Sustainability & Comfort
Working Group TensiNet

PFAS Restriction Proposal
Comments by the TensiNet Association for the Annex XV restriction report
25-09-2023

Substance name
Per- and polyfluoroalkyl substances (PFAS)

SECTION I. Personal information
Submitted by: Carol Monticelli

SECTION II. Organisation
On behalf of an organisation or institution: **TensiNet Association**, **International Non-Profit Association**, **Belgium**

SECTION III. Non-confidential comments
General Comments
The response is a reply provided by the members of the TensiNet Association. The content has been discussed during several online meetings of the Working Group Sustainability & Comfort.

The TensiNet Association stands as a prominent force within the realm of membrane structures, bringing together professionals from various fields such as design, architecture, engineering, manufacturing, supply, and installation. This esteemed association operates primarily on a European scale, while also functioning worldwide, fostering collaboration, knowledge exchange, and innovation in the domain of tensioned membrane constructions. Through its diverse membership base and extensive expertise, TensiNet plays a pivotal role in advancing the development, understanding, and implementation of these unique architectural marvels.

Background:

The initial TensiNet project (2001-04) has been funded by the European Commission for three years. The consortium of TensiNet consisted of 22 participating organisations with representatives from 9 EU member states. The membership formed a complementary group representing multi-disciplinary industries (coater and weaver, manufacturer, producer, engineering and architecture offices), universities and other associations.
Within the thematic programme GROWTH (Promoting Competitive and Sustainable Growth) the partners made the knowledge of their specific domain available and exchanged know-how between different disciplines.
The publication of the first “European Design Guide for Tensile Surface Structures” (B. Forster, M. Mollaert (Eds.), *European design guide for tensile surface structures*, TensiNet Association, Brussel, 2004) was the result of these three years of assembling, structuring and analysing existing knowledge and data.

Mission/Aim:

The TensiNet Association is driven by the mission to empower its members to make meaningful contributions within their respective activities in the field of tensile membrane buildings. The association focuses on several key objectives to achieve this aim:
1. Providing Information and Advice in the field of tensile membrane buildings
2. Supporting Research and Technical Studies

3. Bridging the Gap between Research and Practice
4. Enhancing the Quality of Tensile Membrane Buildings
5. Expanding Architectural Applications
6. Facilitating the Translation of Scientific Results into Practice
7. Stimulating Research Initiatives

The association facilitates the exchange of information and encourages joint working among its members, creating a supportive network that enhances the overall quality of tensile architecture.

Objectives:

The TensiNet Association creates a platform for all parties interested in tensioned membrane structures.
TensiNet supports teaching, workshops and training activities in the field of tensioned membrane construction and provides information about these events.
TensiNet publishes the TensiNews newsletter twice a year. TensiNet organises every three year the TensiNet Symposium.
TensiNet continues to publish reference documents, Working Group publications and the proceedings of the TensiNet symposium.
TensiNet has launched several Working Groups (WG Sustainability and Comfort, WG Pneumatic structures, WG Specifications and EUROCODE, WG Specifications GOOD PRACTICE etc.). Each Working Group focuses on a specific topic and is responsible for its operation.
TensiNet maintains the website www.tensinet.com, containing a projects database, reference documents, research reports etc.

With respect to the PFAS Restriction Proposal, the TensiNet Association supports the statements and replies made by

- its members:
  - Membrane and foil producers, coating and weaving companies: Sioen, AGC and Chukoh Chemical Industries
  - Tensile architecture manufacturers and fabricators: Taiyo Europe GmbH and Vector Foiltec
- the Industrieverband Kunststoffbahnen e.V. (IVK Europe, answer uploaded 7/9, reference e6fabaeb-86f0-4292-aa5f-dc946e348491) representing Sioen, Mehler Texnologies, Sattler, Serge Ferrari and Verseidag,
- the FluoroPolymer Product Group (FPG, see https://fluoropolymers.eu/wp-content/uploads/2023/08/FPG-DRAFT-REACH-Restriction-Consultation-Response_FINAL.pdf) with member AGC.

For detailed information the TensiNet Association refers to their replies.

The TensiNet Association requests an exemption of all fluoropolymers from the PFAS Restriction Proposal under the REACH regulation.
By grouping all various PFAS substances together and restricting them as a single class, the PFAS Restriction Proposal would restrict numerous PFAS substances that have not been risk-assessed and for which no unacceptable risk has been demonstrated.

