberglass (with or without PTFE coating). Also, it is acknowledged that higher temperatures may lead to the melting of plastic

[5] https://eippcb.jrc.ec.europa.eu/sites/default/files/2020-01/JRC118637_WI_Bref_2019_published_0.pdf.

	components of the filter with a potential for fires and that high humidity in the flue-gas may cause the filter materials to stick together, leading to shutdowns. PTFE is mentioned as material to improve the removal of such sticky salts and solid particles from the bags. Due to low temperature resistance of most materials and insufficient resistance of fiberglass to acids and alkalis, polyimide is the only non-PFAS material available according to the BREF document. Please note that the temperature limits mentioned in the BREF document do not fully correspond with our understanding of the mentioned materials; however, the order of magnitude is more or less correct. See also further information on the performance requirements and materials below.
Performance requirements	The catalytic process always needs a relatively high temperature (minimum 180°C) to ensure sufficient destruction of the toxin. The temperature is needed to speed up the chemical reaction between catalyst and toxin, since the gas is in contact with the filter only for a short period of time (~0.1 seconds), thus the reaction needs to be fast. Catalytic Filter Bags are used in different applications, including waste incineration, chemical and metallurgical processes, and cement production. The requirements in these applications are slightly different: • Waste incineration: The baghouses equipped with catalytic filter bags are operated at 180-240°C. The flue gas contains acid and chemically aggressive gases (primarily HCl, HF, SO_2, NOx, NH_3) and corrosive constituents (e.g. $CaCl_2$). The filter cake can be hygroscopic, wet and sticky, especially at OTNOC Conditions (OTNOC = Other than normal conditions, e.g. start-up or process upsets). • Chemical processes: Among others, catalytic filters are applied for fumed silica production and optical fiber production. In these processes, the concentration of HCl in the gas can exceed 20%. Chlorine gas is also present. The operating temperature is 200-240°C. • Metallurgical processes: Relevant processes comprise steel manufacturing (e.g., sinterband, lime kiln, coke oven), aluminum recycling (via pyrolysis) and other similar applications. The flue gas contains corrosive and chemically aggressive compounds (primarily NOx, NH_3). The operating temperature of baghouses in these applications is 180 – 240°C. • Cement production: The gas contains corrosive and chemically aggressive compounds (primarily SO_2, NOx, NH_3), and high concentrations of abrasive dust ($CaCO_3$, CaO). The operating temperature of baghouses in these applications is 180 – 240°C. The filter material needs to be temperature and chemical resistant and cleanable under these conditions. Cleanability is needed, since, in addition to the pollutants mentioned above, the flue gas always contains dust/fine particulates. If a filter cannot be cleaned the product life will be tremendously shortened and the amount of catalyst material needed increases substantially. The cleaning process is performed by blasting compressed air from the clean side, knocking off the collected dust, which then drops down into the hopper and dust discharge device of the baghouse. If filters cannot be cleaned while installed, frequent process shutdowns would be needed to maintain/clean or change the filter.
Products on market without use of fluoropolymers/ fluoromaterials	There are no products without fluoropolymers on the market which can be used under the conditions outlined above (corrosive and chemically aggressive compounds in flue gas and temperatures between 180 – 240°C). Filters made from alternative non-fluoropolymer materials (e.g., polyimide, fiberglass, polyester) on the market are only used in less demanding applications (e.g., to collect coarse, non-hazardous dust from air streams at lower temperatures).

