**General comments and answers to specific information requests**

**Specific information requests:**

1. **Sectors and (sub-)uses**: Please specify the sectors and (sub-)uses to which your comment applies according to the sectors and (sub-)uses identified in the Annex XV restriction report (Table 9). If your comment applies to several sectors and (sub-)uses, please make sure to specify all of them.
2. **Emissions in the end-of-life phase**: The environmental impact assessment does not cover emissions resulting from the end-of-life phase. To get a better understanding of the extent of the resulting underestimation, (sub-)use-specific information is requested on emissions across the different stages of the lifecycle of products, i.e. the manufacture phase, the use phase and the end-of-life phase. Please provide justifications for the representativeness of the provided information. In particular:
3. Please provide, at the (sub-)use level, an indication of the share of emissions (as percentages) attributable to these three different stages. An indication of annual emission volumes in the end-of-life phase at sector or sub-sector level would also be appreciated.
4. If possible, please provide for each (sub-)use what share of the waste (as percentages) is treated through incineration, landfilling and recycling. Please provide information to justify the estimates as well as information on the form of recycling referred to.
5. **Emissions in the end-of-life phase**: With respect to waste management options, additional information is requested on the effectiveness of incineration under normal operational conditions (for different waste types, e.g. hazardous, municipal) with respect to the destruction of PFAS and the prevention of PFAS emissions.
6. **Impacts on the recycling industry**: To get an understanding of the impacts of the proposed restriction on the recycling industry, information is requested on:
7. The impacts that the concentration limits proposed in paragraph 2 of the proposed restriction entry text (see table starting on page 4 of the summary of the Annex XV restriction report) have on the technical and economic feasibility of recycling processes (together with a clear indication on the waste streams to which the described impacts relate).
8. The measures that recyclers would need to take to achieve the proposed concentration limits.
9. The costs associated with these measures.
10. **Proposed derogations – Tonnage and emissions**: Paragraphs 5 and 6 of the proposed restriction entry text (see table starting on page 4 of the summary of the Annex XV restriction report) include several proposed derogations. For these proposed derogations, information is requested on the tonnage of PFAS used per year and the resulting emissions to the environment for the relevant use. Please provide justifications for the representativeness of the provided information.
11. **Missing uses – Analysis of alternatives and socio-economic analysis**: Several PFAS uses have not been covered in detail in the Annex XV restriction report (see uses highlighted in blue and orange in Table A.1 of Annex A of the Annex XV restriction report). In addition, some relevant uses may not have been identified yet. For such uses, specific information is requested on alternatives and socio-economic impacts, covering the following elements:
12. The annual tonnage and emissions (at sub-sector level) and type of PFAS associated with the relevant use.
13. The key functionalities provided by PFAS for the relevant use.
14. The number of companies in the sector estimated to be affected by the restriction.
15. The availability, technical and economic feasibility, hazards and risks of alternatives for the relevant use, including information on the extent (in terms of market shares) to which alternative-based products are already offered on the EU market and whether any shortages in the supply of relevant alternatives are expected.
16. For cases in which **alternatives are not yet available**, information on the status of R&D processes for finding suitable alternatives, including the extent of R&D initiatives in terms of time and/or financial investments, the likelihood of successful completion, the time expected to be required for substitution (including any relevant certification or regulatory approvals) and the major challenges encountered with alternatives which were considered but subsequently disregarded.
17. For cases in which **substitution is technically and economically feasible** but more time is required to substitute:
    1. the type and magnitude of costs (at company level and, if available, at sector level) associated with substitution (e.g. costs for new equipment or changes in operating costs);
    2. the time required for completing the substitution process (including any relevant certification or regulatory approvals);
    3. information on possible differences in functionality and the consequences for downstream users and consumers (e.g. estimations of expected early replacement needs or expected additional energy consumption);
    4. information on the benefits for alternative providers.
18. For cases in which **substitution is not technically or economically feasible**, information on what the socio-economic impacts would be for companies, consumers, and other affected actors. If available, please provide the annual value of EU sales and profits of the relevant sector, and employment numbers for the sector.
19. **Potential derogations marked for reconsideration – Analysis of alternatives and socio-economic analysis**: Paragraphs 5 and 6 of the proposed restriction entry text (see table starting on page 4 of the summary of the Annex XV restriction report) include several potential derogations for reconsideration after the consultation (in [square brackets]). These are uses of PFAS where the evidence underlying the assessment of the substitution potential was weak. The substitution potential is determined on the basis of i) whether technically and economically feasible alternatives have already been identified or alternative-based products are available on the market at the assumed entry into force of the proposed restriction, ii) whether known alternatives can be implemented before the transition period ends (taking into account time requirements for substitution and certification or regulatory approval), and iii) whether known alternatives are available in sufficient quantities on the market at the assumed entry into force to allow affected companies to substitute.

A summary of the available evidence as well as the key aspects based on which a derogation is potentially warranted are presented in Table 8 in the Annex XV restriction report, with further details being provided in the respective sections in Annex E.

To strengthen the justifications for a derogation for these uses, additional specific information is requested on alternatives and socio-economic impacts covering the elements described in points a) to g) in question 6 above.

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

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

More information is needed on alternatives and socio-economic impacts to conclude on substitution potential, proportionality, and the need for specific time-limited derogations. Therefore, specific information (if not already included in the Annex XV restriction report or covered in the questions above) is requested on alternatives and socio-economic impacts covering the elements listed in points a) to g) in question 6 above.

1. **Degradation potential of specific PFAS sub-groups**: A few specific PFAS sub-groups are excluded from the scope of the restriction proposal because of a combination of key structural elements for which it can be expected that they will ultimately mineralize in the environment. RAC would appreciate to receive any further information that may be available regarding the potential degradation pathways, kinetics or produced metabolites in relevant environmental conditions and compartments for trifluoromethoxy, trifluoromethylamino- and difluoromethanedioxy-derivatives.
2. **Analytical methods**: Annex E of the Annex XV restriction report contains an assessment of the availability of analytical methods for PFAS. Analytical methods are rapidly evolving. Please provide any new or additional information on new developments in analytics not yet considered in the Annex XV restriction report.

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| **4262** | **Date:**  2023/05/23 16:00  **Content:**  Baseline  Information on alternatives  Other socio economic analysis (SEA) issues  Request for exemption  **Type:**  BehalfOfAnOrganisation  **Org. type:**  Company  **Org. name:**  Repack-S  **Org. country:**  France  **Attachment:**  <redacted> | **General Comments:**  Repack-S business is based on designing and manufacturing polymer and elastomer based sealing solutions. Repack-s is a down stream user of fluoropolymer compound billets (in PTFE, modify PTFE, PVDF, PCTFE, FEP and PFA) as well as billets and finished parts in FKM, FEPM and FFKM. |
| **Answer to specific info request 1:**  Sealing components for machines and associated equipments as used in food & beverage, pharma, biotech, mining, paint spray, renewable energy (hydropower), motorsport, oil & gas, denfense, aerospace, and many industrial applications. |
| **Answer to specific info request 2:**  By weight, Repack-s parts contrbute to the overall weight of the construction to a minor extent only. Manufacturing phase: as Repack-S is only machining the part at ambient temperature there are no emission generated. Use phase: If the part are used according to the supplier specification, no emission is generated. End of life phase: sealing components are embedded into metallic environment. They are following the thermal steel recycling way. This guaranties heat treatment higher than 800°C for more than 3s. As a consequence the fluoropolymer parts are completely mineralised with no generation of emission of toxic gas. |
| **Answer to specific info request 3:**  We are aware of scientific projects performed by KIT institute in Karlsruhe/ Germany. report is expected for june 2023. |
| **Answer to specific info request 4:**  As the fluoroplymer parts of Repack-s are following the steel recycling loop, the condition for steel recycling garanty the complete mineralisation of the fluoropolymers. No special measures have to be undertaken by the recycling industry. |
| **Answer to specific info request 5:**  Per year Repack-S is processing approximatly 4 tons of fluoropolymer products. The risk of emission generation is minimized by the mineralisation of the product after end of life. |
| **Answer to specific info request 6:**  a) annual tonnage 4 tons, emission are negligible, PTFE and FKM b) sealing function combined with low coefficient of friction, low COF garanties low energy consumption and low CO2 generation. c) 450 companies will be affected and rely on Repack-S products as a uniquely qualified sealing solutions. d) There are no alternative materials providing the same functions available. see more detail in the attached compative material report. e)there are 3 fundamental reasons why fluoropolymers are differents to alternative materail candidates. These 3 reasons are: - Carbon fluorin bond is the strongest bond in organic chemistry and cannot be subtituted by any other bond - the perfect shielding of the carbon backbone by fluorine atoms of the correct size makes chemical attacks to the carbon backbone impossible - the extremely high molecular weight of fluoropolymer minimise the concentration of chemically reactive endgroups. No reaction can happen at the end of the molecules. Conclusion: As the basics, why the fluoropolymers are special, will not change in the future, the wasting of time for developing alternative solutions, we propose to avoid. g) see attached document (Socio economic impact Q6g) |
| **Answer to specific info request 7:**  see comment on the lack of availabilty of alternative material fulfilling the same function. |

