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

Public consultation

Request for Derogation:
Filter for Gas Turbine

August 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 **filters for gas turbines** is needed and justified. Further, we would like to explain why a transitional period of 13.5 years is required.

The conclusions from our statement are summarized as follows:

- In the Restriction Proposal, uses for Gas Turbines have not been researched in detail and requirements for filters have not been taken into account.
- Gas turbines have very demanding filtration performance requirements in order to protect the equipment from airborne particulates, water ingress, and salt. Filtering these contaminants ensures an optimal gas consumption efficiency of the unit. No non-PFAS alternatives are currently available that would meet the performance requirements.
- Without a derogation, non-PFAS alternatives would be used which have a lower filtration efficiency, increasing the fouling of the turbine blades. This will impact gas turbine efficiency leading to a direct increase in fuel consumption, operating costs, and emissions of greenhouse gases.

I. Derogation Request

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

Filters for gas turbines until 13.5 years after EiF

II. Description of the End Use

To increase the efficiency of gas turbines, the air required for combustion is compressed before it is combined with the fuel and injected to the combustion chamber. Compression is achieved by intake of large volume of air through various blades.

Over the course of a year, gas turbines typically run about 8000 hours, taking in hundreds of millions of cubic meters of air for the combustion cycle. Depending on the location, ambient air may carry dissolved salt, hydrocarbons, sand, water, and other contaminants. When such contaminants come into contact with the blades of the compressor or combustion chamber, they will cause fouling and corrosion. These two outcomes reduce the compressor efficiency and operators need to increase the fuel consumption to compensate. The damage is often irreversible, resulting in higher maintenance costs and more frequent replacement cycles. To avoid this outcome, the intake air is filtered by gas turbine filters before entering the compressor.

The hydrophobic filters ensure prolonged use and protect the compressor of the turbine against external elements. They provide high filtration efficiency, removing submicron dust, water, and salt particulates, while allowing high airflow for improved turbine performance.

Locations of gas turbines vary significantly, often being in remote areas (e.g., artic, offshore). Therefore, the operating conditions, associated maintenance, and substances found in air intake are also very different from location to location. Filters must be able to operate across these conditions, and also be able to withstand the physical demands of use, so the durability of the material is critical especially for remote areas where excessive maintenance is a challenge. 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.

To clearly define the proposed derogation, a detailed description of the product and its reliance on PFAS is provided below (Table 1). The product example is a Gore product, as details of comparable products manufactured by other companies are not publicly available. We believe that this product is representative of products manufactured and placed on the EU market by other companies, which we believe all use PFAS at this level of filtration performance.

Table 1. Filters for gas turbines

Product	Illustrations	Description
GORE® Turbine Filters		An efficient particulate air filter (EPA) is a proprietary thin, three-layer filter used in gas turbines to generate electricity. Such gas turbines are used by oil and gas exploration industry (i.e., LNG, offshore oil platforms), power generation industry, or chemical industry. The durable and watertight technology ensures longevity by maintaining clean engine performance, minimising downtime, and reducing maintenance costs of gas turbines. The filter only lets pure air through by pre-screening larger contaminants, capturing small contaminants, and blocking water droplets. Furthermore, the filter prevents ingestion of both dry and soluble contaminants helping to eliminate processor fouling over a long lifetime. Hence, the filters are suitable for operators who run intermediate and base load engines, experience fouling-induced losses in compressor efficiency and power output, and seek protection from corrosion due to salt ingestion.

Turbine filter media is a three-layer material, one of which is made of PTFE which meets the criteria for Polymers of Low Concern (PLCs) under the definition provided by the OECD Expert Group on Polymers (Table 2).

Table 2. PFAS used in Gas Turbine Filtration Products

Example product	Type of PFAS	CAS number
GORE® TURBINE FILTERS	PTFE	9002-84-0

III. Reference in Restriction Proposal

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. This derogation does not apply to turbine filters, since only water but no oil repellency is needed.

Also, the derogation in Paragraph 6f for fluoropolymer applications in the petroleum and mining industry of the Restriction Proposal is not sufficient since turbine filters are not only used in the petroleum and mining sector but also by other industries (e.g., power generation and chemical industry).

Even though turbine filters are explicitly mentioned under the sub-use technical fibers of the TULAC applications in the Restriction Proposal (see Annex A, Section A.3.3.1.1., page 27f), the need to use PFAS has not been discussed in detail. The necessity is rejected with the argument that only water repellence and no oil repellence is required for such filter products. For water repellence, non-fluorinated alternatives are considered available, but such alternatives are not specified in the Restriction Proposal.