For now, there are no alternatives at hand and the restriction would mean the end of lightweight tensile structures in Europe.

Specific Information Requests

1: **Sectors and (sub-)uses**:

Construction products / Architectural membranes and ETFE foils

Membrane structures, also known as tensile surface structures or fabric structures, are architectural constructions that utilize flexible membranes ((un-)coated fabrics or foils) to create self-supporting roofs, canopies, and other types of enclosures (Ignasi de Llorens J., 2015).
These structures derive their strength and stability from the tension forces exerted in the surface (Stranghöner, N., Uhlemann, J., et al., 2023), which is typically made of materials like:
(1) PVC-coated polyester,
(2) PTFE-coated fiberglass, or
(3) ETFE and other films (more than 1500 buildings erected worldwide).

(Gabler M., Cremers J., et al., 2010, Gabler M., Cremers J., et al., 2011)
Advantages of membranes structures include:

- **Lightweight**: Membranes are significantly lighter than traditional building materials such as steel or concrete. This property allows for easier transportation, reduced foundation requirements, and overall cost savings (Monticelli C., Zanelli A., 2021). Due to the 'lightweight principle' and the 'lightweight nature of the cladding material' the corresponding substructure can be significantly optimized leading to minimal quantities for the structure, that is associated to a significant reduced carbon footprint / grey emission of the building (Göppert K., Paech C., 2015).
- **Versatility of design**: The flexible nature of membrane materials enables architects and designers to create unique and innovative shapes and forms that are challenging to achieve with conventional construction methods. Membrane structures offer great design freedom and aesthetic appeal (Xu J., Zhang Y., et al., 2022, Zanelli A., Monticelli C., et al., 2021, Forster B., Mollaert M. (Eds.), 2004).
- **Natural lighting**: Membrane materials can be translucent or transparent, allowing natural light to penetrate the building. This feature reduces the need for artificial lighting during the day, resulting in energy savings and a more pleasant indoor environment (Forster B., Mollaert M. (Eds.), 2004).
- **Cost-effective**: Compared to traditional construction, membrane structures can be more cost-effective due to reduced material requirements, shorter construction times, and simplified foundations. They can provide an economical solution for various applications.
- **Quick construction**: Membrane structures are often prefabricated off-site, allowing for rapid installation and construction. This aspect makes them ideal for temporary or semi-permanent structures, public space canopies, event venues, and disaster relief shelters (Ignasi de Llorens J., 2015).
- **Durability and weather resistance**: High-quality membrane materials are designed to withstand challenging weather conditions such as wind, rain, and snow. They are often treated to be fire-resistant and UV-stable, ensuring long-term performance and reduced maintenance requirements (Beck P., 2021, Philip M., Al-Azzawi F., 2018, Mailler P., Nemoz G., et al., 2016, João L.S., Carvalho R., et al., 2016, Dezső Hegyi K.H., 2005).
- **Sustainability**: Membrane structures have the potential to be environmentally friendly. They require fewer materials, generate less waste during construction, and can be dismantled and reused in other projects. Coated fabrics or printed foils provide shade. The translucent membranes contribute to energy efficiency by reducing the need for artificial lighting (Monticelli C. et al., 2013, Monticelli C., 2010; Tim C. R. Finlay, 2021, Eryuruk, Z., Mollaert, M., 2023, Eryuruk, Z., Mollaert, et al., 2023, Cremers J., 2013, Chilton J., Pezeshzadeh S., et al., 2013).

Membrane structures find applications in a wide range of industries and sectors due to their versatility, lightweight nature, and aesthetic appeal. Some common applications include (Motro R., (Ed.), 2011):