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| **4263** | **Date:**  2023/05/23 16:31  **Content:**  Scope or restriction option analysis  Information on alternatives  Other socio economic analysis (SEA) issues  Request for exemption  **Type:**  BehalfOfAnOrganisation  **Org. type:**  Industry or trade association  **Org. name:**  DWV - German Hydrogen Association  **Org. country:**  Germany | **General Comments:**  Green hydrogen production and use is a cornerstone for security of supply in a defossilised energy economy. Fuel cells, electrolysers and hydrogen compressors are indispensable for this. For the safe operation of these technologies, there are currently no substitute alternatives available for the material PFAS. Exemptions for the use of PFAS are therefore indispensable for achieving the climate targets. Otherwise, the entire green hydrogen economy will come to an abrupt end and a central pillar of the energy transition will be lost. The entire hydrogen industry is aware of its responsibility in dealing with PFAS and is already looking for alternative substances to substitute PFAS. In the short term, however, it is not guaranteed that products with the necessary technical requirements will be available. In concrete terms, this would mean that the production and use of hydrogen, e.g. in steel production, for eFuels, green ammonia, or in fuel cell vehicles and many other green transformation fields would no longer be possible in Europe. This must be prevented through legislation with a sense of proportion. In joint dialogue with politics and science, the industry is willing to define and agree on binding processes for recycling and sector-specific circular economy. The industry wants to and will face these challenges and contribute with its products to both climate and environmental protection and accordingly find a responsible way of dealing with PFAS. According to the definition of the European Chemicals Agency (ECHA), there are more than 10,000 types of PFAS with different properties. The draft ban does not differentiate here and also includes fluoropolymers in the ban, which are considered "polymers of low concern" (PLC). DWV and its members aim at a complete substitution of PFAS by alternative substances in the long run and will introduce these new materials to the market as substitutes for PFAS after successful tests. In the transition phase, however, an investment-safe and economically viable solution for the continued use of PFAS in hydrogen technologies must be made possible by regulation.  Current status of alternatives: Currently, there are no technologically mature alternatives for these critical components, as only PFSA ionomers have reached technological maturity for these functions in the harsh environment of fuel cells or electrolysers (e.g. proton exchange membranes). Alternative materials based on non-fluorinated hydrocarbon polymers are at an early stage of development and are not yet eligible for commercial use because various technical parameters, such as performance, lifetime and industrial scaling, do not meet the high requirements.  Requirements PFAS are still indispensable in many applications of our modern world, such as energy and hydrogen applications, and thus belong to the category of "essential uses". Many applications, especially electrolysers, fuel cells and lithium-ion batteries, have high hopes of contributing to a more sustainable, green energy supply. For the components necessary for the construction of these technologies, exemptions must therefore be made in accordance with the Montreal Protocol until corresponding efficient, affordable, environmentally friendly alternatives are available. In order to avoid or reduce the discharge of pollutants into the environment and in particular into bodies of water, a risk assessment of possible discharge pathways that may arise in the course of the production or use of the aforementioned technologies should be carried out in a timely manner. Based on this, a risk classification of the various PFAS compounds must be carried out in order to be able to prioritise the development of alternatives. In addition, processes for recycling should also be considered. A direct dialogue with the relevant associations of the German water industry is recommended. In addition, research must be significantly intensified, especially in the area of alternative materials for PFSA ionomers, as well as materials research on necessary components for fuel cells and electrolysers.  DWV welcomes ECHA's consultation process and sees it as an opportunity for legislators and industry to jointly implement solutions in the interest of climate and environmental protection. The hydrogen industry is aware of its responsibility here and proposes the following adjustments for the PFAS ban and further legislation: - Include hydrogen applications in the area of "essential use" and therefore list them as an exemption category. - Continue research efforts to find non-fluoropolymer alternatives that offer their application benefits (i.e. taking into account quality, durability, efficiency and cost aspects) and support with appropriate resources for R&D. - Delimitation: Regulation should also distinguish in which production / use steps potential risks arise and how they should be dealt with: o Production: the manufacturing process of polymers is the most critical stage, as individual components and solvents are in liquid form. The process of manufacturing ionomers is a complex process that requires safe and responsible manufacturing. Here, the legislator should prescribe a uniform Europe-wide guideline on the topic of responsible manufacturing and emission control/reduction and then also regulate/incentivise this accordingly. o Use / processing: In the processed / bonded form, there is no risk from this material. o Recycling: At the end of the life cycle, recycling (maximising the recovery rate and minimising incineration) should become an obligation and all market participants should participate in this common goal. These recycling processes for fuel cells, electrolysers as well as other PFAS products should fully control the PFAS risk at the end of life and recover the fluoropolymer contained. The precious metal content of PEM fuel cells and electrolyzers and the associated economic aspect are an incentive to promote new creative recycling processes. On the one hand, it should be ensured that recycling takes place under European or comparable environmental standards. - Introduce evaluation cycles for hydrogen applications: This should be done in regular cycles (10 or 15 years) to check the extent to which alternative substances have been developed to substitute PFAS and what their industrial scalability is. The goal of phasing out PFASs in the medium to long term is supported by the hydrogen industry. - Take-back obligations for PFAS: In the case of a classification as "essential uses", a take-back obligation for products containing PFAS would be the logical consequence in order to oblige the industry here. This would involve a monetary incentive system for the return of PFAS. |
| **Answer to specific info request 1:**  Energy Sector |
| **Answer to specific info request 2:**  During the manufacturing of fluoropolymers, PFAS emissions are strictly controlled at production sites. Manufacturing companies must already comply with rigorous environmental standards. It is important to note that, as it is implied in the general comments of this section, and identified in the restriction proposal, the volumes of fluoropolymers used in the hydrogen sector is dwarfed by PFAS substances used in other sectors, where the use of these substances may not be essential. During the use of fluoropolymer-containing components in electrolyser and fuel cell applications, there are negligible PFAS emissions in the water or in surrounding equipment. Nevertheless, a number of companies are currently undertaking a data gathering exercise that will provide robust, sufficient data supporting the claim that the amount of PFAS emissions in the water or in the surrounding equipment is negligible. We aim at providing findings in a second submission to this ECHA public consultation in September, before the ECHA deadline. End of life incineration, including exhaust gas treatment in a safe and controlled way is the current standard operation for fluoropolymer membranes used in all types of electrolysers and fuel cells. All exhaust gases are treated at the highest standards and in line with EU and local legislation, and there is no indication that PFAS remains after incineration under the conditions used. Still, there is no EU-level legislation on PFAS emissions regarding incineration. A mutual standard on this is a prerequisite for future legislation. Industrial actors had already initiated alignment to work out a proposal on this topic; this should be a regulatory priority, as opposed to a complete ban on the materials. Taking fuel cells in mobility applications as an example, at end-of-life stage, vehicles containing fuel cells are dismantled, and the modules are removed, after which the stack itself is dismantled to collect the cells. The cells are then -as described above- incinerated to recycle the platinum group metals (PGMs), while the ionomers are fully destroyed with hydrogen fluoride (HF) emissions. The resulting fluor-containing emissions are then captured and treated, whilst the results are also measured against rigorous environmental standards. However, to date there is no specific data collection available on PFAS emissions – hence need for a monitoring, reporting and verification (MRV) system. It should be made clear that the way forward is for recycling to progressively replace abovementioned incineration practices. Also, due to overwhelming economic imperative, it is obvious that PEM fuel cells will be recycled when significant volumes at end of life are reached. In fact, it is possible that close to 100% of platinum recyclability can be reached. Since the applications would be relatively undiversified, take-back systems are highly realistic to enable this recycling. Certain Members of have already started to systematically take back end-of-life products and some argue that in just 5 years there will be no landfilling of PFAS containing components from fuel cells and electrolysers. Besides incineration, there are research tracks underway aimed at enabling regaining the ionomers. While it is possible to separate the precious metals from the membrane, right now the ionomer is altered so far that it cannot be used again in another fuel cell. Currently there are no known processes to “repair” the material back to sufficiently high grade, which would be necessary for fuel cell applications. Additionally, the risk of ionomer diversity in the different PEM fuel cell products raises the issue of having to develop slight variations of recycling technologies. A value chain for recycled end of life materials from high-demanding applications to raw materials for lower-demanding applications needs to be established. The tabled restriction would prevent this, as it would limit the already low volumes. Therefore, a robust recycling process requires both development time and sufficient volume of end-of-life components and applications where the regained materials can be used in. PEM electrolysers and PEM fuel cells rest on the same scientific basis and are developed as similar technologies. Although they are different products, this was not acknowledged in the restriction proposal. Moreover, synergies could be developed, whereby the recycled ionomer materials from fuel cells might be utilised in water electrolyser technologies. However, these processes would have to be developed, which requires legal certainty for the industry to carry out continued use and development with fluoropolymer components. Unfortunately, the recycling of both PGMs and fluoropolymers for both fuel cells and electrolyser systems could be jeopardised by the PFAS restriction proposal, as there would be no more end-market. As a nascent market, fuel cell vehicles have not yet reached the necessary volume at end of life. This is the main reason for the lack of development of a recycling ecosystem. It should be noted that by 2030, even assuming a 10% waste along the value chain, the accumulated volumes would already be significant even with a small number of devices having reached end of life. Nevertheless, investment has been committed to research on the topic, for example the HyTechCycling project. The US Dept. of Energy is planning to invest $50M into recycling research for PEM fuel cell and electrolysis between 2023-2027, with additional funding planned for projects scaling up ionomer recapturing. In addition, the Dept. of Energy collaborated with industrial partners, the American Institute of Chemical engineers, universities and national laboratories to develop technology relevant to circularity, recycling in the hydrogen economy, and to address end of life and critical supply chain challenges. The Clean Hydrogen Partnership also financed cooperation on developing projects tacking the recycling of end-of-life hydrogen technologies. For instance, the BEST4Hy project (2021-2023) with a €1.5 million is aiming to demonstrate high recovery yield of ionomers (80%), and the re-manufacturing of new cells/stacks with at least 70% of ionomer and 95% of platinum in PEM stacks. It could apply life-cycle assessment (LCA) and life-cycle costing (LCC) methodologies to the whole life cycle of electrolysis and fuel cell technologies, which could bring fact-based information on potential environmental impact of these technologies’ end-of-life. Additional efforts by close cooperation of research institutes and industry are invested in the currently running BReCycle project, with a total funding of €1.2 million Further, sealing elements out of reciprocating compressors for Hydrogen applications of PTFE are produced from semi-finished bushings. Bushings are optimized in diameter and height to minimize waste and safe costs as good as possible. Nevertheless, approximately 70 % of the used material is PTFE (because of filler components like graphite, glass fibres and others). Approximately 30 % of the machined bushings are waste during the machining process at the production of the sealing elements. This waste can be recycled, and such a recycling process has already been established in this industrial sector. |
| **Answer to specific info request 3:**  Today, there is an overwhelming economic imperative to recover PEM stacks (both fuel cells and electrolysers) at the end of the life cycle in order to reclaim and recycle the expensive PGM (Platinum Group Metals) catalysts contained within the membrane/electrode assemblies, as well as the fluorine. Recycling processes enable the recovery of the fluorine contained in the ionomer, for instance in the form of calcium fluoride, made of fluorspar, or fluorite (which is on the EU’s 2020 critical raw materials list). Calcium fluoride can then be used as a raw material input for further production of fluorine-containing material. Therefore, it is financially discouraged that associated fluoropolymer components will enter the general waste stream. Furthermore, there is strong promise that the fluoropolymer ionomers can be recovered and reused in the polymer form at the end of its lifecycle as demonstrated in the UK Research and Innovation (UKRI) project Frankenstack and by Carmo et al. 2019 in PEM catalyst separation, recovery and recycling. In addition, several patents exist entailing methods for recovering and recycling catalyst coated membranes (CCMs) through dissolving the membranes and separating the components. Recent peer-reviewed studies carried out by Aleksandrov (2019) on the disposal of end-of-life PTFE have shown incineration to be an appropriate way to dispose of the fluoropolymer too, with no environmental concern. The said study found that the combustion of PTFE under typical waste incineration conditions (municipal level) and using Best Available Techniques (BAT) does not degrade into the identified PFAS of environmental concern. It also showed that in standard municipal waste incineration conditions, PTFE is essentially transformed to carbon dioxide and hydrofluoric acid. They thus concluded that the municipal incineration of PTFE should therefore be considered an acceptable form of waste treatment. It should be noted, additionally, that the Dutch Institute for Public Health and Environment (RIVM) drew slightly fewer concrete conclusions, mentioning that, although it can be assumed that the polymer molecules are destroyed with the gasification process, this does not provide enough information on the kind and degree of by-products formed and on the rate of mineralisation. Additional research would therefore be needed on the topic to fill in those gaps. Regarding the sealing devices in the hydrogen ecosystem, including in reciprocated compressor systems, it can be concluded that with an established PTFE recycling process, the incineration of PTFE-based products will not be needed. It is therefore visible that in the wider hydrogen industry recycling is the preferred way forward, not only based on sustainability but also on efficiency and on economic considerations. |
| **Answer to specific info request 4:**  Recycling of PTFE-based sealing materials for Hydrogen compressor systems is already established. If materials are collected grade by grade, the recycling process can be enlarged to cover nearly 100 % of all waste inhouse. Professional grinding companies are already on the market that allow the recycling of these perfluorinated polymers. A Process Technology is providing efficient grinding equipment for the recycling process and Dressler Group is providing grinding service for their customers. Basically, the recycling of perfluorinated polymers is split into 4 steps: 1) Collecting grade-specific waste 2) Grinding process with milling particles down to about 20 – 30 microns 3) Mixing grinded material with new material (Normal powder mixing process) 4) Producing new semi-finished products from new mixture including recycling material Recycling costs are roughly 10€ per kilogram which is nearly equal to the costs of the new material. This means, that it is feasible from a financial point of view . |
| **Answer to specific info request 5:**  Before all, it should be noted that it is extremely difficult to calculate the amount of fluoropolymer needed by the hydrogen sector. Therefore, it needs to be mentioned that the below are estimations only for PEM fuel cell and water electrolysis and that those are only based on the current state of the technology, and do not account for possible efficiency improvements. This innovation could be substantial and should not be ignored, particularly if membrane development history gives an accurate indication of potential future performance. To illustrate, the PEM industry has been developing for over 20 years and in that time has reduced the thickness of membranes dramatically. Starting with Nafion® 117 from Chemours, considered an industry standard at 175 µm thick, this was replaced with Nafion® 115 at 125 µm thick. Developments are still underway to reduce membrane thickness even further. Proton exchange membranes’ thickness for fuel cells used in automotive applications is typically under 20 µm, whereas thickness is usually around 100 µm for water electrolyser membranes. In total, a 60-kW PEM fuel cell stack with a total weight of 28.5 kg contains the following amounts of fluorinated components: • 2.5 kg sealing material (typically, ETFE, PTFE, FEPM and FFKM; seal-on-MEA assumed) • 0.2 kg ionomer carrying sulfonic acid groups (in the ionomer membrane, reinforced with PTFE) • 0.15 kg PTFE in the gas diffusion layer (GDL; protection around the ionomer membrane) The weights presented above per component clearly show that the largest volumes of fluorinated material are in the sealants, whereas the amounts in catalyst-coated membrane (CCM) and GDL are much lower. Switching to a different sealing concept, i.e., using a metal-bead seal with an elastomer layer will reduce the amount of elastomer significantly compared to an injection-moulded volume seal. Using the same data, without consideration for possible ameliorations and assuming the CCM and GDL will still contain fluorinated compounds by then, this distribution would imply a PTFE need of 44.25 tonnes, and an ionomer (e.g., Nafion) need of 3.25 tonnes to reach an indicative 1 GW of fuel cell capacity. Based on a prospective demand of 100,000 fuel cell trucks and 1,000,000 fuel cell light vehicles on the roads by 2030, the total of required ionomer would amount to around 500 tonnes. Yet, there is no clear estimate today on the future fuel cell capacity needs for 2030, aggregating the various applications (all transport modes, stationary applications...). Besides, it is obviously extremely unlikely for the fuel cell capacity to be reached by one unique technology, in that case, PEM. The estimation therefore represents an upper bound of fluorinated compound need. In May 2022, the European Commission introduced its REPowerEU Plan, which revised upwards the hydrogen targets of the 2020 EU Hydrogen Strategy . According to the new figures, the EU will need to secure 10 million tonnes of imported renewable hydrogen and would have to ensure the production of another 10 million tonnes of renewable hydrogen by 2030. It is important to note that the calculations made in the Restriction proposal were based on old and outdated targets (i.e. 40 GW electrolyser capacity until 2030, based on the EU’s Hydrogen Strategy). If the EU were to reach its new REPowerEU objective for the production of 10 million tonnes of renewable hydrogen (i.e., ca. 140 GW of electrolyser capacity in terms of electricity input) only with PEM technology (which requires the ionomers ), we would need a maximum of 1750 tonnes of ionomers , using the following assumptions: Operating voltage of 2 V, current density of 2 A/cm², 50% of membrane is within the active area, 127 µm membrane is used, basis weight is 0.25 kg / m². In the case of Nafion, nearly all material makes it into the end-product (<10% would be lost in manufacturing). The progress made in reducing membrane thickness, highlighted above, clearly shows potential to reduce this estimated tonnage. Just like for fuel cells, it is extremely unlikely for the electrolysis capacity to be reached by one unique technology, in that case, PEM. The estimation therefore represents an upper bound for the accumulative fluoropolymer use in water electrolysers through 2030, and the actual use is likely to be much lower, also because of the gradual improvements in the technology. It is very difficult to make predictions past 2030 because cell construction, mode of operation, and market size are either unknown or difficult to predict. Hydrogen Europe collects operational water electrolysis deployments. Based on data as of August 2022, there are 106 water electrolysers that are operational today, for which Hydrogen Europe knows the electrolyser technology. This corresponds to 142.2 MW of capacity. PEM represents 83.5 MW from 55 deployments and ALK represents 57.7 MW from 42 deployments. The remaining difference is filled with operational solid oxide, anion exchange membrane (AEM), or other technologies. In addition to the volumes in electrolyser and fuel cell applications, number of fluoropolymer uses in the hydrogen industry is substantial due to their unique characteristics. As it has been evaluated above, a variety of fluoropolymers are being used as valves, sealing devices and other membranes in all stations in the value chain, from production through infrastructure applications to hydrogen-specific end-uses. To give an idea on the volumes, one Hydrogen Europe Member is processing approximately 20 tons of PTFE-based sealing materials per year into wear parts for reciprocating compressors. The PTFE content is on average 70 % which gives a total use of PTFE in the manufacturing of about 14 tons. 30 % are collected in-house as waste from machining (~ 4.2 tons). This material can be recycled as described above. The remaining 9.8 tons are used as sealing elements in reciprocating compressors. Thereby roughly 20 % (~ 2 tons) are wear debris entering the industrial processes. The remaining 8 tons are currently reaching end of life in incineration or landfilling, but they could also be recycled after grade-specific collection and purification, as described in Q4. Thus, the whole process of using 20 tons of sealing materials could be reduced to 2 tons of PFAS ending up as waste in industrial processes. Please note that this is the volume of one company in the sector, the cumulative volume of fluoropolymer in sealing devices is difficult to predict. However, based on the same benchmark of 140 GW electrolysis capacity in terms of electricity input (which would amount to around 100 GW in terms of hydrogen output), we can predict that other fluoropolymer use for the sealing materials (especially PTFE) would roughly amount to 8,750 tonnes at manufacturing, resulting in about 4,375 tonnes in the end-product. |