Alternative materials known or discussed in Restriction Proposal and performance of such materials	Polyester (PET)	Polyester (PET) filters are commonly used as filter media in industrial as well as HVAC applications, usually in the form of a felt. **PET filters can only be used at temperatures below 135°C, and only if the gas is sufficiently dry (normal humidity). In humid gases the temperature is limited to 100°C. Thus, PET filters are not a viable alternative to catalytic ePTFE filter bags where 180°C is the required minimum temperature.** In addition, PET filters are less efficient. In particular, the dust collection efficiency is in general lower than of ePTFE membrane filters (‹90 % vs. › 99.9 %). An efficiency of 90% is not sufficient to comply with the EU BAT Conclusions for Waste Incinerators. The EU BAT Conclusions for Waste Incinerators sets dust emissions limits of ≤ 2-5 mg/Nm³, for certain Heavy Metals (Cd, Tl) ≤ 0.005 – 0.02 mg/Nm³ and for Dioxin ≤ 0.01 – 0.08 ng/Nm³. As an example, the dust content in the raw gas, together with the purposely injected additives, typically is on the order of 10-1000 g/Nm³. Hence the overall filtration efficiency needs to be at least (10,000 mg – 5 mg)/10,000 mg = 99.95 %. Dioxins need to be reduced from typically 2-3 ng/Nm³ in the unfiltered flue gas; hence the destruction removal efficiency needs to be at least (2 ng-0.08 ng)/2 ng = 96 %. Besides the minimum requirements of EU wide regulations, often there are stricter local or regional regulation.
	Polyurethane (PU)	Polyurethane (PU) filters are commonly used as filter media in HVAC applications, usually in the form of a foam. **PU filters can only be used at temperatures below 100°C. Thus, PU filters are not a viable alternative to catalytic ePTFE filter bags where 180°C is the required minimum temperature.** In addition, PU filters are less efficient. In particular, the dust collection efficiency is in general lower than of ePTFE membrane filters (~75 % vs. › 99.9 %). An efficiency of 75% is not sufficient to comply with the EU BAT Conclusions for Waste Incinerators (see above). Also, PU filters cannot be cleaned during operation – they are so-called depth filters, while ePTFE membrane filters are surface filters. Additionally, since PU filters are much thicker than ePTFE membrane filters (› 10 mm vs. 1-2 mm), they cannot be produced in the form of a filter bag, which is required for the installment in a baghouse to control industrial emissions.
	Polyimide	Polyimide (PI) has been used by Gore as part of a catalytic filter system in the past in combination with an ePTFE membrane filter for use in certain less demanding applications. Even though the temperature resistance is considered to be 240°C , it showed 70 to 80% strength loss over 3 years at an operation temperature of 180 to 200°C. See Chart 1 below. Therefore, it was replaced by pure PTFE filters which last for 6-8 years. At higher temperatures, an even faster deterioration rate of the PI is expected. Due to the strength loss, the filter bags made from PI and PTFE broke in particular during the cleaning process (blasting of compressed air from the clean side).

Chart 1. Strength over time for PTFE and Polyimide Felts



Besides lower temperature resistance and lower resistance against aggressive and corrosive chemicals compared to PTFE, pure polyimide filters are not a viable alternative to catalytic ePTFE filter bags since PI cannot be expanded and therefore not be filled with the catalyst material. Since PI filter bags cannot be filled with catalyst but only coated, they have limited capability to load catalyst. Coating only gets to a maximum [redacted] catalyst area density, by filling it is possible to load greater than double that amount. The lower density results in faster decrease of efficiency and a shorter product life since the efficiency will fall under the minimum efficiency requirement much faster. Efficiency degrades because of undesired side reactions and deactivation of the catalyst. Once the efficiency reaches the minimum, the bags have to be replaced. If the initial efficiency is higher, it takes longer until the minimum is reached, hence bags with higher initial efficiency have a longer service life.

