Xylem’s position on the restriction of PFAS

Contents

1 Summary

Xylem Inc welcomes the opportunity to respond to the public consultation of proposal by five EU Member States to restrict under REACH the manufacture and use of per- and polyfluoroalkyl substances (PFASs) in the EU.

The current restriction dossier identifies a wide range of uses of PFAS, and proposes exemptions and time-limited derogations for a number of them. The ECHA public consultation makes a specific request for information about uses which have not yet been identified in the dossier. Xylem's use of PFAS in water and wastewater treatment, liquid transport, monitoring and analysis have not been identified in the current dossier, and hence are not currently proposed for derogation. This means that these uses will be banned 18 months after entry into force of the restriction. Xylem believes that the impacts of such a ban would be disproportionate and a derogation is justified. Moreover, Xylem considers that these uses of PFAS are safe and do not generate an unacceptable risk to human health or the environment which needs to be addressed at the EU level. Any risks which do occur would be more cost-effectively managed through conditions placed on manufacture, use and end-of-life.

Xylem is a globally recognised leader in providing innovative water technology solutions. It is headquartered in Washington, but has facilities (sales, distribution) in every EU country and across the globe. Xylem has research, development and manufacturing locations in Germany, Sweden, Luxembourg, Italy and Hungary. The company's diverse portfolio of products and services encompasses the entire water cycle, ranging from the collection, transportation, treatment, and distribution of water to the responsible handling of wastewater and the advancement of smart technologies for water monitoring and analysis.

Xylem is a downstream user of PFAS, more specifically fluoropolymers (including fluoropolyethers), and a global provider of high technology products and systems designed to effectively meet the demands and challenges of every aspect of water, relating to pumping, piping, metering (flow measurement), analytical instrumentation, treatment (ground, drinking and wastewater) and process control and maintenance (e.g., pipe inspection).

Xylem's products and services serve a wide range of industries and sectors including agriculture and irrigation, aquaculture, boats and recreational vehicles, commercial shipping and ship building, construction, chemicals, mining, oil and gas, pharmaceuticals and life sciences, food and drink, commercial and residential buildings, municipal drinking water treatment and supply, and municipal sewage handling and waste treatment.

Xylem uses fluoropolymers in these applications because they provide a unique **combination** of essential physical and chemical functionalities that ensure that components meet key technical and safety requirements, including:

- high chemical and thermal resistance
- elasticity
- high abrasion resistance
- resistance to fouling and biofouling
- hydrophobicity
- low coefficient of friction
- compliance with other surfaces (i.e. in valves and seals to prevent leakage)
- dielectric (electrical resistance) properties.

These properties mean the PFAS components (and hence the equipment they form part of) can operate in extremely harsh conditions (temperature and pH extremes), reliably and safely. They allow the use of highly effective pollution treatment technologies to achieve elevated levels of water quality and removal of contaminants. They enable sensitive measurement to extremely low concentrations, so that known and emerging pollutants – including PFAS – can be accurately monitored and controlled. Despite being expensive relative to traditional materials, their reliability and high performance means they are highly efficient and cost-effective, increasing process speeds and reducing energy use and maintenance requirements, and extending equipment lifetimes.

Alternative do exist, but it should be recognised that PFASs were developed and adopted directly in response to the inherent weaknesses of existing materials. Engineering and other technological improvements over time can compensate for some of these weaknesses to an extent, but the materials themselves cannot be changed and hence their weaknesses will always remain. As explained in this submission, this means that banning PFASs in these uses would inevitably lead to a reduction in performance, less effective treatment and less effective pollution control. There will be an increased risk of leakages and accidents involving substances which can be hazardous. Equipment will be less efficient, less accurate, and will last for shorter periods and need more maintenance. Many thousands of existing installations in the EU will need to be retired prematurely and replaced at significant cost.

This means a ban would be disproportionate, and a derogation from the existing proposal is justified. However, the Dossier Submitters recognise that losses of PFAS during the use stage of fluoropolymers are minimal. Emissions during the waste stage are also minimal, and can be effectively eliminated if waste is incinerated according to standards recommended in the RAC opinion of PFAS fire-fighting foams. Any emissions during the manufacture of fluoropolymers can also be minimised through the use of appropriate process conditions and workplace standards. Therefore, Xylem argues that seeking the substitution of PFAS in uses where they are critical, as is the case with the uses considered in this submissions, is not an appropriate way of addressing any risks they pose. Xylem encourages the Dossier Submitters, RAC and SEAC to undertake a more comprehensive assessment of regulatory management options and to consider measures which target the risks more directly and allow the significant societal value of these uses of PFAS to be maintained.