| **Answer to specific info request 8:**  Additional input on alternatives in PEM electrolysers, other electrolysers and PEM and other fuel cells: • Membrane o Fluorine-free ionomers and membrane materials have been around in science for decades. Research work has been ongoing for hydrocarbon membrane and sulphonated polyetheretherketone (PEEK) membrane development, for instance o Usually, properties and performance of these materials can be reasonably good whereas the durability is often poor, as oxidation by oxygen radicals, which are inevitably generated at the cathode electrode, occurs. The non-fluorinated membrane concepts are mainly at laboratory or pilot scale, unproven on industrial scales and, are still highly immature, lasting only dozens of hours against lifetime requirements of >25,000 hours for fuel cell applications. In PEM electrolysis, membrane support, aromatic chemistries (e.g. sPEEK) have too low durability. Suitable chemistry would need to be found to accommodate for this major barrier. If, and only if, suitable chemistry (with overall reduction of risk through lifecycle) were to be found one day, deployment cycles are in 10-year timeframes, with a minimum of 5-year demonstration period with reasonable scale, i.e. adding another 15 years on top of the time required to find the substance. Although certain indicators of performance of non-PFSA membranes can be excellent, these non-PFSA membranes (such as hydrocarbon) in electrolyser applications have failed to demonstrate a pathway to commercial lifetimes (>50,000h for electrolyser applications) or at relevant temperature (>79°C). In fact, to consider the alternatives to be truly commercially viable regarding PEM electrolysers, durability of well beyond 50,000h should be hit, as you can see a Nafion membrane lasting beyond 100,000 hours. However, so far very few non-perfluorinated alternatives have come close to even 1000, and none to 10,000 hours. Hydrocarbon membranes have an issue with certain chemicals that are formed regular operation, like hydroxy radicals (.OH) and hydroperoxy (.OOH) radicals that are generated by HOOH breaking down, which is itself a by-product of any fuel cell or electrolysis process. This radical can easily break down C-H bonds, as well as aromatic and ether linkages. In the 1990s there was great interest in substituting Nafion and other fluoropolymer-based membranes, since those were more expensive and released HF, which can attack the steel bipolar plates. Still, all of these programmes failed to produce viable alternatives. In the 2010s, there was another surge of hydrocarbon membrane interest, as companies have tried non- and partially fluorinated chemistries. From 2013 onwards $30 million has been spent by the United States’ Dept. of Energy on membrane/ionomer R&D, including two thirds on non-PFSA approaches. None of these led to commercial polymers for fuel cells or electrolysers. o In PEM fuel cell Membrane Electrode Assemblies, there are currently durability challenges with aromatic hydrocarbons. The European Clean Hydrogen Alliance project GAIA (2019-2022) supported by €4.5 million of Horizon2020 funding set out to find hydrocarbon alternatives to PFSA ionomer membranes, however found that similar performance is not possible. IMMORTAL another project with €3.8 million Horizon2020 funding and ELECTROHYPEM a project with EU funding of €1.3 million concluded that alternative membrane technologies known to date are simply too far behind in terms of durability. There are currently no commercially viable hydrocarbon membranes that simultaneously meet the chemical and mechanical durability requirements necessary. In PEM fuel cell applications, as membrane support, PTFE has the necessary mechanical durability, dimensional stability upon water uptake, and chemical inertness under radical attack. There are no alternatives, as PPP (polyphenylene) is thermally and chemically not stable, while being not processable at elevated temperatures (>100 °C). One Member of Hydrogen Europe argues that in-house tests for hydrocarbon materials for ionomers and reinforcement were taken for 15 years, concluding that there are significant gaps, e.g. unfit-for-use trade-offs between performance and durability in chemical and mechanical aspects. It would be challenging to identify PFAS alternative porous films as replacement for ePTFE (expanded PTFE) reinforcement for PEM fuel cell applications in short-and medium term. Current experience shows that effective additive technologies, including state-of-the-art mobile and immobile additives are not sufficient in enhancing the chemical stability of hydrocarbon membrane ionomers. o In PEM electrolysis membranes, hydrocarbon ionomers are technically not feasible, as they are too stiff, with often no sufficient mechanical durability. Critically relevant characteristics of PFSA polymers, such as proton conductivity, oxidation stability under high anode potentials during regular PEM electrolyser operation, and processability (lower glass transition temperature compared to hydrocarbon ionomers) are not hit by hydrocarbon alternatives. One Member of Hydrogen Europe did tests with hydrocarbon membranes in their PEM electrolysers. o Also in PEM fuel cell applications, hydrocarbon alternatives are poor in situational performance, particularly under reduced RH (relative humidity) of <50% and thus operationally relevant conditions: we experience a strong dependence of electrochemical performance on material hydration, and greater material swelling and dimensional instability. In the catalyst layer, PFSA ionomers are used as they have the unique characteristic of being able to provide both ion conductivity and hydrophobic properties to the electrode catalyst layer. The hydrophobicity is a function of the fluorinated PFSA backbone and is therefore very difficult to replace, as hydrocarbon polymers are inherently not as hydrophobic as fluorocarbons. There are additional issues with implementation in a manufacturing setting, as the new materials’ mechanical properties in a membrane electrode assembly cause poor adhesion between the catalyst layer and membrane. Solutions to this problem are unclear and unproven. The timescale to resolve these performance and manufacturing issues would go far beyond the time provided by any of the time-limited derogations. Research activities to replace the conventional perfluorinated ionomers by fluorine-free materials have been ongoing for the last 25 years but so far, no commercial product has indeed been released due to poor oxidation stability. Fuel cell and electrolyser manufacturers are in close contact with the manufacturers of the components to test the materials at relatively early stage and thus identify and qualify promising materials, promote their industrialisation and replace the current perfluorinated compounds, as early as possible. However, building from past experience, it is impossible to know for sure when a validated alternative material may be available in volume. o As for the reinforcement material, promising approaches are currently made to replace the PTFE by fluorine-free compounds like electrospun PBI-type (polybenzimidazole) materials. These electrospun polybenzimidazole-type materials show promise as a fluorine free mechanical support. However, the technology is not validated in PEM fuel cell systems. Considering the time needed to develop an ePTFE- based solution (regarding both performance and manufacturing) that meets present and future requirements, it is estimated that the implementation of this new approach could take min 15-20 years to implement at scale – provided continued success. In addition to electrospun aromatic engineering polymers (PBI, PES), woven monofilament polymers (PEEK, PES, etc) have been experimented with. For example, the European Clean Hydrogen Alliance supported IMMORTAL project focused on fluorine-free polymer nanofiber reinforcements, showing promise but necessitating considerable further steps, as these are not drop-in solutions. Electrospun nanofibers, as a class, have poor mechanical strength and today are not able to provide the support needed for PEM electrolysers operated under differential pressure. Woven monofilament supports are limited to thicknesses of approximately 60 microns or more and may not be suitable for thinner membranes required to meet performance targets. Regarding the performance of hydrocarbon alternatives to PTFE reinforcements, a chemically stable and mechanically strong porous film is critical as a reinforcement in PEM to achieve the required durability. It is visible that using state-of-the-art hydrocarbon instead of ePTFE as reinforcement, the composite PEM exhibited poor mechanical stability as well as poor power output. The hydrocarbon reinforcement is significantly worse than 2nd generation ePTFE. In addition, as can be seen on, severe mechanical strength decay was observed for PEM using hydrocarbon reinforcement after exposing the PEM to chemical degradation tests. o It is necessary to mention that beyond PEM electrolysis technologies, the existence of alkaline electrolysis (ALK) technologies would also be jeopardised by the universal PFAS restriction. This is because as a best available technique, the electrolyte necessary for the functioning of the ALK electrolysis – Potassium Hydroxide (KOH) – is manufactured using electrolysis utilising fluoropolymer-based membrane cell technology (eg AGC’s Flemion or equivalents). Potassium salt in the form of brine is electrolysed to produce KOH, Chlorine and Hydrogen. An alternative to this manufacturing process is the method used before, whereby mercury cells are used or asbestos. However, returning to this – on top of being illegal – would be ill advised both for performance and for environmental reasons. No other alternative is known today. o Beyond PEM and ALK technologies, Solid Oxide Electrolyte Cell (SOEC) and Anion Exchange Membrane (AEM) electrolysis technologies are necessary to be mentioned. Although SOEC applications do not include fluoropolymers in electrolyser stacks, nevertheless on the module and system level they rely on components with fluoropolymer valves and sealing devices, similarly to other types (like PEM e.g.)The AEM technology’s market is nascent; therefore, many different membrane structures are present, some of which include fluorinated components. • Electrodes o Electrodes or catalyst layers using non-fluorinated, hydrocarbon-based ionomers as binder polymer pose another challenge in research and development due to requirements of high gas permeability in the electrode, as mentioned earlier. These drawbacks are also confirmed by recent academic efforts on fluorine-free Membrane Electrode Assemblies (MEAs). Therefore, in PEM electrolyser applications no know alternative exist; reports on hydrocarbon ionomers as binder in electrolysis electrodes are scarcer than in PEM fuel cell applications, and research on the effects of hydrocarbon ionomers on the electrochemically active surface area (ECSA) and catalytic activity is still missing compared with PFSAs. System design changes will be required, and these specifications are not clear currently. Additionally, there are no protocols for accelerated durability testing for PEM electrolyser membrane – both regarding PFSA and hydrocarbon. The timeframe for development of a hydrocarbon-based solution would be well beyond a decade and there is no guarantee that it will ever work. o Regarding PEM fuel cell applications, there is no sufficient performance in at dry operation, hydrocarbon membranes meet PFSA benchmarks only at high humidity; conductivity values at high humidity (<40% RH) are still far from the target for proton conductivity for automotive application (0.1 S cm-1). In the PEM fuel cell catalyst layer, PFSA polymers have no known alternatives, hydrocarbon-based ionomers have an issue with gas permeability, which gets even more critical at lower humidity. At dry conditions (<30% RH) the main issue is the absence of water, which leads to low proton conductivity of not only the membrane but also of the electrode that results in a lower catalyst utilisation. Although the development of highly oxygen permeable hydrocarbon ionomers for the catalyst layers could in theory enable improvement of the performance of fully hydrocarbon MEAs, especially for PEM fuel cell, the development of tailored ionomers had not even started as of 2022. As another consideration, in PEM fuel cell membrane electrode assemblies, PEEK materials have been found to have poor chemical durability, leading to early mechanical failure. In general, the presence of a hetero-atom leads to such issues. • Gas Diffusion Layer (GDL) o Hydrophobisation of the GDL is today always achieved using PTFE. Currently, the PTFE impregnation of the GDL cannot easily be replaced and some effort will have to be made to find alternative hydrophobising agents that are as durable as PTFE. It would surely be desirable to set up funding for projects with the aim to find replacement for the PTFE in the GDL, a topic that has been addressed only sporadically in the past, with no success. The European Clean Hydrogen Alliance projects GAIA (2019-2022) and DOLPHIN both set out to identify alternatives to fluoropolymer components, including in the GDL, however they found no alternatives. • Sealing devices o Some provided input was considered under ‘gaskets and seals’ potential replacement line on ‘PEM fuel cells’. However, data on gaskets and seals a few lines below for ‘PEM electrolysers / fuel cells’ related again to gaskets and sealings should be merged with the above, as the issue is the same for PEM electrolysers and fuel cells and should be treated as a whole (and not systematically exclude electrolyser). On top of already provided input, Hydrogen Europe would like to remind the following: in Alkaline, in SOEC and in PEM electrolysis technologies, PVDF, PFA, FKM, PTFE are used as sealings, inliners, diaphragms, in ball-diaphragms, seat and butterfly valves for their durability and consistent performance in extreme circumstances. Given the presence of liquids and chemicals, it is imperative that proper sealing exists between the stacks of the electrolysers. In this regard ePTFE tapes are used between the stacks to provide superior sealing. Expanded PTFE not only has a compressibility of up to 60% - allowing it to make a very robust seal even at low torques – but is also weatherable, resistant to chemicals, and highly effective even in extreme pressures. The exact dimensions of the ePTFE tape can vary from project to project, depending on the construction of the electrolyser. However, a thickness of 1.5-2.5mm is typically used with a width of 25-50mm. The tape is easily applied and can even be layered on to itself, eliminating the use of a standard cut gasket. This is relevant because the diameters of the electrolysers can be as high as 2 meters, meaning that a standard cut gasket would be very wasteful. Considering that a 5 MW alkaline electrolyser requires around 500 seals, this saving is particularly vital. o In addition, in solid storage technologies, alternatives for fluoropolymer-based valves are required to have low friction, large temperature range, and hydrogen material compatibility. In gas grids, liquid H2 storage or H2 shipping uses, fluoropolymer valves are used for their cryogenic capability, therefore alternatives without fluoropolymers must have hydrogen compatibility and low load sealing (<2N/mm in circumference) with the ability to sustain up to 1 000 bars. Today, there are no alternatives to provide sufficient durability, chemical resistance and the necessary flexibility as fluoropolymer sealings or diaphragms. Based on failed past efforts in research for alternatives, we predict that those will surely be standard for another 10 years at least. Efforts are made to gradually eliminate the fluoropolymers from the sealing materials as soon as possible. Some elastomers without fluorine exist and could potentially be used in the future for this function. As for gas-permeability and cost, these fluorine-free materials are superior to fluorinated elastomers thus also from technical and economical point of view, replacement of these materials is desirable when possible. However, those are not stable in pressurised deionised water, leading to contamination of the MEA, which would lead to irreversible loss of performance. Moreover, those are not as chemically stable, and therefore not sufficiently durable. o Regarding sealing devices for reciprocating hydrogen compressors, there are no available alternatives, proven by available literature and R&D testing. Concisely, the material properties of perfluorinated polymers are unique and impossible to replace in the near future. Restrictions on fluoropolymers, including PTFE and ionomers with bound PFSA, would make several critical applications from water electrolysis, fuel cells, to hydrogen transport technologies unfeasible or would dramatically reduce their service life, efficiency and increase the probability of malfunction (this goes thus far beyond PEM fuel cell only). Such lowering of the performance of essential applications in the hydrogen industry would drastically slow down the ramp up of this nascent industry, potentially killing such a crucial industry for decarbonisation and jeopardising both our climate objectives and industrial competitiveness. All polymeric alternatives’ performance, such as that of hydrocarbon membranes, is still very low because they suffer from reduced thermal and chemical stability, reduced efficiency (e.g., higher ionic resistance) and/or inapplicable mechanical properties and have high deterioration rates and short life expectancies. Earlier R&D, as described above has shown that there is no business case for building electrolysers based on hydrocarbon membranes. |
| **Answer to specific info request 10:**  As mentioned in our response to question 2(b), there is currently no legislation and harmonised monitoring system for PFAS lifecycle emissions. It is essential to develop a mutual standard or benchmarking system that industrial actors can use, and which can be the basis for targeted legislation on emissions. A binding monitoring, reporting and verification (MRV) system, ideally harmonised across industry and Member States, should be established and implemented across all life stages of fluorinated materials of our sectors. Where detected, PFAS emissions should be abated. For end of life, this includes the implementation of binding take-back systems regarding fluoropolymer-containing components and products of our sectors, where the circularity potential offers great opportunities. Industrial actors already initiated work on a proposal on this topic. In a nutshell, addressing emissions (monitoring and abating) on the basis of common standards should be a regulatory priority, as opposed to a complete ban on the materials. Industry-wide emission monitoring and calculation methodologies can be a far more effective tool in dealing with such substances than a blanket restriction, while not impairing the development of entire industries that are fundamental to the economy’s decarbonisation. With the proper legislative framework in place to address fluoropolymers’ lifecycle emissions, the European Chemicals Agency should propose an exemption for fluoropolymer production and use under the PFAS restriction. |