	Fiberglass	**Fiberglass has only "fair to good" resistance against corrosive and chemically aggressive gas components (see table in BREF document above). Although filter bags made from fiberglass can withstand the conditions for short periods of time (<1 year), a longer service life is not possible due to continuous degradation over time. Thus, pure fiberglass filters are not a viable alternative** to catalytic ePTFE filter bags since for all applications where catalytic filter bags are used, they need to be resistant under such conditions for a longer period of time (filter bags made from pure PTFE last for 6-8 years). The use of fiberglass filter bags would lead to the following unacceptable disadvantages: • Frequent shutdowns to change filter bag before it breaks • Increasing risk of breaks during operation which would lead to high dust emissions to the environment the need to immediately shut down the plant to install a new filter bag • Significant increase of consumption of catalyst materials which typically contain heavy metal oxides including some Critical Raw Materials (e.g., vanadium(V) oxide and tungsten trioxide) due to more frequent replacements • Significant increase of waste due to more frequent replacements Similar to the polyimide example above, fiberglass cannot be filled with a catalyst the way the expanded PTFE can, so coatings are used to provide catalytic functionality. Samples were tested and demonstrated severely reduced level of NOx capture efficiency (23.9%), as compared to a fluoropolymer-based catalytic filter (87.9%)
Alternative techniques known or discussed in Restriction Proposal and performance of such techniques	Solid catalysts	Other than fluoropolymer-based Catalytic Filter Bags, which combine dust removal and catalytic gas cleaning where toxins like dioxin and NOx are destroyed in one device (the catalytic baghouse), solid catalysts where toxins are destroyed but dusts are not removed need to be combined with a regular dust filter. The toxins removal efficiency (DRE) of solid catalysts is comparable to the performance of catalytic filter bags. Also, they are resistant with regard to temperature and corrosive and chemically aggressive compounds. Because they do not remove dust, they would need to be combined with dust filters. However, as described below in the section on industrial dry filtration uses, there is no viable alternative without the use of PFAS with a sufficient filtration performance that can be used at the required temperature of above 180°C. In addition, there are several disadvantages of solid catalysts compared to catalytic filter bags: <u>Increased capital costs</u> Solid catalysts can be applied in the form of pellets (filled in a fixed bed reactor) or are embedded in ceramic bodies, which have channels where the gas flows through (so-called honeycomb elements). Both forms require separate housing to hold the catalyst, including a steel support structure as well as various controls, and connections (pipes,

		ducts, electrical, etc.). The capital costs for installation are significantly higher than the cost for installation of filter bags, and a retrofit to existing plants sometimes is not possible, because of a lack of space. Higher operating costs and energy use Both forms (fixed bed reactors and honeycomb elements) cause additional pressure loss which leads to higher operating expenses since more energy is needed to move the gas through the flue gas cleaning system. Most of the commercially available solid catalysts operate at a higher temperature than the catalytic filter bags (›250°C instead of 180-240°C). Also, they need to be regenerated frequently (every 1000 hours) by heating them up to › 300°C. The higher temperature for solid catalysts is needed since the gas does not flow through the catalyst (like it flows through the filter bags) but passes by the catalyst (flows through the channels of the honeycomb). Therefore, the contact between gas and catalyst is much less intensive, which needs to be compensated by a higher temperature and more active catalyst material, that the chemical reaction takes place faster and more gas turbulence occurs. Without the frequent regenerating process the unwanted side reactions that are unavoidable would over time block the catalyst and significantly reduce the efficiency. This further increases the carbon footprint and the operating expenses due to the higher heat energy (steam, gas firing) consumption. Greater consumption of Critical Raw Materials and Increased Waste For solid catalysts more catalyst material is needed since the gas just “flows by” with less contact of flue gas and catalyst instead of “flowing through” like in case of filter bags. This is particularly important with regard to the catalyst materials which typically contain heavy metal oxides including several Critical Raw Materials (e.g., vanadium(V) oxide and tungsten trioxide). Finally, solid catalysts have on average a shorter lifespan than catalytic filter bags (3-5 years instead of ›7 years), and thus consume more resources, generate more waste and cause more frequent plant shutdowns to do the replacement. Due to the shorter lifetime of solid catalysts, approximately twice the amount of hazardous and rare catalyst materials is needed.
	Absorbent systems	As for solid catalysts, absorbent systems where toxins are not destroyed but bound need to be combined with a regular dust filter. When using absorbent systems, temperature, and corrosive and chemically aggressive compounds are not of issue. The toxins removal efficiency (DRE) of absorption systems depends on the quantity of sorbent which is applied. Fixed bed reactors filled with sorbent typically have a higher performance than catalytic filter bags. The DRE of sorbent injection systems depends on the amount of sorbent injected and the distribution of it in the flue gas. Typically, the DRE is