2 Introduction to Xylem

Xylem Inc. is a globally recognized leader in providing innovative water technology solutions. With a rich history spanning over a century, the company has consistently demonstrated its commitment to solving the world's most pressing water-related challenges. Headquartered in Washington, DC, Xylem operates as a dynamic and forward-thinking corporation with a focus on delivering sustainable and efficient water management solutions across the globe. Xylem has facilities (sales, distribution) in every EU country. Xylem also has research, development and manufacturing locations in Germany, Sweden, Luxembourg, Italy and Hungary.

Xylem's mission revolves around the fundamental importance of water in our lives. The company's diverse portfolio of products and services encompasses the entire water cycle, ranging from the collection, transportation, treatment, and distribution of water to the responsible handling of wastewater and the advancement of smart technologies for water monitoring and analysis. With a global presence and a dedicated workforce, Xylem plays a pivotal role in ensuring the availability and quality of water resources, safeguarding the environment, and empowering communities to thrive in an increasingly water-conscious world. Xylem’s core values, key business segments, and its significant impact on addressing water-related challenges on a global scale.

Xylem is a downstream user of PFAS, more specifically fluoropolymers (including fluoropolyethers)[1], and a global provider of high technology products and systems designed to effectively meet the demands and challenges of every aspect of water, from:

- pumping
- piping
- metering (flow measurement)
- analytical instrumentation
- treatment (ground, drinking and wastewater)
- process control and maintenance (e.g., pipe inspection).

Xylem has more than 17,000 employees around the world who work together with our customers to solve the most critical global water and resource challenges by providing end to end solutions with unmatched portfolio of products, solutions, and services.

Xylem has 34 brand companies (Annex A) that specialize in specific water products and services sold in more than 150 countries including the EEA as shown in Figure 1. These products can be grouped into four main categories:

- Water and wastewater treatment technologies
- Instrumentation and analytics (measurement and control)
- Pumps, valves, plumbing accessories

[1] The following fluoropolymers have been identified to be used in Xylem products: Polytetrafluorethylene (PTFE), Polychlorotrifluoroethylene (PCTFE), Fluoroelastomers (FKM, FFKM), Polyvinylidenfluoride (PVDF), Ethylentetrafluorethylen (ETFE), ethylenechlorotrifluoroethylene (ECTFE), Fluorethylenpropylene (FEP, PFEP), Tetrafluoroethylene (TFE), Perfluoroalkoxy (PFA), Fluorinated high-density polyethylene (FLPE), Fluorinated polypropylene (FLPP)

- Accessory material to the above e.g., electrical components (sensors, control panels, switches etc)

Xylem’s products and services serve a wide range of industries and sectors including:

- agriculture & irrigation
- aquaculture
- boats & recreational vehicles
- commercial buildings
- commercial pools & water parks
- commercial shipping & ship building
- construction
- environmental monitoring & analysis
- energy & power
- food & beverages
- general industry
- life sciences,
- pharma & bioprocess,
- mining & quarrying/aggregates
- municipal drinking water treatment & distribution
- municipal sewage handling & waste treatment
- oil & gas,
- residential

With deep application expertise in the water industry, Xylem uses fluoropolymers to produce highly efficient water technologies that use less energy, reduce lifecycle costs and ensure the quality and safety of drinking water and protection of the environment from the effects of polluted wastewater on users and the communities in which they operate.

Figure 1: Xylem's global presence

As currently proposed, a ban on all PFASs will have significant negative impacts on the water and wastewater industry and, as a result, European society. The impacts of a PFAS ban on many critical uses in the water and wastewater industry have not yet been identified and assessed in the Annex XV report. This is a significant limitation of the Annex XV report and is not consistent with evidence-based decision-making and the principle of better regulation. Xylem considers that the restriction proposed by the Dossier Submitters (i.e. a ban on all uses of PFASs), specifically for industrial and professional uses where risks can be controlled and releases minimised, is disproportionate, and will result in significant socio-economic challenges to the EU and unintended consequences for the provision of safe drinking water and the effective treatment of wastewaters. An alternative restriction proposal, including a derogation for the continued use of fluoropolymers in industrial and professional applications in the water industry where safety for human health and the environment are assured over their complete lifecycle, would be a more appropriate regulatory measure than a ban and would avoid disproportionate impacts to the EU.

3 Xylem's use of PFAS

Xylem uses PFAS in a great number of products across four main product categories:

- Water and wastewater treatment technologies
- Instrumentation and analytics (measurement and control)
- Pumps, valves and plumbing accessories
- Accessory material to the above e.g. electrical components (sensors, control panels, switches etc)

A list of all the brands under the four categories and a brief description of the products they produce has been included in Annex A.

Xylem uses fluoropolymers in these applications because they provide a unique **combination** of essential physical and chemical functionalities that ensure that components meet key technical and safety requirements, including:

- high chemical and thermal resistance
- elasticity
- high abrasion resistance
- resistance to fouling and biofouling
- Hydrophobicity
- low coefficient of friction
- compliance with other surfaces (i.e. in valves and seals to prevent leakage)
- dielectric (electrical resistance) properties.