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| **4264** | **Date:**  2023/05/23 16:50  **Content:**  Scope or restriction option analysis  Hazard or exposure  Environmental emissions  Baseline  Information on alternatives  Information on benefits  Request for exemption  **Type:**  BehalfOfAnOrganisation  **Org. type:**  Company  **Org. name:**  <redacted>  **Org. country:**  Italy  **Company name confidential:**  Yes  **Attachment:** | **General Comments:**  The main goal of our contribution is related to bring information supporting an exemption request of the FLUOROPOLYMERS substances category of PFASs, due to their unique characteristics and their importance for the entire society. Our contribution to each specific topic will be given in the SECTION IV\_Non-confidential attachment. |
| **Answer to specific info request 1:**  - Manufacture (Annex E.2.1.): Sector as a whole - Food contact materials and packaging (Annex E.2.3.): Industrial food and feed production; Plastic packaging; Other packaging applications - Medical devices (Annex E.2.9.): Diagnostic laboratory testing; Packaging of medical devices - Electronics and semiconductor (Annex E.2.11.): Electronics; Semiconductors - Energy sector (Annex E.2.12.): Sector as a whole - Construction products (Annex E.2.13.): Bridge and building bearings; PTFE thread sealing tape - Petroleum and mining (Annex E.2.15.): Fluoropolymer applications |
| **Answer to specific info request 3:**  Information in SECTION IV. Non-confidential attachment |