		comparable to the DRE that catalytic filter bags provide. However, because they do not remove dust, they need to be combined with dust filters. **Since there are no dust filters without the use of PTFE with a sufficient filtration performance that can be used at the required temperature of above 180°C (see information on Industrial Dry Filtration Products below) there is no viable alternative without the use of PFAS.** In addition, there are several disadvantages of absorbent systems compared to catalytic filter bags: Absorbents can be applied in the form of granules or pellets (filled in a fixed bed reactor) or by continuous injection into the flue gas. Both techniques require a continuous consumption of sorbent material (e.g., activated carbon produced from wood, coke or coal). The quantity of sorbent materials required is several orders of magnitude higher compared to filter bags. Further, it must be noted that the entire amount of used sorbent material ends up as hazardous waste since it contains the toxins that have been removed from the gas stream; in essence the pollution is only moved from gas to solid phase. This is in contrast to filter bags where toxins are destroyed. Furthermore, this technique leads to much higher operating expenses due to the high amount of sorbents needed and the additional costs of disposal of hazardous waste. Although the capital costs are lower compared to catalytic conversion, the total cost of ownership for catalytic systems typically are lower than for adsorption systems.

Alternative Assessment for Industrial Dry Filtration Products

R&D activities conducted	See above	
Performance requirements	Dry filtration products are used in different applications, including waste incineration, chemical and metallurgical processes and applications and cement production. The requirements in these applications are slightly different. In most of the applications, the dry filtration products must be able to withstand flue gas containing corrosive and chemically aggressive compounds (comparable to conditions stated above) and the operating temperatures exceeding 200°C. Only in a small number of applications (10% within our portfolio), the dry filtration products do not need to be resistant to corrosive and chemically aggressive compounds and the needed temperature resistance may vary from ambient (e.g., post-processing area where products are packed) to medium temperatures (e.g., venting of product and raw material silos) below 100°C.	
Products on market without use of fluoropolymers/ fluoromaterials	Various fabrics made from polymer fibers are used as filtration media. At present, only PTFE can be used in environments which require resistance against corrosive and chemically aggressive compounds and high temperature. If harsh chemicals do not get in contact with the filtration media, alternative polymers (such as polyimide, polyphenylene sulphide or meta-Aramid) or fiberglass can be used up to certain temperature limits (see below). However, these materials alone provide a much lower filtration performance (particulate removal efficiency, pressure loss, lifetime) than filtration media that utilize the superior properties of expanded PTFE (ePTFE) membranes for filtration. Hence, it became industry standard to combine almost any filtration media with an ePTFE membrane (two-layer laminate).[6] Even when there is only a requirement with regard to temperature resistance fluoropolymers continue to need to be used. Recently, new membrane air filters based on [redacted] have been introduced into the market. Currently, the filtration performance of these is far below that of ePTFE. Also, the temperature and chemical resistance (e.g., against solvents) is much lower for the [redacted] filters. However, Gore believes that [redacted] could be modified to have a comparable/sufficient performance in ambient/medium conditions (temperature up to max. 100°C) in the future.	
Alternative materials known or discussed in Restriction Proposal and performance of such materials	Polyester (PET)	**As stated above, polyester (PET) filters can only be used at temperatures below 150°C, and only if the gas is dry (no humidity). In humid gases the temperature is limited to 100°C. Thus, PET filters could only be used in ambient to medium temperature environments.** However, also in such environments PET filters are not a viable alternative since they are less efficient. In particular, the dust collection efficiency is in general lower than that of ePTFE membrane filters (‹90 % vs. › 99.9 %), since PET cannot be modified in a way that the structure is fine enough to capture fine particles with high enough efficiency. An efficiency of 90% is not sufficient to comply with the EU BAT Conclusions for Waste Incinerators (see above)

[6] See https://www.baghouse.com/products/baghouse-filters/ptfe-filters/.