1. **Architectural Roofs and Canopies**: Membrane structures are used in stadiums, convention centres, outdoor theatres, and shopping centres. They provide weather protection while creating visually striking spaces.
2. **Exhibition and Event Spaces**: Membrane structures are frequently employed as temporary or semi-permanent exhibition spaces, trade show pavilions, and event venues. They offer quick installation, flexibility in design, and can be easily customized to fit specific event requirements.
3. **Transportation Facilities**: Membrane structures are utilized in transportation infrastructure, including airport terminals, train stations, and bus terminals.
4. **Sports Facilities**: Membrane structures are used for tennis courts, swimming pool covers, indoor sports arenas, and practice fields. Their lightweight construction allows for clear-span spaces without columns, providing unobstructed views for spectators.
5. **Commercial and Industrial Buildings**: Membrane structures are employed for warehouses, storage facilities, manufacturing units, and distribution centres.
6. **Hospitals**: Transparent ETFE foils cover inner areas for surgery (better cleaning and no bacteria). Membrane structures are used as roof systems and shade nets provide sun protection.
7. **Environmental Structures**: Membrane structures are used in environmental applications such as greenhouse covers, botanical gardens, zoos, and aviaries. They create controlled environments, allowing for optimal growth of plants or providing appropriate habitats for various species.
8. **Military and Disaster Relief Shelters**: Membrane structures are utilized in military applications as temporary barracks, command centres, or hangars.
9. **Cultural and Recreational Facilities**: Membrane structures are utilized in cultural and recreational projects such as museums, art installations, theme parks, and amphitheatres. They provide visually appealing spaces that enhance the visitor experience.
10. **Educational Facilities**: Membrane structures are employed as school playground covers, outdoor classrooms, and shade structures. They create comfortable and functional spaces.
11. **Residential Structures**: Membrane structures are used in residential applications as patio covers, shade sails, carports, and pergolas.

These are just a few examples of the diverse applications of membrane structures. Their lightweight, durable, and customizable nature makes them suitable for a wide range of architectural, commercial, and industrial projects.

The trends in architecture are to combine the shapes of facades with thermal and acoustic properties to achieve the net zero carbon requirement by 2023/2050, and that lightweight and membrane-based building systems offer promising solutions to achieve more efficient and less impacting building structures due to their lightness.
In addition to an impact quantified at around 14-30% (Table 1 in the Annex XV Restriction Report, for the Use Phase of Construction Products), the cessation of the production of membranes for lightweight construction - compared to its PFAS part of the impact - will have the counter effect of halting the most promising research projects aimed at developing new membrane-based products, and will consequently bring about a detriment to the technological progress of the entire construction sector, for which academics (in the fields of architecture, design and construction), public/private research institutions, companies, professional associations, architectural and engineering design societies and studios have devoted years of research, human resources and funding, and whose activities have in many cases been financed by EU and national/regional funds, with proven and recognised results.

For more literature references see Annex I.

2: Emissions in the end-of-life phase:

Distinction should be made between the emissions in the different stages of the lifecycle of a product, i.e.
(I) the manufacture phase,
(II) the use phase and
(III) the end-of-life phase.

The three product families concerned by tensile architecture are:
(1) PVC-coated PVDF top-coated polyester fabric,
(2) PTFE-coated glass fabric and
(3) ETFE foil.

a: emissions attributable to the three different stages

(I) Manufacture phase: See the appropriate EPD's

- Mehler Texnologies: EPD-MTX-20130164-IBA1-EN, EPD-MTX-20130165-IBA1-EN, EPD-MTX-20130166-IBA1-EN, EPD-MTX-20130019-IBA1-EN, EPD-MTX-20130167-IBA1-EN, EPD-MTX-20130168-IBA1-EN,
- Serge Ferrari: INIES_IMEM20210507_152654, 26711, INIES_IMEM20210507_155452, 26710, INIES_IMEM20210507_160928, 26709,
- Sioen: EPD-SIO-20220324-IBJ1-EN,
- Vector Foiltec: EPD-VFA-20170121-IBE1-EN, EPD-DVN-20140043-IBE1_EN, EPD-DVN-20210122-IBJ2-EN,
- TAIYO: EPD-TAI-20190092-ICB1-EN,
- Novum: EPD-NMG-20170152-IBC1-EN,
- PFEIFER: EPD-PFE-20220207-IBC2-EN

(II) Use phase: The fluoropolymers used in membrane structures are long lasting, even longer than initially (thirty years ago) expected. These fluoropolymers are employed for their durability, and they stay on the buildings for more than 20 years. EN1990 specifies a "design service life" of 25 years for "replaceable structural parts" (João, L.S., Carvalho, R., et al., 2016, Ambroziak, A., Kłosowski, P., 2021)