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| **4265** | **Date:**  2023/05/23 17:32  **Content:**  Environmental emissions  Information on alternatives  Information on benefits  Other socio economic analysis (SEA) issues  Transitional period  Request for exemption  **Type:**  BehalfOfAnOrganisation  **Org. type:**  Company  **Org. name:**  <redacted>  **Org. country:**  Germany  **Company name confidential:**  Yes  **Attachment:**  <redacted>  **Privacy statement:**  The confidential comments include business critical information. | **General Comments:**  Our company manufactures air filtration solutions, covering a broad scope of air filtration technologies including PTFE media filters. In this contribution, we provide information supporting a derogation request for the use of PTFE media filters in air filtration. The PTFE media filter use sectors to which our comment applies are the following: • Sector: TULAC o Use: Technical textiles（5e） • Sector: Food contact materials and packaging o Use: Industrial food and feed production（6a） • Sector: Electronics and Semiconductors o Use: Semiconductors（5ee） • Sector: Pharmaceutical Industry, Healthcare, Biological Safety Labs (not included in the restriction dossier) o Use: Clean environments (isolators, workbenches, RABS, cleanroom ceilings)  Please note that there are also filters for liquid filtration, but these are not in our scope of applications. This contribution is complemented by the report and scientific literature submitted as confidential attachments. As regards PTFE media filters’ unique and most crucial features for air filtration, we would like to underline the following: Low boron, Low outgassing and chemical resistance PTFE media filters ensure low boron, low outgassing, chemical resistance and low pressure drop. To clarify, we use the term ‘low’ where releases remain below the limit of detection (LOD). Reduction of CO2 emissions The fibre diameter of the PTFE media ranges from 30 nm - 200 nm, which is extremely thin compared to other types of media, including glass fibre media, so that the filter pressure drop can be very low. As a result, significant energy savings are achieved, which contributes greatly to the reduction of CO2 emissions. It should be noted that PTFE media filters are mainly used in high performance filtration applications in professional or industrial settings (including semiconductors, pharmaceuticals, food, etc.) which present high volumes of air flow and where PTFE media filters allow to maintain a high level of air cleanliness. It should be noted that filtration applications relying on PTFE media go beyond the examples provided in Annex E of the restriction dossier, more specifically in the sections on TULAC and Electronics and semiconductor applications. About the latter, we would like to highlight that PTFE media filters are essential for semiconductor manufacturing equipment and high purity clean rooms for semiconductors. The main reason is that PTFE media filters ensure low boron, low outgassing, chemical resistance and low pressure drop. Absence of suitable alternatives Unlike what is claimed in Annex E (Section E. 2.2.4.2. under TULAC, pp. 83-84 and 120) of the restriction dossier, polyurethane and polyethylene are not suitable alternatives to PTFE in filtration applications. At present, filters using alternative materials to PTFE present many challenges and cannot be considered as potential alternatives. We continue our R&D effort to identify any potential alternative in the future. Views and requests on derogation period We understand the proposed derogations under paragraphs 5(e), 5(ee), and 6(a) cover PTFE media filters. In addition, PTFE media filters are used in the pharmaceutical industry, healthcare and biological safety labs. These uses are not covered in the restriction dossier. As mentioned above, no material has been found that meets all the requirements of low pressure drop, low boron, low outgassing, chemical and mechanical resistance. Therefore, a derogation request of at least 13.5 years, subject to review after 13.5 years, is considered necessary for PTFE media filters for air filtration. Disposal PTFE media filters are collected by professional waste contractors and subject to high-temperature incineration in accordance with the European Waste Code 150202 established under the Waste Framework Directive (2008/98/EC). |
| **Answer to specific info request 1:**  The sectors to which our comment applies are the following: Sector: TULAC Use: Technical textiles Technical textiles include filtration media under the TULAC category in the restriction report. More specifically, this contribution covers the use of PTFE media filters in high performance filtration applications in professional or industrial settings. Sector: Food contact materials and packaging Use: Industrial food and feed production Relevant for air filtration applications using PTFE media filters. Customers in that segment request prove of compliance with food contact regulations. The main reasons are that PTFE media filters ensure low outgassing and low pressure drop. Sector: Electronics and Semiconductors Use: Semiconductors Relevant for air filtration applications using PTFE media filters. The main reasons are that PTFE media filters ensure low boron, low outgassing, chemical resistance and low pressure drop. Sector: Pharmaceutical Industry, Healthcare, Biological Safety Labs (not included in the restriction dossier) Use: Clean environments (isolators, workbenches, RABS, cleanroom ceilings) Relevant for air filtration applications using PTFE media filters. Customers in that segment have special requirements in terms of integrity (biological safety) of their clean environment. The main reasons are that PTFE media filters ensure low outgassing, low pressure drop and chemical resistance, particularly with regard to H2O2 vapors. |
| **Answer to specific info request 2:**  a. During manufacturing: The PTFE media we used in our filters is not manufactured in the EU. Our manufacturing activities within the EU consist of filter sheet material pleating and filter assembly. Production scraps can be generated when the side edge of the media is cut. This waste is properly collected as industrial waste and incinerated. It is considered that almost no releases can be generated during these steps. During use: When the product is in use, the scattering of PTFE fibres from filter media is very unlikely due to the nature of the product. No PFAS releases are detected at PTFE media air outlets when we monitor the air flow. At end of life: Please see our answer to Q3. b. At the end-of-life phase, fluorine-containing filter waste is collected by professional companies and incinerated in a professional disposal facility. This is the standard disposal procedure for industrial waste in the EU. |
| **Answer to specific info request 3:**  When the filter is replaced, a professional waste company is contacted and the filter is disposed of in a professional disposal facility. PTFE media filters are disposed of as industrial waste in accordance with the European Waste Code 150202 established under the Waste Framework Directive (2008/98/EC). Research has found that the incineration of PTFE at between 870 and 1020ºC with a residence time of between 4.0 and 2.7 seconds, respectively, while using BATs, ensures a complete mineralisation of the carbon bonds. In addition, an effective system to monitor the amount of PFAS products disposed of would be to request relevant waste disposal companies to report on the amount of PFAS-containing waste annually handled. |
| **Answer to specific info request 4:**  a. The filters themselves cannot be recycled. PTFE media used in the filters are processed in accordance with the European Waste Code 150202 established under the Waste Framework Directive (2008/98/EC), as noted in our response to Q3. |
| **Answer to specific info request 5:**  Our response on this question relates to our derogation request for PTFE media filters used in air filtration, subject to review after 13.5 years. This is due to the absence of alternatives achieving the most critical properties of PTFE media filters, including low pressure drop, chemical resistance, low outgassing and, especially for semiconductor manufacturing, low boron content. Our derogation request covers the following derogations as proposed in the restriction report, as well as the additional sub-uses mentioned below: - Proposed derogation 5(e) – Water and oil repellent filtration and separation media for industrial or professional applications until 6.5 years after EiF (derogation proposed is not adequate, please see our response to question 6); - Proposed derogation 6(a) – Food contact materials for the purpose of industrial and professional food and feed production until 6.5 years after EiF (derogation proposed is not adequate, please see our response to question 6); - Potential derogation marked for reconsideration 5(ee) – Semiconductor manufacturing process until 13.5 year after EiF; and - Missing use (not included in the restriction dossier) – Pharmaceutical industry, healthcare, biological safety labs. Please refer to the attached report. |
| **Answer to specific info request 6:**  Our response on this question relates to our derogation request for PTFE media filters used in air filtration, subject to review after 13.5 years. The applications (sub-uses) covered are the following: • PTFE media filters for manufacturing of pharmaceuticals; • PTFE media filters used in biological safety labs and healthcare applications. a. Please refer to the attached report. b. The key properties of PTFE media filter for these applications are the following: - Low pressure drop/energy and CO2 savings: PTFE media filter provide low air flow pressure drop due to its nano-scale fibres, which are much finer than other types of media. Low air flow pressure drop leads to energy/CO2 savings. It also allows to minimise the size of the filter and of the fan, allowing for more compact semiconductor equipment. - Low boron (please see our reply to Question 7) - Low outgassing (please see our reply to Question 7) - Chemical resistance (e.g. resistance to acids in the case of semiconductor manufacturing, resistance to hypochlorous water for food filling equipment): The PTFE media filter is alkaline resistant and, therefore, does not deteriorate and generate impurities. In the pharmaceutical sector, H2O2 vapour is often used for sterilisation of equipment. PTFE media filter is highly resistant to aggressive H2O2 vapour. - Mechanical resistance: High mechanical stability is critical to prevent leaks. Leaks can lead to uncontrolled product leakage or product contamination, as a result of which neither product safety nor occupational or environmental safety can be guaranteed. - Hydrophobicity and oleophobicity: This is important in applications where oily substances are handled in a containment but even more during the production process of the filter. Oleophobicity, in particular, prevents hot melt adhesive (spacer between the folds of the filter media) or polyurethane (potting compound to bond the filter media to the frame) from being completely absorbed by the filter media and thus unable to perform its function. c. Please refer to the attached report. d. Alternatives are difficult in the light of the above and do not exist. Although polyurethane and polyethylene are mentioned as potential alternative materials in the restriction dossier, they cannot be considered as suitable candidates due to their significantly reduced lifespan, natural deterioration and high pressure drop. g. As noted we consider necessary to have a derogation of at least 13.5 years combined with a review clause in order to properly understand the progress on alternatives over time. |
| **Answer to specific info request 7:**  Our response on this question relates to the potential derogation marked for reconsideration 5(ee), which covers the use of PTFE media filters in the semiconductor manufacturing process until 13.5 year after EiF. Overall, PTFE media filters are essential for semiconductor manufacturing equipment and clean rooms for advanced semiconductor manufacturing due to their chemical resistance (in particular acid-resistance), low boron and low outgassing, in addition to low pressure drop and mechanical resistance. Annex A, Table A.49 summarizes PFAS use cases for each semiconductor manufacturing process and refers to air filters only for exposure equipment. However, PTFE media filters are also used for the following specific processes: - Thermal oxidation method (Diffusion furnace) - Wet station (Chemical cleaning) - Coater developer (Photoresist coating) - Chemical Mechanical Polishing (Flatting equipment) - Testing of wafer device (Prober) - Wafer transfer between processes (FOUP and EFEM) a. Please refer to the attached report. b. The key properties of PTFE media filters are the following: The following properties are of crucial importance for semiconductor manufacturing: - Low boron: In semiconductor manufacturing, boron is used as a dopant. Therefore, the boron concentration in the environment must be controlled very strictly and precisely. Therefore, PTFE media filters that ensure extremely low release of boron from the filter material is critical. It should be noted that glass media filters cannot be used because the filter material release boron into the air, making it impossible to control the boron concentration in the semiconductor manufacturing environment. - Low outgassing: Metal contaminations, such as sodium, can disrupt the control of the transistor output current when they enter the wafer's oxide film. Therefore, PTFE media filters that ensure extremely low release of metal impurities from the filter material, including sodium, is essential. - Chemical-resistance (acid-resistance): the filter material must be resistant to hydrofluoric acid. If the hydrofluoric acid used in the cleaning process touched the filter material, BF3 vapor would be generated, causing contamination in the semiconductor plant. The other parameters related to low pressure drop / energy and CO2 savings, as well as mechanical resistance are described in our reply to Question 6. c. We supply PTFE media filters to many semiconductor equipment manufacturers and semiconductor clean room engineering companies (i.e., for high performance filtration applications in industrial settings). e. Alternatives are difficult in the light of the above and do not exist. Although polyurethane and polyethylene are mentioned as potential alternative media in the restriction dossier (Annex E, Section E. 2.2.4.2. under TULAC, pp. 83-84 and 120), they cannot be considered viable alternatives due to their significantly reduced lifespan, natural deterioration and low performance in terms of energy efficiency/CO2 savings. g. As noted we consider that it is necessary to set a derogation of at least 13.5 years subject to review in order to properly understand the progress on alternatives over time. |