Because of their relatively high cost, which varies from 2.5 times to nearly 100 times the cost of other natural or synthetic elastomers, the use of fluoropolymers is limited to a very small percentage of all applications. Uses of fluoropolymers have already been substituted where this is possible, and they are used only when absolutely necessary. A key advantage of fluoropolymer materials over alternatives is that they have excellent chemical resistance to many highly aggressive liquids (as shown, for instance, in *Figure 2*), where standard elastomers will quickly fail. Even if alternatives can offer reasonable performance under certain circumstances, the range within which performance is acceptable is often quite narrow. For instance, *Figure 2* shows that some non-fluorinated polymers can be chemically compatible at 20° C, but compatibility can fall at lower and/or higher temperatures. Fluoropolymers, however, maintain their elasticity and sealing properties at temperatures where other standard elastomers will harden, often within a few hours or days of use, and fail. Fluoropolymers are used in industrial applications when alternatives cannot offer the required combination of these properties over a wide-enough range of operating conditions.

As Xylem will demonstrate in this submission, alternatives on the market are not able to offer the required combination of properties to achieve the necessary level of performance for our uses. The use of these alternatives would lead to lower technical performance, shorter lifetimes, system failures and increased maintenance. While some alternatives might have a similar performance to fluoropolymers for a particular parameter or property, it is the **combination of properties across the operating range** that is required for our applications.

	ETFE	FEP/TFE/FPA	FLPE	FLPP	HDPE	LDPE	PC	PETG	PP	PVC	TPE***
Acids, Dilute or Weak	E	E	E	E	E	E	E	G	E	E	G
Acids, **Strong/Concentrated	E	E	G	G	G	G	G	N	G	G	F
Alcohols, Aliphatic	E	E	E	E	E	E	G	G	E	G	E
Aldehydes	E	E	G	G	G	G	G	G	G	G	G
Bases/Alkali	E	E	F	E	E	E	N	N	E	E	F
Esters	G	E	G	G	G	G	N	G	G	N	N
Hydrocarbons, Aliphatic	E	E	E	G	G	F	G	G	G	G	E
Hydrocarbons, Aromatic	G	E	E	N	N	N	N	N	N	N	N
Hydrocarbons, Halogenated	G	E	G	F	N	N	N	N	N	N	F
Ketones, Aromatic	G	E	G	G	N	N	N	N	N	F	N
Oxidizing Agents, Strong	E	E	F	F	F	F	F	F	F	G	N

*Not for tubing chemical resistance (except PVC) **Except for oxidizing acids (See oxidizing agents, strong) ***TPE gaskets

EXCELLENT
30 days of constant exposure causes no damage. Plastic may tolerate for 30 years.

GOOD
Little or no damage after 30 days of constant exposure to the reagent.

FAIR
Some effect after 7 days of constant exposure to the reagent. The effect may be crazing, cracking, loss of strength or discoloration.

NOT RECOMMENDED
Immediate damage may occur. Depending on the plastic, the effect may be severe crazing, cracking, loss of strength or discoloration, deformation, dissolution or permeation loss.

Figure 2: Classes of Substances at 20°C, Chemical Compatibility Chart[2]

***ETFE**=Ethylene tetrafluoroethylene, **FEP**=Fluorinated ethylene propylene, **TFE**=Tetrafluoroethylene, **FPA**=Perfluoroalkoxy alkanes, **FLPE**=Fluorinated Polyethylene, **FLPP**=Fluorinated polypropylene, **HDPE**=High-density polyethylene, **LDPE**=Low-density polyethylene, **PC**=Polycarbonate, **PETG**=Polyethylene terephthalate glycol, **PP**=Polypropylene, **PVC**=Polyvinyl chloride, **TPE**=Thermoplastic elastomer*

Many of these alternative substances were used in the applications Xylem services decades ago, but were replaced by fluoropolymers which were developed in direct response to the inherent weaknesses in those alternatives. Therefore, banning fluoropolymers to force a return to these older materials will inevitably mean having to accept a reduction in performance. Some technological and engineering improvements might be able to compensate to an extent, but the performance weaknesses of these older materials are inherent and cannot be changed.

Moreover, even if a new alternative can be identified – or even if an existing, older material is to be reintroduced – it will still need to be certified for use in drinking water applications, which entails testing the materials regarding functionality i.e., performance, stability and quality; obtaining certification from drinking water authorities for materials and components and having the water system in which they will be used validated. This is a drawn-out, time-consuming process, and it is estimated it would take a minimum of 10 years from finding a new alternative to being ready to launch a new certified and validated product.

A ban on the use of PFAS will consequently result in disproportionate impacts to society unless uses in water and wastewater applications are specifically acknowledged and differentiated appropriately.