- (1) For PVC-coated PVDF top-coated polyester fabric: the top coating assures the durability. The materials are generally more resistant to abrasion than without a top coating (Ansell M.P., 1985),
- (1) and (2) PTFE-coated glass fabric: According to the state-of-the-art, Fluoropolymers at the surface of a membrane are chemically bonded (Asadi H., Uhlemann J., et al., 2021a, Asadi H., Uhlemann J., et al., 2021b),
- (3) For ETFE films: Concerning the use of the ETFE material, up to now it is not documented if emissions occur. The Fluoropolymers' anti-adhesion property highly reduces the cleaning needed during the service life, although the aluminium frames can still require to be cleaned (Beck P., Hornig J., 2022, Beck P., 2021).

(III) The end-of-life phase:
(3) For ETFE films: Some companies are controlling the end-of-life stage: the contract with the client, provides the "take back" collection, ensuring the recycling chain and avoiding landfill disposal or incineration.

b: which percentage of (1), (2), (3) is incinerated, landfilled, and recycled?
The production of wastage during the manufacturing is low, due to the optimized engineered design and manufacturing.

(I) Manufacture phase:
(1) For PVC-coated PVDF top-coated polyester fabric and (2) PTFE-coated glass fabric: waste about 15% depending on the architectural shape.
(3): Production of ETFE foils: waste 2-3%; manufacturing and tailoring: waste less than 10%.

(III) The end-of-life phase:
(1) For PVC-coated PVDF top-coated polyester fabric and (2) PTFE-coated glass fabric: After the final application (reuse, recycling...), the material eventually will be burned.
(2) For PVC-coated PVDF-top-coated polyester fabric recycling is at research and exploratory level. KKF reVinyl GmbH (http://re-vinyl.de/) already does PVC/Polyester recycling. Regulations could increase the recycling rate.
(3) For ETFE foils: At end-of-life, the materials are recyclable and downcycled in tubes, valves and other products. In the EU PETERS-plastic GmbH (Kelkheim, Germany), Aturon (Widnau, Switzerland), Marubeni International (Europe) GmbH (Düsseldorf, Germany) and Nowofol Kunststoffprodukte GmbH & Co. KG (Siegsdorf, Germany) do this recycling of ETFE. Marubeni has a Recycling Scheme for the collection of transparent and printed ETFE film in individual foldable boxes. The cushion foils from the Vodafone project for instance have been taken back for downcycling (Sonmez, G., 2021).

3: Emissions in the end-of-life phase:

The question is about waste management options + incineration effectiveness:
(2) For PTFE-coated glass fabric: PTFE burned at temperatures typical of a municipal waste incinerator does not degrade into the identified PFAS of Environmental Concern. Under standard municipal waste incineration condition, PTFE is essentially transformed to carbon dioxide and hydrogen fluoride (see https://www.gore-tex.com/sites/default/files/docs/Chemosphere_Incineration%20Study_Executive-Summary%20(002).pdf)
The study examined what happens to a PTFE polymer at the end of its life - when it's thrown away and ends up in a municipal waste incinerator (Aleksandrov K., Gehrmann H.-J., et al., 2019)

4: Impacts on the recycling industry:
No information on this topic.

5: Proposed derogations – Tonnage and emissions:
No information on this topic.

6: Missing uses – Analysis of alternatives and socio-economic analysis:

a: emissions (at sub-sector level) per type of PFAS associated with the relevant use.
No information

b: functionalities provided by PFAS for the relevant use.
(1) PVC-coated PVDF-top-coated polyester fabric: PVDF, providing protection for PVC, allows to improve the durability of the PVC-coated polyester fabric to 25 years or more (instead of 10 years).
(2) PTFE-coated glass fabric: this is considered as an indispensable material for building roofs, especially large-span stadia.