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| **4266** | **Date:**  2023/05/23 18:25  **Content:**  Scope or restriction option analysis  Other socio economic analysis (SEA) issues  Request for exemption  **Type:**  Individual  **Country:**  Germany | **General Comments:**  In 2021, the number of the EU-registered passenger cars reached 253 million. Based on actual assumptions every car contains several PFAS in very different areas. The car industry can give details on this. Based on the ECHA definition of "placing on the market", also selling of used cars will be prohibited after the regulation comes into force. As the average age of cars in EU is 11,8 years, it is obvious, that over lifetime a car enters the market several times as used car. Especially as leasing of cars became very popular not only for company cars but also for private cars, some of these cars enter the used car market already after 3 years. Assuming that the average worth of a car is 10.000 Euro, the total size of this business is 2.530.000.000.000 Euro. A prohibition to sell used cars containing PFAS will create a huge damage for the society as the worth of these cars will drop to zero at the date of the prohibition. In addition the ECHA definition of "placing on the market", also prohibits to add these products to the recycling process. This will create another damage. First used cars are special waste with special treatment, which adds additional costs to the owners. Second there is a huge impact on material. Assuming an average weight of a car is 1.300 kg, about 600 kg steel, 150 kg aluminum and 10 kg of copper are used. This would be 152 million tons of steel, 38 million tons of aluminum and 2,5 million tons of copper which will be removed from the circular economy. The content of recycled material in steel, aluminium and copper will be drastically reduced by this for many years. This has to be compensated by an equivalent amount of virgin steel, aluminum and copper. Another social impact would be that sellers of used cars have to close their business for years, until a new generation of PFAS-free cars are entering the used car market. Thousands of jobs will be lost. The most severe social impact is, that lower income people are reliant on the used car market, as they can not effort new cars. For them there is no possibility of owning a car for many years. Based on this the only way to solves this is a time unlimited exemption for placing on the market of used cars, including spare parts for these used cars for maintenance and repair. |
| **Answer to specific info request 4:**  As mentioned above, assuming an average weight of a car is 1.300 kg, about 600 kg steel, 150 kg aluminum and 10 kg of copper are used. At 253 million cars this would be 152 million tons of steel, 38 million tons of aluminum and 2,5 million tons of copper which will be removed from the circular economy. As the ECHA definition of "placing on the market" would prohibit to recycle these cars, this amount of material is removed from the circular economy and from the market of the recycling industry. The content of recycled material in steel, aluminium and copper will be drastically reduced by this for many years. |
| **Answer to specific info request 6:**  Used cars and spare parts for cars are missing, see also general comments above, repeated here: In 2021, the number of the EU-registered passenger cars reached 253 million. Based on actual assumptions every car contains several PFAS in very different areas. The car industry can give details on this. Based on the ECHA definition of "placing on the market", also selling of used cars will be prohibited after the regulation comes into force. As the average age of cars in EU is 11,8 years, it is obvious, that over lifetime a car enters the market several times as used car. Especially as leasing of cars became very popular not only for company cars but also for private cars, some of these cars enter the used car market already after 3 years. Assuming that the average worth of a car is 10.000 Euro, the total size of this business is 2.530.000.000.000 Euro. A prohibition to sell used cars containing PFAS will create a huge damage for the society as the worth of these cars will drop to zero at the date of the prohibition. In addition the ECHA definition of "placing on the market", also prohibits to add these products to the recycling process. This will create another damage. First used cars are special waste with special treatment, which adds additional costs to the owners. Second there is a huge impact on material. Assuming an average weight of a car is 1.300 kg, about 600 kg steel, 150 kg aluminum and 10 kg of copper are used. This would be 152 million tons of steel, 38 million tons of aluminum and 2,5 million tons of copper which will be removed from the circular economy. The content of recycled material in steel, aluminium and copper will be drastically reduced by this for many years. This has to be compensated by an equivalent amount of virgin steel, aluminum and copper. Another social impact would be that sellers of used cars have to close their business for years, until a new generation of PFAS-free cars are entering the used car market. Thousands of jobs will be lost. The most severe social impact is, that lower income people are reliant on the used car market, as they can not effort new cars. For them there is no possibility of owning a car for many years. Based on this the only way to solves this is a time unlimited exemption for placing on the market of used cars, including spare parts for these used cars for maintenance and repair. |