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[2] Chemical Compatibility Chart - LDPE, HDPE, PP, Teflon Resistance (calpaclab.com)

Due to the diverse use of fluoropolymers in Xylem's products and the short time for the public consultation, we are unable to cover all the uses extensively. In this submission, we will demonstrate the uses of fluoropolymers in the three of the identified main categories using specific examples of water and wastewater treatment (ultraviolet (UV) and ozone systems, chlorination), analytical equipment and pumps. We outline the combination of properties (e.g. thermal and chemical resistance, corrosion and wear resistance) that the materials used in these applications should meet to ensure reliability and proper functioning. While we only use a few examples to illustrate the harsh operating conditions for different Xylem products for which fluoropolymers are critical, these conditions are applicable to the other sectors our products are used in.

In the rest of this section, we will describe Xylem's broad uses of PFAS, the conditions they are required to operate in, and how alternatives compare, in three example applications: water and wastewater treatment; analytical instrumentation; and pumps.

3.1 Water and wastewater treatment

Xylem has a wide range of water and wastewater treatment technologies that enable the water utility industry to monitor and treat water and waste water to eliminate contaminants, including micropollutants and contaminants of emerging concern such as 1,4-dioxane and PFAS. This equipment is also used by industries and companies which have their own specific requirements for water and wastewater treatment (e.g. food and beverages). Xylem provides a wide range of utility water purification solutions: clarification; filtration; disinfection as well as micropollutant, taste and odour removal. The solutions include technologies such as granular activated carbon (GAC), UV, ozone and chlorination.

The components where fluoropolymers are used include:

- Seals e.g. in ozone and UV reactors
- Valves
- Pumps
- Membranes
- Electrical components e.g. switches
- Wiper-rings, spindle interfaces, lamp connectors in UV,

Figure 3: Use of fluoropolymers in water treatment systems components

PFAS is used in various components of these water and wastewater treatment systems due to the combination of their unique properties and performance – thermal and chemical resistance, and abrasion and wear resistance. These are required for a number of reasons – for instance, the reactivity of the process chemicals used in treatment, and the installation conditions and situation of the equipment.

The use of materials in Xylem products is regulated by existing regulations. In the EU, the Drinking Water Directive (DWD) 98/83/EC[3] which was recently revised and entered into force on the 12th of January 2021: Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption (recast), provides a framework for quality standards for European drinking water and applies from the source to the tap, including treatment, materials and products used in contact with water used for drinking, cooking, food preparation, and other domestic purposes. The DWD sets out an obligation for European Union Member States (MSs) to protect human health against any deterioration of water quality related to materials in contact with drinking water. Essential quality standards are set at the EU level and cover microbiological, chemical, physical and aesthetic parameters (taste, odour, colour, etc.).

The new Article 11 of the EU Drinking Water Directive "*Minimum hygiene requirements for materials that come into contact with water intended for human consumption*" obliges EU MSs to draw up European positive lists and to monitor the substances or materials used in contact with drinking water. In each MS, national or local authorities can set standards higher than those of the DWD or include additional requirements relevant within their territory. MSs are however not allowed to set lower standards than the DWD, as the level of protection of human health should be at least this minimum within the whole European Union.

The use of several PFAS materials has been approved in different MSs for use in drinking water applications according to national standards and in line with the Drinking Water Directive. PTFE and FKM are approved in Germany by the German Technical and Scientific Association for Gas and Water (DVGW) and PTFE in France by Standard "Attestation de Conformité". PTFE is currently under review to be included in the combined list of the four Member State initiative (4MSI)[4]. PTFE, ETFE and FKM are also approved in the United Kingdom (UK) by WRAS (ETFE is also approved) and in the USA by the National Science Foundation (NSF Ansi 61). Xylem's materials and products used in drinking and process water applications and that are in contact with the water throughout the entire water cycle i.e. pumping, piping, measuring, analyzing, treatment (ground, drinking and wastewater) and maintenance (e.g., pipe inspection), comply with these standards and do not release any substances into the drinking water that would adversely affect it. Thus, there is no concern reported for these kinds of fluoropolymers in drinking water applications.

PTFE is also authorised under requirements laid down in Regulation (EU) no 10/2011 on plastic food contact materials and other specific national requirements. PTFE is authorised under this regulation on the grounds that leach rates are below a maximum threshold and any leachate is non-toxic. In Annex B of the PFAS restriction proposal, the DSs recognise that emissions of PFAS from fluoropolymers in the use phase are minimal.

Two principal approaches to water and wastewater treatment will be described in the following sections: treatment based on the use of UV and ozone; and, treatment based on chlorination. Both

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:01998L0083-20151027&from=EN#:~:text=This%20Directive%20concerns%20the%20quality,it%20is%20wholesome%20and%20clean.

[4] The initiative was announced in January 2011 as initiative of France, Germany, the Netherlands and the United Kingdom (4MS) to work together on harmonization of tests for the hygienic suitability of products in contact with drinking water to ensure the hygienic safety of drinking water. Denmark joined in 2018, and the UK left the EU in 2020, so the organisation was renamed the 4 Members States Initiative (4MSI).

of these approaches involve harsh substances and operating environments which make PFAS necessary for safe and effective processes.