(3) ETFE foil: is employed as an alternative to glass, with a fraction of its self-weight, and hence, a fraction of weight of the supporting structure.

c: number of companies in the sector estimated to be affected by the restriction: All.
Taking the Tensinet Association as a representative group for Europe, it covers

- Membrane and foil producers, coating and weaving companies: 11
- Tensile architecture manufacturers and fabricators: 36
- Architecture and engineering offices: 40
- Software companies and products: 4
- Steelwork and ropes producers: 2
- Universities: 21
- Other: 3

To get the opinion of the TensiNet members, the following was published on www.tensinet.com:
Statement PFAS restriction:

The TensiNet Association, promoting the quality of tensile surface structures since 2000, formulates the following statement with respect to the PFAS restriction proposal:

For more than half a century, structural membranes, including PTFE-coated glass fabric, PVC-coated (with PVDF-top-coat) polyester fabric, ETFE-foils, and other variants, have found widespread use. These Fluoropolymers are classified as Polymers of Low Concern (PLC) (Henry, Barbara J, Carlin, Joseph P, et al., 2018).

Unfortunately, there is currently no alternative material with comparable performance in terms of longevity, durability, strength, and fire-resistance, and the consequences of the PFAS restriction for the tensile surface structures sector (membrane structures sector) would have a non-compensatable negative impact.

Given that tensile surface structures occupy a specialised niche, it is needed to group effort to ensure an effective communication. The TensiNet Association wants also to speak for modest companies, engineers, architects, and other stakeholders.

If you share this point of view, we cordially invite you to support the petition, thereby helping to preserve the future of membrane structure.

Outcome of the petition – 61 members signed (see annex II):

- Membrane and foil producers, coating and weaving companies: 8
- Tensile architecture manufacturers and fabricators: 17
- Architecture and engineering offices: 12
- Software companies and products: 1
- Steelwork and ropes producers: 1
- Universities: 22

d: risks of alternatives for the relevant use: currently no alternatives with comparable performance exist (see above, also mentioned in the petition statement).
(1) Thanks to the PVDF-top-coating, PVC-coated polyester membranes developed long-lasting products (up to a service life of 37 years): no alternatives offer this longevity.

(2) The durability of PTFE membrane is 40 to 50 years: no alternatives offer this longevity. Stadium owners are unlikely to accept the cost of frequent replacements within a short period.
(3) There are no other transparent resins that can replace ETFE, there is currently no substitute material with equivalent properties available.

e: For cases in which alternatives are not yet available, information on the status of R&D processes for finding suitable alternatives:
No information

f: For cases in which substitution is technically and economically feasible but more time is required to substitute:
No information

g: For cases in which substitution is not technically or economically feasible, information on what the socio-economic impacts would be:
No information

7: **Potential derogations marked for reconsideration – Analysis of alternatives and socio-economic analysis**:
No information on this topic.

8: **Other identified uses – Analysis of alternatives and socio-economic analysis**:
No information on this topic.

9: **Degradation potential of specific PFAS sub-groups**:
No information on this topic.

10: **Analytical methods**:
No information on this topic.

ANNEX I – Bibliography
State of the art documents

(all copyrights remain with the authors)

EPDs' list
- *Mehler Texnologies: EPD-MTX-20130019-IBA1-EN*
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ANNEX II - Petition

STATEMENT PFAS restriction

The per- and polyfluoroalkyl substances (PFAS) restriction proposal was pre-published on the ECHA (European Chemical Agency) portal on 7 February 2023. https://echa.europa.eu/-/echa-publishes-pfas-restriction-proposal *This so-called Universal PFAS Restriction would prohibit the manufacture, use and placing on the market of around 10 000 PFAS, including fluoropolymers, F-gases and C6 fluorotelomers.*

The TensiNet Association, promoting the quality of tensile surface structures since 2000, formulates the following statement with respect to the PFAS restriction proposal:

For more than half a century, structural membranes, including PTFE-coated glass fabric, PVC-coated polyester fabric, ETFE-foils, and other variants, have found widespread use. These Fluoropolymers are classified as Polymers of Low Concern (PLC).

Unfortunately, there is currently no alternative material with comparable performance in terms of longevity, durability, strength, and fire-resistance, and the consequences of the PFAS restriction for the tensile surface structures sector (membrane structures sector) would have a non-compensatable negative impact.

Given that tensile surface structures occupy a specialised niche, it is needed to group effort to ensure an effective communication. The TensiNet Association wants also to speak for modest companies, engineers, architects, and other stakeholders.

TensiNet members sharing this point of view have supported the petition, thereby helping to preserve the future of membrane structure.