We would like to take this opportunity to explain why there are currently no alternatives to fluoropolymers in Gas Turbine Filters based on the demanding filtration performance requirements, even though they do not have to be oil-repellent.

IV. Need and Justification for Derogation Request

A derogation for gas turbine filters is needed and justified. **Without a derogation, significant increases of fine dust, salt and water would access the gas turbines and foul compressor blades, leading to increased fuel consumption (operating costs) and generating additional CO_2 emissions.** We propose a long derogation is justified based on the following points:

- The **performance requirements** for gas turbine 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

Performance needs vary based on the specific local environment and condition of use of the turbine and its filters, but typically include the following combination of requirements:

i) High Filtration Efficiency and Low Pressure Drop

To prevent corrosion and fouling of the turbine engine, the filter prevents particulates and water from entering. At the same time, the filters must maintain airflow and minimal pressure drop to provide sufficient airflow for turbine operation.

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 for a specific particle size.

Greater efficiency means cleaner intake air and more efficient operation of a gas turbine. There are standard classifications for filter efficiency. Relevant to this use, E12 HEPA filters block › 99.5% of the most penetrating particle size (MPPS), allowing ‹ 0.5% to pass through, effectively eliminating compressor fouling. E10 HEPA filters only block 85% of the particles known to cause compressor fouling, allowing 15% to enter the turbine — significantly reducing compressor efficiency. Additionally, most E10 filters don’t eliminate water. Water carries salt (corrosion) and dirt (fouling) into the clean side of the turbine or compressor.

Figure 1, “Spectrum and standards of filtration processes” contrasts typical particulate sizes in micrometers, using techniques to characterize and identify the particulates in reference to existing specifications. It also includes for reference types of particulate material and typical separation technologies for collecting said particulate material. Of importance from this table, EN1822 covers a smaller range of particulate sizes. E12 and E10 filters have different performance within the range highlighted by the red box (EN1822). There are other, even lower performing filter grades such as F9 which are classified in the brown box (EN799) and are only capable of capturing much larger particles, allowing smaller ones to pass through.

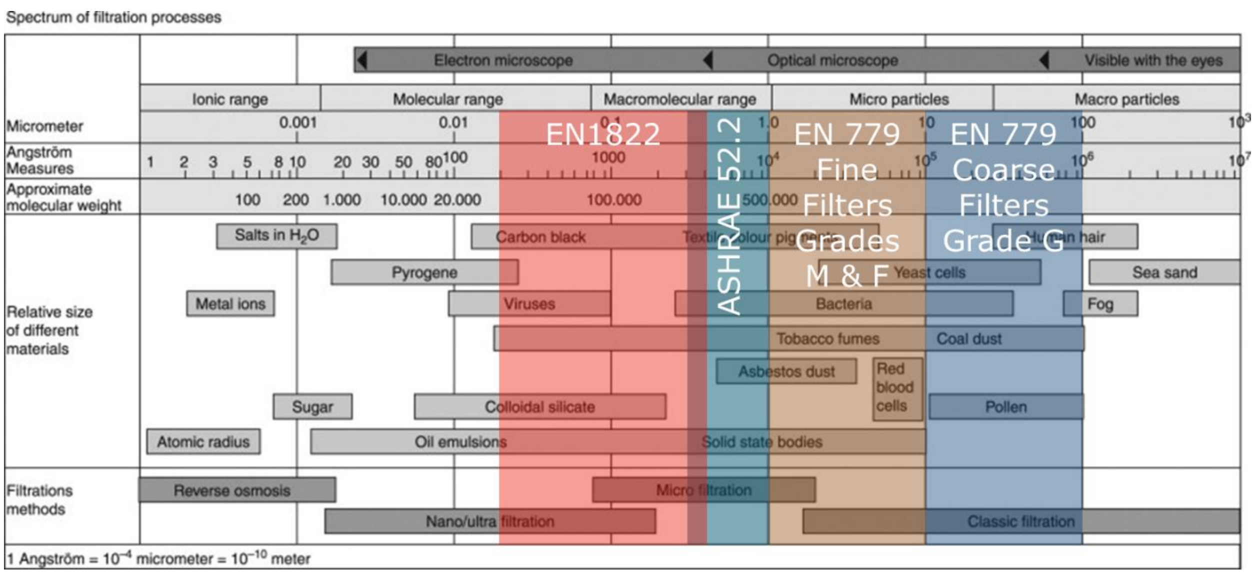

Figure 1. Spectrum and standards of filtration processes

ii) Hydrophobicity

Hydrophobicity is important for filter media to prevent blockage of the filter pores by water and cleaners as well as prevent passage of water into the turbine where it can lead to corrosion. Surface energy is a material property which determines its hydrophobicity. Lower surface energy, as described by a lower critical surface tension and a higher contact angle with water, indicates a more hydrophobic material which is inherently more resistant to water and water borne contaminants.