3.1.1 UV and Ozone

UV water treatment is a chemical-free technology that is acknowledged to be the best in class for numerous disinfection tasks in drinking water and wastewater treatment. UV radiation at 260 nm is the most effective wavelength for the inactivation of a majority of microorganisms. The occurrence of significant differences in microbial response and an increased potential for by-product formation should also be noted at wavelengths below 240 nm.[5] UV disinfection is most typically used at the end of industrial and municipal water disinfection processes (drinking water, process water and even wastewater).

[5] https://www.dwi.gov.uk/private-water-supplies/pws-installations/uv-systems/

Table 1: Applications of UV and Ozone in water treatment

Area	Application	Specific function
Industrial	Algae treatment	Taste & Odour removal
		Removal of algae by separation (e.g. flotation, filtration)
	AOP & REUSE	Advanced Oxidation Processes
		REUSE
	Aquaculture	Aquarium / Zoo
		Recirculating aquaculture systems (RAS) circuit processes
		Limit value
	Food & Beverage	Disinfection
		Rinsing
		Bottling
		Process water conditioning
		Washing processes
	Cooling water circles	Disinfection and biofilm reduction
	Exhaust air treatment	Odour removal e.g. H_2S removal
		NOx removal
	Pharmaceutical industry	Conditioning
		Water for injection (WFI)
	Pulp & Paper	General
	Inorganic oxidation	Iron removal
		Manganese removal
		Nitrite (NO2-) Oxidation
		Hydrosulfide H2S reduction
		Ammonium (NH4+) Oxidation
	Industrial wastewater	COD Reduction
		Decolorisation
		Deodorisation
	Laminating	Laminating
	Ozonolysis	Ozonolysis
Municipal	Drinking water	Disinfection
		Surface water (Pre-Oxidation)
		Surface water (Main-Oxidation)
		Ground water i.e. water from aquifers e.g. wells
		Iron removal
		Manganese removal
		Nitrite (NO2-) Oxidation
		Hydrosulfide H2S reduction
	Excess sludge	Sludge disintegration
	Landfill leachate	COD reduction
	Municipal wastewater	COD reduction
		Micropollutant removal
		Disinfection of secondary treated wastewater
		Disinfection by UV
		Nitrite (NO2-) Oxidation
		Hydrosulfide H2S reduction
	Swimming pool water	UV application

Ozonation is an Advanced Oxidation Process (AOP) based on ozone gas generation and its dissolution into polluted water. It is used for both disinfection and treatment of micropollutants. Ozone is a powerful oxidant able to degrade or mineralize inorganic and organic matter. When the process is carried out at neutral or acidic pH, the ozone selectively attacks certain organic substances, whereas at pH of 9 or higher, hydroxyl radical (●OH) is generated. Hydroxyl radical is one of the most powerful oxidant species, which has the capacity to non-selectively degrade, or also mineralize, different types of organic matter[6]. Ozone is generated by passing high voltage electric arcs (basically "controlled lightning") through a stream of very clean and dry air or concentrated oxygen inside a closed vessel. Irrespective of the type of treatment, ozone is generated *in-situ* (on demand) so there is no need for storage of potentially dangerous chemicals (as opposed to chlorination).

UV/O_3 can cause the photolysis of certain organic compounds and inactivate microorganisms[7]. For the highest quality and safety requirements on water quality (*drinking water, process water for food and beverage or pharmaceutical uses or re-use waters for different purposes*), the combination of these treatment steps (*ozone and subsequent UV*) builds the optimal treatment for high disinfection requirements (e.g., 4 log or higher log reduction of bacteria, virus, parasite reduction). When combined with UV, simultaneously or successively, the dissolved ozone molecules absorb UV light with a peak absorbance of 260 nm and a molar absorptivity of 3292 ± 70 M/cm[8], thus making ozone undergo photolysis reactions to yield hydrogen peroxide[9]. The combination of UV and ozonation produces a greater quantity of hydroxyl radicals and other reactive oxygen species (ROS) compared with separate processes.

Xylem supplies UV and ozone equipment to be used extensively in various applications as demonstrated in **Error! Reference source not found.**. The components used in these systems must possess specific properties to withstand the conditions of the operating environment, to ensure proper functioning of the system and the safety of operators, and to meet drinking water standards.

For ozone equipment, since ozone is a very strong oxidant, it reacts very quickly with many other chemicals and materials and therefore all materials that are in contact with this gas must be highly resistant to corrosion. Poor quality materials will cause ozone leaks or react with the gas and contaminate the water. Materials must be able to perform at cryogenic/ultracold temperatures, because ozone equipment uses liquefied oxygen at -183 celsius. This has to be considered for all components in the ozone system including the ozone generator. Likewise, components of UV systems demand the use of materials with high resistance to aggressive media i.e. strong UV irradiation. The combination of high chemical resistance and structural flexibility is needed for components such as seals, valves, connectors and gaskets, in UV and Ozone applications.