	Polyurethane (PU)	**As stated above, polyurethane (PU) filters can only be used at temperatures below 100°C. Thus, PU filters could only be used in ambient to medium temperature environments. However, also in such environments PU filters are not a viable alternative since they are less efficient. In particular, the dust collection efficiency is in much lower than of ePTFE membrane filters (~75 % vs. › 99.9 %).** An efficiency of 75% is not sufficient to comply with the EU BAT Conclusions for Waste Incinerators (see above). In addition, PU filters are not a viable alternative since they are so-called depth filters, while ePTFE membrane filters are surface filters. This means that they collect the dust in its internal structures. Therefore, PU filters cannot be cleaned during operation but have to be replaced when saturated. Since PU filters are much thicker than ePTFE membrane filters (› 10 mm vs. 1-2 mm), they cannot be produced in the form of a filter bag, which is needed for the installation in a baghouse to control industrial emissions.
	Polyimide	**As stated above, polyimide (PI) filters have a lower temperature resistance compared to PTFE. Even though temperature resistance is considered to be 240°C, it showed 70 to 80% strength loss over 3 years at an operation temperature of 180 to 200. Thus, PI filters could only be used in ambient to medium temperature environments. However, also in such environments PI filters are not a viable alternative since they are less efficient. In particular, the dust collection efficiency is in lower than of ePTFE membrane filters (~99 % vs. › 99.9 %)** and an efficiency of 99% is not sufficient to comply with all requirements under the EU BAT Conclusions for Waste Incinerators (see above).
	Polyethylene	Polyethylene (PE) is not sufficiently resistant against chemicals, since it is susceptible to certain acids and organic solvents as Table 4 demonstrates. As stated above, PE has just been introduced as a filter medium recently. Currently, the dust collection efficiency is still lower than of ePTFE membrane filters (~99 % vs. › 99.9 %) and an efficiency of 99% is not sufficient to comply with all requirements under the EU BAT Conclusions for Waste Incinerators (see above).

Table 4. Chemical Resistance of Polytetrafluoroethylene (PTFE) and Polyethylene (PE)

(Temperature 50C; 30 days exposure)

Chemical	PTFE	PE
Acids		
Acetic acid 99%	**	**
Nitric acid 20%	**	*
Sulfuric acid 50%	**	**
Bases		
Ammonia	**	**
Sodium Hydroxide	**	**
Caustic Soda 30%	**	**
Aqueous Solutions		
Detergents	**	**
Sodium Chloride	**	**
Organic Solvents		
Acetone	**	**
Ethanol	**	**
Heptane	**	**
Trichloroethylene	**	X
White Spirit	**	*
Xylene	**	*
Propylene Carbonate	**	**
Diethyl Carbonate	**	**

** Resistant, properties unaffected
* Moderately resistant, slight reduction of properties
X Not resistant, significant reduction of properties

Source: Figure 3 from Galka/Saxena/Crosby, Filtration+Separtion, 30 Jul 2009 (https://www.filtsep.com/content/features/high-efficiency-air-filtration-the-growing-impact-of-membranes/)

Polyphenylene sulphide	**Polyphenylene sulphide (PPS) filters can only be used at temperatures below 190°C. Thus, PPS filters cannot be used at very high temperatures like PTFE. In addition, PPS filters are not a viable alternative since they are less**

		efficient. In particular, the dust collection efficiency is much lower than of expanded PTFE membrane filters (99.7 vs. › 99.9 %). **While numerically this may seem close, it means that the PPS filter allows more than 50 times more particulate to pass through than the PTFE membrane filter based on lab testing.** An efficiency of 99.7% is not sufficient to comply with the EU BAT Conclusions for Waste Incinerators (see above).
	Meta-Aramid	**Meta-Aramid (mA) filters can only be used at temperatures below 200°C. Thus, mA filters cannot be used at very high temperatures like PTFE. In addition, mA filters are not a viable alternative since they are less efficient**. In particular, the dust collection efficiency is much lower than of ePTFE membrane filters (~95 % % vs. › 99.9 %). An efficiency of 95% is not sufficient to comply with the EU BAT Conclusions for Waste Incinerators (see above).