While filtration performance prevents passage of airborne salt into the turbine, hydrophobicity prevents passage of waterborne salt in fog, which is necessary to protect equipment installed offshore or close to the sea. [1]

iii) Temperature Resistance

The filters are required to function in conditions from the coldest exterior environments to desert-like locations. They must perform their function across a range of temperatures, depending on the region on the globe from -40°C to › 50°C. This includes artic environments with heavy snow and frigid conditions, and hot, desert applications with heavy sandstorms.

iv) Physical Strength

The filter material needs to be sufficiently strong to withstand the physical stresses experienced during use which can include high pulses as part of a periodic cleaning process. If material fails during use, particulates and other substances will enter and damage critical components of the turbine.

Overall performance relies on the combination of material properties

The microporosity and membrane thickness influence the filter trade-off characteristic of permeability, filtration efficiency, and contaminate loading level. These attributes in turn influence overall filter performance and lifetime. The thinner and more porous a membrane structure, the higher the airflow and lower the filtration efficiency. As such, there is an optimum balance between a polymer's hydrophobicity, permeability, filtration efficiency, and lifetime.

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 I** to this derogation request. The SEA contains a comprehensive assessment of alternatives (see Section 3 (pages 36-42)).

In addition, we have summarised our analysis of alternatives as follows:

i) Filtration Efficiency

All E12 filters on the market contain PFAS in the filtration media. Generally, operating an E12 filter for 2 years will result in a 0-1% loss in compressor efficiency. Lower grade filters (for example, F9 class made without PFAS) tend to see much larger drops of compressor efficiency, around 8%, that in turn drives up fuel consumption and CO_2 emissions.

Non-PFAS materials have lower filtration efficiency, which increases fouling of the turbine blades by ~3.5% per year, resulting in ~USD$220K per year[2] in higher fuel consumption. In turn, this produces approximatively 4600 Tonnes of emission of greenhouse gases per year on average.

[1] fine salt fog mist can result in rusting or corrosion of susceptible materials
[2] Assuming fuel cost of USD$0.1 per m^3

Non-PFAS alternatives used in less demanding filtration applications have not demonstrated to ability to be made in microporous structures that meet E12 filtration performance standards.

ii) Hydrophobicity/Surface Energy

Table 3 contains typical surface energy values for common polymers with some fluoropolymers highlighted in yellow.

Table 3. Critical Surface Tension and Contact Angle with Water for Various Polymers[3]

Polymer abbr.	Polymer Name	Surface Energy (dynes/cm)	Contact Angles (degrees)
PES	Polyethersulfone	46	90
	Styrene butadiene rubber	48	
PPO	Polyphenylene oxide	47	75
	Nylon 6/6 (polyhexamethylene adipamide)	46	
PC	Polycarbonate	46	75
	Nylon-6 (polycaprolactam)	38	
PET	Polyethylene terephthalate	42	76
PMMA	Polymethylmethacrylate	41	82
SAN	Styrene acrylonitrile	40	74
	Polyimide	40	83
PVC r	Polyvinyl chloride, rigid	39	90
	Polyester	41	70
	Acetal	36	85
ABS	Acrylonitrile butadiene styrene	35	82
PPS	Polyphenylene sulfide	38	87
PVA	Polyvinyl alcohol	37	10
	Polyacrylate (acrylic film)	35	
PVC p	Polyvinyl chloride, plasticized	35	89
PS	Polystyrene	34	72
	Nylon-12	36	
	Surlyn ionomer	33	80
PBT	Polybutylene teraphthalate	32	88
CTFE	Polychlorotrifluoroethylene	31	
PP	Polypropylene	30	88
PU	Polyurethane	38	85
PE	Polyethylene	30	88
PVF	Polyvinyl fluoride	28	
PVDF	Polyvinylidene fluoride	25	80
	Natural rubber	24	
PDMS	Polydimethyl siloxane (silicone elastomer)	23	98
FEP	Fluorinated ethylene propylene	20	98
PTFE	Polytetrafluoroethylene	19	120

PTFE is preferential over other polymers, e.g., PP or PE, because of its lower surface energy. PTFE is naturally hydrophobic and has a surface energy of 19 dynes/cm. This allows it to easily repel fluids with surface tensions such as water with a surface tension of 72 dynes/cm, but it also repels cleaners which can have much lower surface tension than pure water.