The combination of these specific features of fluorinated polymers coupled with low friction characteristics makes fluoropolymers such as PTFE, PFA, PCTFE FFKM and FKM ideal for use in manufacture of UV and Ozone components as shown in Figure 4. Fluoropolymers are essential for

[6] https://mp.watereurope.eu/d/technology/1026/
[7] Bajpai, P., Chapter 7 - Emerging Technologies for Wastewater Treatment. In: Bajpai, P (Ed.). Pulp and Paper Industry., 2017
[8] Hart et al., 1983
[9] Beltrán, F. J., Ozone reaction kinetics for water and wastewater systems, 2004

guaranteeing equipment safety and integrity, preventing ozone gas emissions, and ensuring adequate lifetime and performance.

OZONE ENGINEERING INFORMATION

IOA

MATERIALS AND OZONE COMPATIBILITY GUIDELINES

Guideline: 30010A
Date: 04/22/2013
Rev: 1

Object and Range of application
Guidelines for excellent/good compatibility of materials in contact with ozone dry gas in concentration up to commercial concentration limit of 14% by weight to date.
These are general guidelines which may not apply to every circumstance. The only way to ensure computability is to perform exposure test on samples replicating the environment expected. For more information, contact ozone equipment suppliers or consulting firms, material suppliers.

In the followings $[O_3]_g$ stands for ozone concentration of the dry gas, ✔ stands for excellent/good.

METALS
Typically used for piping

Ozone Concentration (% by Weight)	$[O_3]_g < 2\%$	$2\% < [O_3]_g < 10\%$	$10\% < [O_3]_g > 14\%$
316 L Stainless Steel	✔	✔	✔
Hastelloy-C	✔	✔	✔

PLASTICS
Typically not used for large-scale industrial or small or large municipal applications

Ozone Concentration (% by Weight)	$[O_3]_g < 2\%$	$2\% < [O_3]_g < 10\%$	$10\% < [O_3]_g < 14\%$
Polyvinyl chloride PVC	✔		
Chlorinated polyvinyl chloride CPVC	✔		
Polyvinylidene fluoride PVDF	✔	✔	✔
Ethylene chlorotrifluoroethylene ECTFE	✔	✔	✔
Polytetrafluoroethylene PTFE	✔	✔	✔
Polyether ether ketone PEEK	✔	✔	

Note: Structure consideration need to be evaluated

ELASTOMERS
Typically used for gaskets

Ozone Concentration (% by Weight)	$[O_3]_g < 2\%$	$2\% < [O_3]_g < 10\%$	$10\% < [O_3]_g < 14\%$
Ethylene propylene diene monomer EPDM	✔		
Silicone	✔		
Fluorosilicone	✔	✔	
Fluoroelastomer FPM (VITON) FKM	✔	✔	
Fluoroelastomer FKM FFKM	✔	✔	✔
Perfluoroelastomer KPFE (KALREZ)	✔	✔	✔
Polychlorotrifluoroethylene PCTFE (Kel-F)	✔	✔	✔

Note 1: These guidelines apply to dry ozone gas. Wet gas is generally more aggressive towards any material.
Note 2: In conditions where ozone concentration is higher than 14 % independent validation should be persued.

Useful Reference
Sleeper and Henry, "Durability Test Results of Construction and Process Materials Exposed to Liquid and Gas Phase Ozone", *Ozone: Science & Engineering*, 24:249-260 (2002).

Figure 4: Materials and ozone compatibility: International Ozone Association

Figure 4 suggests that some non-fluorinated polymers might be suitable for ozone engineering at lower concentrations. However, It is also important to note that ozone concentrations lower than 8% wt. are rarely used now due to technology advancements and commercial viability of the ozone systems. Higher ozone concentrations permit higher levels of treatment more quickly and more cheaply. Current typical designs operate within 10-16% wt. with some as high as 21% wt. and thus the corrosion resistance of the materials used is even more relevant. While some alternatives might have a similar performance to fluoropolymers for a particular parameter or property, it is the combination of different properties that is required for the UV and ozone applications where fluoropolymers are used. At these concentrations used in modern ozonation equipment, as indicated by Figure 4 and Figure 5 (which provides further compatibility guidance from a specialist plastics supplier for piping, pumps etc)[10], non-fluorinated polymers do not work.