Alternative Assessment for Mercury and SO_2 Control Modules

R&D activities conducted	We have investigated [redacted] as a potential surrogate for ePTFE. It showed very low mechanical stability and integrity and does not provide sufficient level of hydrophobicity. Therefore, it is considered not technically feasible.
Performance requirements	Mercury and SO_2 Control Modules (GMCS) are primarily applied in flue gas cleaning of coal fired power plants, sludge incinerators and other processes where the flue gas needs to be cleaned from sulfur dioxide (SO_2) and/or mercury. The modules consist of a frame which houses a PTFE based composite that contains adsorptive and catalytically active components. By the absorptive components gas phase mercury emissions are captured and converted into stable mercury compounds which can be safely disposed of. For SO_2 control a catalyst is used to convert SO_2 to saleable sulfuric acid, a valuable and versatile chemical used for production of certain types of fertilizers. Both systems rely on the unique properties of PTFE to create highly porous, chemically inert scaffolds to hold the catalyst and sorbent particles, allowing for high activity in use. Furthermore, it is the hydrophobic nature of PTFE that allows the particles to maintain their activity in a wet environment. As sulfuric acid is formed by the reaction with SO_2, this must be removed from the individual catalyst particles, otherwise the reaction will effectively shut down due to mass transport limitations caused by liquid films. The PTFE structure supports the liquid to flow away from the catalyst surface, allowing the catalyst or sorbent to function for many years continuously without requiring any regeneration. In the processes where our modules are applied, there is always a high level of SO_2 present, often also other acid gases and corrosive constituents. The flue gas typically is saturated with water vapor. While the environment can be considered harsh because of this demanding combination of chemicals, the temperature level usually is around 50-70°C.
Products on market without use of fluoropolymers/ fluoromaterials	No comparable products on the market

Alternative materials known or discussed in Restriction Proposal and performance of such materials	There are no known alternative materials. As already described above, other polymers are not sufficiently resistant to corrosive and chemically aggressive flue gases and would not withstand the conditions where Mercury and SO_2 Control Modules are operated. In addition, other materials like polyethylene, polyester and polyurethane show a lack of hydrophobicity, since they have a higher surface energy than PTFE. Therefore, these non-PFAS materials cannot be used in a water saturated atmosphere where the modules are operated – the water would block the pores immediately and the flue gas could not pass through anymore. The hydrophobic nature – which based on current knowledge only PTFE provides – is essential to force liquids away from the catalysts and sorbents in order to preserve their activity.	
Alternative techniques known or discussed in Restriction Proposal and performance of such techniques	Adsorption systems	The next best technique for flue gas cleaning from mercury is the use of adsorption systems. Due to the water-saturated environment, traditional fixed bed reactors filled with sorbent material do not work, unless the flue gas is reheated ~20°C above the dew point. Therefore, the sorbent material (activated carbon) needs to be continuously injected to the flue gas stream. An adsorption system would also have to be combined with a limestone based wet scrubbing system, which comes with further challenges (described below). Even though the destruction removal efficiency (DRE) may be, depending on the amount of injected material, comparable. **this technique does not meet the performance need of removing both mercury and SO_2 from the flue gas.** In addition, there are further significant disadvantages of absorption systems: a very large amount of carbon is required to capture a relatively small quantity of mercury. The result is 3-4 orders of magnitude more solid waste generated compared the Mercury and SO_2 Control modules. As an example, 1 kg of media used in Mercury and SO_2 Control modules can replace 15,000 kg of activated carbon powder which would be needed if using absorption systems. Activated carbon can also contaminate other process residues that otherwise may have some beneficial use, such as fly ash use in concrete and cement, resulting in even larger waste volumes. Also, the process of producing activated carbon releases CO_2. In total the emissions of carbon dioxide are a hundred times higher than if using Mercury and SO_2 Control modules. While there are other filtration products available for reducing mercury and acid gas emissions, their overall performance is inferior to GCMS because: they require very large amounts of carbon to capture a relatively small quantity of mercury, resulting in 3-4 orders of magnitude more solid waste that must be managed; activated carbon can also prevent beneficial reuse of other by-products (such as fly ash use in concrete and cement), resulting in even larger waste volumes; use of activated carbon increases the total emissions of carbon dioxide by 100X compared to use of GCMS; higher energy and resource consumption is needed to produce and maintain absorption and limestone based wet scrubbing systems to achieve comparable overall emissions reduction performance of GCMS;