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| **4267** | **Date:**  2023/05/23 19:16  **Content:**  Scope or restriction option analysis  Hazard or exposure  Environmental emissions  Information on alternatives  Information on benefits  Other socio economic analysis (SEA) issues  Transitional period  Request for exemption  **Type:**  BehalfOfAnOrganisation  **Org. type:**  Company  **Org. name:**  <redacted>  **Org. country:**  United Kingdom  **Company name confidential:**  Yes  **Attachment:**  <redacted>  **Privacy statement:**  We are a publicly listed company and are, per the UK and EU Market Abuse Regulation, currently in a "closed period" before publication of our end of year financial results. Public disclosures (which would include submissions to public consultations such as this) need to be controlled. In addition, there is potential for the content of these documents to undermine the protection of our commercial interests. Therefore, at this time, we require to treat the attachments and our company name as confidential. Once the closed period ends, we will endeavour to make what we can non-confidential. | **General Comments:**  We are a global company with leadership in sustainable technologies, operating in more than 30 countries with around 15% of our employees located in the EU across 7 major manufacturing sites. We are a downstream user of PFAS, in applications that require mechanical and chemical resistance and for which PFAS are uniquely suited. E.g. our noble metal refineries utilise fluoroelastomers and fluoropolymers in critical process equipment, and our current catalyst-coated membranes (CCM) technologies, which are key components of fuel cells (FC) and electrolysers (EL), employ polymeric PFAS. We also receive end-of-life FC and EL containing PFAS for processing to recover the platinum and iridium.  Our global expertise in these areas gives us a unique perspective on the troubling impacts of this proposed restriction, particularly on the energy transition and security of critical raw materials, and our comments seek to highlight these concerns. In particular, the evidence provided in the restriction proposal does not justify a universal PFAS restriction as the most appropriate option to address the putative risks from such a broad and variable group of substances. For example, most types of fluoropolymers have been demonstrated to meet the OECD ‘polymer of low concern’ criteria. The available data do suggest that enacting regulatory measures to limit emissions of non-polymer PFAS will meet the goals of the dossier submitters, without doing serious harm to other important EU policy goals.  The EU has dedicated itself to sustainable development and has set a very ambitious target of becoming the first climate-neutral continent by 2050. To meet this target, the EU put in place the European Green Deal, a hydrogen strategy and REPowerEU, with the development of the EU hydrogen economy a strong focus across all three. To achieve the hydrogen goals, the Commission outlined plans to produce 10 million tonnes of renewable hydrogen by 2030 domestically and to import a further 10 million tonnes. To meet the 10 million tonne domestic production, the vision is to install 6 GW of renewable hydrogen electrolysers by 2024 and at least 100-120 GW of renewable hydrogen electrolysers by 2030 (today Europe has less than 1.5GW).  One of the fastest growing means of generating hydrogen is from a proton exchange membrane (PEM) electrolyser. Their popularity is increasing because they can operate at high efficiency levels when paired with renewable electricity (converting the electricity that cannot be used at times of low demand into hydrogen). At their core PEM EL use a catalyst coated membrane (CCM) which is responsible for converting water into hydrogen; these CCMs rely on an ion conducting fluoropolymer (ionomer) to function. Under the proposed ECHA definition and restriction these essential components used at the core of PEM EL would be banned. The consequence would be that the European targets for domestic renewable hydrogen production could not be met. The EU would lose the potential to provide the continent with energy security and would therefore become dependent on energy imports.  It is anticipated that the 20 million tonnes of renewable hydrogen proposed in RePowerEU will be predominantly used in three main market sectors: chemicals, heavy industry and mobility. These sectors are positioned in the top five of greenhouse gas emitters in the EU (28% comes from mobility, 26% from industry, 23% from power, 13% from buildings and 13% from agriculture). Across these sectors, fossil fuel combustion is the biggest source of GHGs, accounting for 80% of emissions. Renewable hydrogen can and will play a key role in supporting decarbonisation across these hard-to-abate applications.   Transportation is one of the most significant contributors to greenhouse gas emissions globally, and where electrification is more difficult, fuel cells are an attractive solution to support decarbonisation. Hydrogen fuel cell vehicles use hydrogen to generate power electrochemically without releasing any harmful emissions or particulates. Fuel cells have proven ideal for heavy duty and high usage applications, such as for trucks and buses, as they provide the range, low weight and rapid fuelling times required by commercial fleet operators, with a much lower critical/strategic material intensity than, for example, battery electric trucks and buses. As with electrolysers, a contributory fuel cell technology is also PEM-based, with fluoropolymers being key components (see the Hydrogen Europe position paper for a summary https://hydrogeneurope.eu/wp-content/uploads/2023/02/Hydrogen-Europe-position-paper-on-PFAS-ban\_v12\_FINAL.pdf), with no viable substitutes available today, or expected within the timeframes of the proposed derogation.  Beyond these sector-specific impacts (which are expanded on in the attachments), the restriction proposal does not acknowledge the criticality of fluoropolymers in the chemicals manufacturing and platinum group metal (PGM) refining sectors, where chemical-resistant industrial equipment, such as piping, gaskets, pumps etc. are required to support process safety.  The attachments elaborate on these general comments with supporting evidence, and we believe that fluoropolymers should be removed from the scope of the restriction. However, if this is not achievable, it is imperative the proposed derogations and exemptions consider the following:  1) A full exemption is given for fluoropolymers used in industrial equipment for chemicals manufacturing. In particular, for PGM refining applications, where fluoroelastomer and fluoropolymer industrial equipment is used in these refineries.  2) A time-unlimited derogation is permitted for uses of PFAS in the energy sector (placing on the market, use, repair and recycling) specifically in relation to PEM fuel cells and electrolysers, because the proposed 5-year derogation is not sufficient to allow development and qualification of alternatives in these essential applications, as well as to allow the suppliers of any identified alternatives to scale-up to meet demand (see attachment 06). PFAS emissions from use are negligible (See attachment 05) and at end-of-life can be well-controlled. There is a clear economic case to recover the PGMs from FC and EL and avoid loss of these valuable materials from the circular economy. |
| **Answer to specific info request 1:**  Metal plating and manufacture of metal products (Manufacture of metal products not addressed elsewhere) Energy sector Chemicals manufacture (industrial equipment) is not listed in Table 9. |
| **Answer to specific info request 2:**  Detailed comments are provided in attachment 02. At the heart of PEM EL and FC technologies is the PGM-coated catalyst membrane. At their end-of-life, recovery of the PGMs (critical and strategic raw materials, CRMs) will be a key factor whilst also ensuring the ionomer is not entering uncontrolled waste streams. Current PGM refining employs incineration to destroy the ionomer and control PFAS emissions. PGM recyclers are beginning to focus on new lower energy and higher value retention (ionomer recycle) routes to recycle FC and EL related CCMs from production scrap and / or end-of-life materials, improving on existing incineration technologies. Both old and new technologies control PFAS emissions in the recovery phase.  A ‘closed loop’ recycling model could help ensure that materials move from industry to a recycler and back to industry (for reuse), without loss to land disposal or other waste. The efficiency of both current incineration systems and the future (non-incineration) recycling of CCMs could be enhanced by, e.g., introducing “producer responsibility” regulations and/or regulations mandating end-of-life recycling. These would significantly increase collection efficiency and help ensure high levels of recycling are achieved. The proposed ban on PFAS materials would critically undermine the whole PGM refining industry because of the need for PVDF as a key refinery construction material and also its use in chemical seals that are essential to the aggressive processes needed to recycle PGMs. Clearly anything that undermines Europe’s well-developed PGM recycle industry will undermine European intentions to develop the clean hydrogen industry as well as the myriad of other PGMs applications in environmental clean-up, pharmaceutical, food and health etc. In addition, the PGM recycle industry makes a substantial contribution to climate change mitigation because recycled PGMs create 50-70 times less CO2 eq compared to the only other source of these CRMs (via hard rock mining). |
| **Answer to specific info request 3:**  A recent peer-reviewed study concluded that incineration is an acceptable disposal approach for end-of-life PTFE (Aleksandrov et al. (2019), https://doi.org/10.1016/j.chemosphere.2019.03.191). The use of best available scrubbing approaches suggests that such activities do not emit PFAS with PTFE, and that PTFE was virtually fully transformed to fluorine as hydrofluoric acid which can be easily scrubbed and collected.  See Attachment 03 for more details. |
| **Answer to specific info request 4:**  Please see answer to Specific Information Request 2 and in Attachment 04 |
| **Answer to specific info request 6:**  Please see detail in Attachments 01 and 06 |