Chemical	Concentration (%)	Temp. °C	Temp. °F	PVC	CPVC	PP	PVDF	PTFE/PFA	VITON®	EPDM	NITRILE
Ozone Gas O_3	7000 ppm	20	68	X	X	X	B	A		B	
		40	104					A			
		60	140					A			
		80	176								
		100	212								
		120	248								
Ozone Solution (Aqueous) O_3	10 ppm	20	68	A	A	B	A	A	A	A	
		40	104	A	B	B	A	A	A	A	
		60	140	B	B		A	A	B	B	
		80	176				A	A			
		100	212								
		120	248								
Ozone Solution (Aqueous) O_3	0.5 mg/l	20	68	A	B	X	A	A	A	A	
		40	104	A	B		A	A	A	A	
		60	140	B			A	A	B	B	
		80	176				A	A			
		100	212								
		120	248								

Figure 5 Materials and ozone compatibility: Polymer supplier

Forcing their use through a ban on PFAS in this application would therefore require the acceptance of lower treatment standards and higher treatment costs. PFAS materials permit higher concentration operation at higher temperatures and volumes for longer periods between maintenance and over longer operating lifetimes. Using non-fluorinated polymers would mean equipment was smaller (and hence more units would be required for the same volume), slower (so more energy was required for the same level of treatment), requiring more maintenance (and hence more downtime) and more prone to accidents, leaks etc.

An alternative technology for disinfection of water is chlorination but these systems also rely on fluoropolymers in their systems as will be illustrated in section 3.1.2. Ozone will inactivate many of the same pathogens and oxidize many of the same compounds that chlorine will. However, when ozone reacts with these compounds, it does not generate the same harmful byproducts, like trihalomethanes (THMs) and haloacetic acids (HAAs) that the reaction with chlorine will generate.

3.1.2 Chlorination

[10] https://www.chemline.com/wp-content/uploads/Chemline.Chemical-Resistance-Guide.2020.pdf

Chlorination is a form of chemical water disinfection which is quite common for the treatment of water in the municipal sector (drinking water), industry and aquatics. It encompasses the following forms of chlorine:

- Chlorine gas
- Sodium hypochlorite
- Calcium hypochlorite
- Chlorine dioxide

Chlorine and chlorine dioxide have the benefit of the so-called “depot effect”, as they not only affect the water at their point of injection but also over a certain length of pipe or an entire body of water (e.g. a swimming pool). This mitigates the risk of re-germination after the actual treatment.

Chlorine and chlorine dioxide are injected into the water by different means. In most cases dosage is handled by a control signal from an analyzer and control system with corresponding sensors. The most common methods of dosing are (depending on the form of chlorine):

- Vacuum systems in combination with a venturi injector (chlorine gas)
- Diaphragm pumps (sodium hypochlorite, chlorine dioxide, calcium hypochlorite)
- Diaphragm pumps in combination with a feeder device to create the solution from dry product (calcium hypochlorite)

All types of chlorination, i.e. chlorine (in one of the above forms) and chlorine dioxide, are based on strong oxidants which are highly corrosive in concentrated form. The actual degree of wear and tear imposed on components and equipment is strongly depending on the actual chlorine concentration and other factors like pH or the presence of humidity/water. The following PFAS materials are used in at least one component/part of the chlorination process for either of the chlorination types:

- FKM
- PVDF
- PTFE
- ECTFE

The full list of fluoropolymer applications used is shown in Table 2.

Table 2: Use of fluoropolymers in chlorination systems in Xylem's Evoqua brand

Product/Component and fluoropolymer	End use	Product functionalities to be fulfilled
O-rings (FKM, FFKM)	Static and dynamic sealing of hydraulic interfaces	- Chemical resistance and dimensional stability against acids, moist chlorine gas, chlorine dioxide, sodium hypochlorite solution over a temperature range (5 – 70 °C) - Elasticity / impermeability
Flat gaskets (FKM, PTFE)	Static sealing of hydraulic interfaces	- Chemical resistance and dimensional stability against acids, moist chlorine gas, chlorine dioxide, sodium hypochlorite solution over a temperature range (5 – 70 °C) - Elasticity (FKM only) / Tightness
Flexible hoses (PTFE)	Routing of chemical streams	- Chemical resistance and dimensional stability against acids, moist chlorine gas, chlorine dioxide, sodium hypochlorite solution over a temperature range (5 – 70 °C)