	Limestone based wet scrubbing	Flue gases can be cleaned from SO_2 via limestone based wet scrubbing. **This technique can only clean flue gasses from SO_2 and not from Mercury, as opposed to PTFE-based technology.** In addition, there are significant disadvantages with limestone-based wet scrubbing: In particular, the carbon footprint of this technique is much higher. Besides the need to install two different techniques to clean both SO_2 and Mercury, CO_2 is generated during the cleaning process. Furthermore, limestone-based wet scrubbing generates gypsum, which is regarded as waste in several countries. The wet scrubbing systems also consume a significant amount of parasitic power, resulting in lower overall plant efficiency.

Alternative Assessment for Industrial Fiber used as Thread or Staple in Filtration Applications

R&D activities conducted	See above for Industrial Dry Filtration Products	
Performance requirements	There are two different uses of expanded PTFE fiber: Threads are used in industrial filtration applications to sew filter bags together. Staple fiber is combined into a felt to reinforce expanded PTFE filter membranes; they are used as a second layer since an ePTFE membrane alone is not stable enough to be used as a filter alone. The performance requirements are the same as for the Industrial Dry Filtration Products (described above). The thread needs to be resistant to corrosive and chemically aggressive compounds and to operating temperatures above 200°C. Only in a small number of applications, resistance against corrosive and chemically aggressive compounds is not required and the resistance in ambient or medium temperatures might be sufficient.	
Products on market without fluoropolymers	There a few products using aramids and/or stainless-steel threads. However, both have limitations and are therefore non-viable alternatives (see section below)	
Alternative materials known or discussed in Restriction Proposal and performance of such materials	PET, PI, PU	As demonstrated above, materials like polyester, polyurethane, polyimide, and polyurethane are not sufficiently resistant to temperature and polyurethane as well as fiberglass are not sufficiently resistant against chemicals. Therefore, in most of the applications they are not a technically feasible alternative since they would lead to early failure of the equipment. Due to the low material thickness, the temperature and chemical resistance is of even greater importance. For example, temperature limitation for threads made from PE and PET would be 80°C and 60°C instead of 100°C. Even though the melting point is at 100°C, softening therefore weakening happens below that temperature. Seam failure and, therefore, uncontrolled emissions would be expected.

		In addition, the high temperature resistance and tenacity (strength to mass ratio) of PTFE thread allows for use of smaller diameter filaments in sewing application, this provides the best seal by minimizing the uneven seam that heavier thread would create.
	Aramids and Steel	Even though aramids have a high temperature resistance, they are not a viable alternative since they would break during cleaning process where compressed air from the clean side is blasted through the filter to knock-off the collected dust. As explained above, in all industrial filtration applications such cleaning is required. Seam failure and, therefore, uncontrolled emissions would be expected. Stainless steel has a high temperature resistance but no sufficient resistance against acids. For environments where only temperature resistance is required, stainless steel is not a viable alternative since it is very difficult to handle. Sewing with steel filaments has to be done with specialized equipment, guides need to be hardened or ceramic materials. A much slower sewing feed is required as well. Finally stainless thread will not conform to tight stitch requirements leaving gaps where bypass can occur at the seams. Similar to aramid thread, abrasiveness of the material would require special sewing considerations and the stiffness while not as severe as steel would not allow for tight stitch patterns needed for good containment. For both steel and aramid larger diameter bags could be used to minimize the thread gaps, however, in addition to redesign and rebuild of the bag house configuration larger bags would increase the space between bags reduces the effective filtration area and the overall efficiency of the system
	Polyamide	Polyamide thread has high strength and fair temperature resistance, however it exhibits brittle behavior when dry. This condition occurs occur with absorption and lime scrubbing noted above and sudden loading in the back pulse used to clean the filter. Seam failure and, therefore uncontrolled emissions would be expected.
	The only viable alternative being sufficiently resistant against high temperature and chemicals would contain asbestos which – for known reasons – has already been restricted.	

Annex II - SEA of restricting the use of PFAS in filters

See file submitted in the attachment