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| **4268** | **Date:**  2023/05/23 22:42  **Content:**  Scope or restriction option analysis  Hazard or exposure  Environmental emissions  Baseline  Description of analytical methods  Information on alternatives  Information on benefits  Other socio economic analysis (SEA) issues  Transitional period  Request for exemption  **Type:**  BehalfOfAnOrganisation  **Org. type:**  Company  **Org. name:**  <redacted>  **Org. country:**  Switzerland  **Company name confidential:**  Yes  **Attachment:**  <redacted>  **Privacy statement:**  Protection of commercial interests including intellectual property would be undermined. | **General Comments:**  See confidential attachments. |
| **Answer to specific info request 1:**  See confidential attachments. |
| **Answer to specific info request 2:**  See confidential attachments. |
| **Answer to specific info request 3:**  See confidential attachments. |
| **Answer to specific info request 4:**  See confidential attachments. |
| **Answer to specific info request 5:**  See confidential attachments. |
| **Answer to specific info request 6:**  See confidential attachments. |
| **Answer to specific info request 7:**  See confidential attachments. |
| **Answer to specific info request 9:**  See confidential attachments. |
| **Answer to specific info request 10:**  See confidential attachments. |

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| **4269** | **Date:**  2023/05/24 05:39  **Content:**  Scope or restriction option analysis  Other socio economic analysis (SEA) issues  **Type:**  BehalfOfAnOrganisation  **Org. type:**  Company  **Org. name:**  <redacted>  **Org. country:**  Japan  **Company name confidential:**  Yes  **Attachment:** | **General Comments:**  MICROZERO supports the statement made by FCJ on the issues of proposed restriction,as per attached in Section IV. |
| **Answer to specific info request 1:**  sectors/Food contact materials and packaging use/Industrial food and feed production (Food and beverage manufacturing machinery) |

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| **4270** | **Date:**  2023/05/24 07:59  **Content:**  Scope or restriction option analysis  Information on benefits  Request for exemption  **Type:**  BehalfOfAnOrganisation  **Org. type:**  Company  **Org. name:**  <redacted>  **Org. country:**  Japan  **Company name confidential:**  Yes | **General Comments:**  In the production of copper-clad laminates, which are used in the production of electronic circuit boards, glass cloth prepreg and copper foil must be hot-pressed at temperatures above 200°C. A hot-press cushioning mat is used as an auxiliary material for this hot-press molding. Heat resistance, thermal conductivity, durability, resilience, non-stickiness, etc. are required for the hot-press cushioning mat. Heat press cushion mat is a strong integrally molded product in which glass cloth and fluororubber are alternately laminated. The glass cloth on the surface is impregnated with fluorine resin to give it non-stickiness. |
| **Answer to specific info request 1:**  Our sector is electronics and semiconductor (Annex E.2.11.), but there is no (sub-)uses to which could apply to our product in the Annex XV Restrictions Report (Table 9). Our product is a cushioning mat for heat press, which is an auxiliary material for equalizing heat and pressure when manufacturing copper-clad laminates. In the production of copper-clad laminates, which are used in the production of electronic circuit boards, glass cloth prepreg and copper foil must be hot-pressed at temperatures above 200°C. A hot-press cushioning mat is used as an auxiliary material for this hot-press molding. Heat resistance, thermal conductivity, durability, resilience, non-stickiness are required for the hot-press cushioning mat. Heat press cushion mat is a strong integrally molded product in which glass cloth and fluororubber are alternately laminated. The glass cloth on the surface is impregnated with fluorine resin to give it non-stickiness. |
| **Answer to specific info request 2:**  Approximately 0.5 tons of PFAS is used annually in the production of cushioning mat for heat press, of which approximately 0.1 tons (20%) is discarded as leftover materials and offcuts. Waste is landfilled as industrial waste in a controlled environment. The amount of PFAS used in products is approximately 0.4 tons (approximately 30% by weight of the product) per year. Heat press cushioning mat are used approximately 200 times in approximately one year as an auxiliary material when manufacturing copper-clad laminates at the customer's site. The product is used in a closed system under reduced pressure conditions and there is no emission of PFSA during use. After use, it will be landfilled in a controlled environment as industrial waste. |
| **Answer to specific info request 3:**  After use, it will be landfilled in a controlled environment as industrial waste. |
| **Answer to specific info request 6:**  a. Fluor resin: 0.1 tone, fluorine rubber: 0.4 tone. b. Heat resistance, non-stickiness, durability provided by Fluor resin; Heat resistance, adhesion, resilience, durability provided by fluorine rubber.　　 c. About 10 primary users, very many secondary users. 　 d. There is no substitute material for both Fluor resin and fluorine rubber in terms of performance. e. At present, there is no substitute material for the properties such as heat resistance, durability, and non-stickiness that fluor resin and fluorine rubber have. Alternatives will require a great deal of effort, including efforts by upstream raw material manufacturers to develop new materials and downstream users to change their production methods. It will take at least several years. 　 g. If not only our company but also similar products cannot be manufactured, it will have a huge impact on the PCB (Printed circuit board) industry. Not all PCB substrate production uses this kind of product (heat press cushioning mat), but the 2022 global market size for PCB substrates was US$67.3 billion |