List

Out of 116 members 61 signed the petition (which was online for 2 weeks - version 25-09-2023)

Universities: 22

Robert Roithmayr	Vienna University of Technology	Austria
Evi Corne	Vrije Universiteit Brussel	Belgium
Marijke Mollaert	Vrije Universiteit Brussel (emeritus)	Belgium
Zehra Eryuruk	Vrije Universiteit Brussel	Belgium
Lars De Laet	Vrije Universiteit Brussel	Belgium
Jean-Christophe Thomas	Nantes Université	France
Jörg Uhlemann	University of Duisburg-Essen	Germany
Sarah von der Weth	IMS BAUHAUS Archineer Institutes e.V.	Germany
Karsten Moritz	IMS BAUHAUS Archineer Institutes e.V.	Germany
Heidrun Bögner-Balz	IMS BAUHAUS Archineer Institutes e.V.	Germany

Jan Cremers	HFT Stuttgart	Germany
Prof. Dr. Natalie Stranghöner	University of Duisburg-Essen, Institute for Metal and Lighweight Structures	Germany
Name not allowed to publish		Germany
Carol Monticelli	Politecnico di Milano	Italy
Alessandra Zanelli	Politecnico di Milano	Italy
Name not allowed to publish		Malaysia
Romuald Tarczewski	Wroclaw University of Science and Technology	Poland
Joao Abrantes	Anhalt University of Applied Science	Portugal
Josep Llorens	School of Architecture - Universitat Politècnica de Catalunya	Spain
Juan Monjo-Carrió	Universidad Politécnica de Madrid	Spain
Paolo Beccarelli	University of Nottingham	United Kingdom
John Chilton	University of Nottingham	United Kingdom

Membrane and foil producers, coating and weaving companies: 8

Name not allowed to publish		Belgium
Farid Sahnoune	Serge Ferrari Group	France
Name not allowed to publish		France
Katja Bernert	Mehler Texnologies GmbH	Germany
Peter Siemens	Verseidag-Indutex GmbH	Germany
Massimo Marcato	Guarniflon SPA - PATI Division	Italy
Shigenori Tamura	Chukoh Chemical Industries, Ltd.	Japan
Alexandra Sonnenberg	Sattler PRO-TEX GmbH	Österreich

Tensile architecture manufacturers and fabricators: 17

Frederic Vander Laenen	Velum AE+D bv	Belgium
Eduardo Alvarez	Etex eirl	Dominican Republic
Michael Wolf	ITF Technical Fabrics GmbH	Germany
Alena Behrmann	Vector Foiltec	Germany
Gabriele Müller	seele	Germany
Carl Maywald	Vector Foiltec Gmbh	Germany

Mathias Noatzsch	NOVUM Membranes GmbH	Germany
Kim Reinsch	Textil Bau GmbH	Germany
EulSeok Jeong	Kyoritsu Industries Co., Ltd	Japan
Andres Villasenor	Dunn LightWeight LLC	México
Rienk de Vries	Buitink Technology	Netherlands
Feike Reitsma	IASO,SL	Spain
Carlos Angulo	Carpas Zaragoza, S.L.	Spain
Name not allowed to publish		South Africa
Fevzi DANSIK	ASMA GERME	Turkey
Paul Romain	Architen Landrell Manufacturing	United Kingdom
Dirk Cos	Lightweight Manufacturing	United States

Architecture and engineering offices: 12

Amandus VanQuaille	The Nomad Concept BV	Belgium
Matti Orpana	Tensotech Consulting	Finland
Bernd Stimpfle	formTL ingenieure für tragwerk und leichtbau gmbh	Germany
Christoph Paech	sbp se	Germany
Alfredo Elías Barillas Nova	TSB-Ingenieurgesellschaft mbH	Germany
Stev Bringmann	3dtex GmbH	Germany
Giugliano Auricchio Paolo	SYNC-1 Consulting	Germany
Giancarlo Moresco	Giancarlo Moresco	Italia
Eoin Casserly	VOLUTA	Ireland
Rogier Houtman	Tentech BV	Netherlands
Javier Tejera Parra	BAT SPAIN BURO TEXTIL · Profesor at Universidad Politécnica de Madrid	Spain
Adam Bown	Tensys Ltd.	United Kingdom

Software companies and products: 1

Name not allowed to publish		Spain

Steelwork and ropes producers: 1

Chrisitian Schloegl	PFEIFER Seil- und Hebetechnik GmbH	Germany