Only PFAS-based filter media can achieve sufficiently low surface energy to resist water and cleaners typically used in gas turbine applications with the durability to last for the required lifetime.

[3] https://www.tstar.com/blog/bid/33845/surface-energy-of-plastics

iii) Conclusion

All known offerings in the European Region that have High Airflow E12 EPA Filtration Efficiency solutions (Figure 1) contain at least one PFAS substance in their portfolios. The final products utilize either short-chain, side chain fluorinated polymers or PTFE for water tightness protection. Thus, there are no known non-PFAS High Airflow E12 alternatives on the market.

c) Timeline

For gas turbines, the Restriction Proposal does not advise a transitional period longer than 18 months, even in cases where no alternative exists or is likely to be found within the transition period. **This provision 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.**

Gore continues to do research on potential alternatives. This is an investment to understand how materials can be made into microporous structures and how laminated material perform in this application. Given that there are not known materials and solutions in the market that can perform at the E12(1) Filtration performance efficiency, the shortest path to transitioning is estimated at ~11 years based on research work that has already been initiated. This estimate is still highly uncertain because technical feasibility of an alternative has not yet been demonstrated.

Table 4 Below describes the pathway and timeline needed to substitute the current solution in gas turbine.

Table 4. Estimated Timeline for Substitution

Steps for substitution	What activities does this step entail?	Time required for step
Discovery	Early scouting of materials and testing	**Unknown** Estimate 2-4 years for this use
Validation and commercialisation of selected materials	Assuming a material is successfully found discovered, it will need to be optimised for the specific requirements of gas turbine. This may involve transitioning processes to pilot scale or small-scale manufacturing.	1-2 years
Trial on live production site	All the possible environments will need to be tested, from artic regions to deserts, coastal area to remote inland locations	2 years min
Production	Analysis and changes for full production replacement.	1-2 years
Transition for all customers	Production, distribution, and installation of filters at customer sites	2-4 years
Total		**8-14 years**

V. Additional Information

a) Direct Impacts on Energy Cost and CO_2 emissions

A restriction of PFAS impacting gas turbine filter products would have several adverse effects. This includes the impact of lower performing (non-PTFE membrane) filters which would allow more particulates, water, salt and other contaminants into gas turbines. As indicated previously, this will reduce the efficiency of gas turbines. The impact will be that more gas will need to be consumed to produce the same amount of energy. As a result, energy costs and CO_2 emissions will increase in direct relation to the loss of efficiency.

b) Other Social and Economic Impacts

The SEA shows that not granting an adequate 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 and gas turbine filters collectively amounts to €1.2 billion per year. Gas turbine filters represents a fraction of this value, but the trends and impacts are similar.

Specific information requested in the stakeholder consultation is available in the full SEA which is attached as Annex I 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 gas turbine filters, therefore, it also contains information on other filtration categories which fall under different applications/sub-uses.

c) Other relevant information

In the following section, 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:

i) 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.

ii) Proportionality Assessment

The SEA attached as Annex I includes a proportionality assessment. Although the assessment applies to filtration applications broadly not just gas turbines, the assessment is indicative of the high costs of a restriction in comparison to potential benefits for related applications. **The assessment does not quantitatively include the direct costs associated with increased fuel use and CO_2 emissions discussed in Section V.a above so those costs specific to Gas Turbines are additional.** The proportionality assessment is summarized below.

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[4] 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[5] 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 reason behind this is that the implied willingness to pay (acceptability of costs) would be higher as the higher the perceived risk of a specific substance. If the Oosterhuis BMs are to be used for substances of low concern, it is reasonable to make some indicative, quantitative or qualitative, adjustments. For example, if the ‘grey zone’ for a PBT ranges from €1,100 – €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.

[4] €1,000 in original study, uplifted to 2022 prices
[5] €50,000 in original study, uplifted to 2022 prices

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 - SEA of restricting the use of PFAS in filters