Product/Component and fluoropolymer	End use	Product functionalities to be fulfilled
		- Maintaining flexibility - Compressive strength
Valve seats (PTFE, PVDF)	Dynamic sealing in valves (e.g. check valves)	- Chemical resistance and dimensional stability against acids, moist chlorine gas, chlorine dioxide - Optimum strength
Flexible Membrane (FKM, PVDF, ECTFE)	Diaphragm metering pumps Pressure or vacuum control valves	- Chemical resistance and dimensional stability against acids, moist chlorine gas, chlorine dioxide - Optimum strength - Maintaining flexibility
Ion selective membrane (PTFE)	Chloralkali electrolysis	- Chemical resistance to acids, alkalis, moist chlorine gas at temperatures up to 70 °C - Preservation of ion selectivity according to the application
Fittings (PVDF, ECTFE)	Routing chemical flows in piping systems	- Chemical resistance and dimensional stability against acids, moist chlorine gas, chlorine dioxide, sodium hypochlorite solution over a temperature range (5 – 70 °C) - Weldability - Compressive strength
Pipes (PVDF)	Chloralkali electrolysis	- Chemical resistance and dimensional stability against acids, moist chlorine gas, chlorine dioxide, sodium hypochlorite solution over a temperature range (5 – 70 °C) - Weldability - Compressive strength
Molded parts (PVDF, ECTFE)	Chloralkali electrolysis	- Chemical resistance and dimensional stability against acids, moist chlorine gas, chlorine dioxide, sodium hypochlorite solution over a temperature range (5 – 70 °C) - Weldability - Compressive strength
Grease (PTFE)	Lubrication of sliding joints and seals	- Reduction of friction in sliding joints in contact with acids, chlorine dioxide and alkalis - Improvement of the sealing of O-rings in contact with brine
Packing (PVDF)	2-phase reactors	- Chemical resistance and dimensional stability against acids, alkalis, moist chlorine gas, chlorine dioxide, sodium hypochlorite solution over a temperature range (5 – 70 °C)
Float switch (PVDF)	Chloralkali electrolysis, chemical tanks	- Chemical resistance and dimensional stability against acids, alkalis, moist chlorine gas, chlorine dioxide, sodium hypochlorite solution over a temperature range (5 – 70 °C)
Flow meter (PVDF)	Chlorine dioxide preparation	- Chemical resistance to acids, alkalis, chlorine dioxide - Compressive strength
Thread sealing tape (PTFE)	Sealing of threaded connections	- Chemical resistance and dimensional stability against acids, alkalis, moist chlorine gas, chlorine dioxide, sodium hypochlorite solution over a temperature range (5 – 70 °C)

Chlorine gas

Pure chlorine gas as provided to the market is pressure liquified and contains no water. This makes it possible to store in ordinary steel vessels with the appropriate pressure rating. The liquified chlorine rapidly vaporises at the point of pressure relief.

The corrosiveness of chlorine gas changes significantly when combined with moisture/water. This is referred to as “wet chlorine” as opposed to “dry chlorine” in the literature. While ordinary steel pipes can withstand dry gaseous chlorine, they are quickly attacked and subsequently destroyed if moisture is present. This is because when in media containing the anion chloride, stainless steels may suffer mainly localized corrosion (for example, pitting). In this case, the corrosive attack will cause gaps in the metal passivation film[11,12]. The formation speed of these gaps increases with the temperature and the concentration of chlorides in the medium the steel is in.

As water is in close proximity by definition in chlorination processes, the avoidance of moisture in the manifold is next to impossible. Therefore, the occurrence of wet chlorine must be accounted for in most parts of the chlorination equipment. This causes significant chemical wear and tear on pipes, valves, gaskets and other equipment in contact with wet chlorine.

Sodium hypochlorite and calcium hypochlorite solution

Both sodium hypochlorite and calcium hypochlorite are dosed into the treated water by appropriate metering pumps. Adding dry calcium hypochlorite directly into large bodies of water (e.g. swimming pools) is possible in theory but is not considered technically sound or controlled. The pH can vary but is generally in the alkaline range. The combination of pH, temperature and chlorine concentration in the solution has a significant impact on the corrosive behavior of the dosed solution. The corrosion potential increases with lower pH, higher temperature and higher chlorine concentration. Hence chemical wear and tear can be moderate to serious.

Chlorine dioxide

Chlorine dioxide is an unstable disinfectant which cannot be stored for periods of time longer than around 48hours. It must always be produced on site by the reaction of at least two chemicals. One of these is sodium chlorite ($NaClO_2$), while the other reactant can either be chlorine or an acidic substance, most commonly hydrochloric acid (HCl). The resulting chlorine dioxide solution is always in the acidic range. Chlorine dioxide has a strong tendency to degas from the liquid which creates special requirements for (temporary) storage.

Chlorine dioxide has a significantly higher disinfection potential compared to chlorine and is usually stored in concentrations of 1 to 3 g/l ClO_2. Concentrations inside the equipment for generating chlorine dioxide range up to 20 g/l. Due to the high corrosion potential and the acidic nature, chlorine dioxide is the most challenging sub type of chlorination when it comes to gaskets and O-rings.

[11] Li K., Sun L., Cao W., Chen S., Chen Z., Wang Y., Li W. Pitting corrosion of 304 stainless steel in secondary water supply system. *Corros. Commun.* 2022;7:43–50. doi: 10.1016/j.corcom.2021.11.010

[12]C.P. Dillon, I Warren: Materials selector for hazardous chemicals : vol 3: hydrochloric acid, hydrogen chloride and chlorine, Materials Technology Institute, St. Louis, MO (1999)

Materials compatibility for chlorination

The Chlorine Institute Pamphlet 164[13] contains a list of various materials and the corresponding reactiveness with gaseous or liquid chlorine, also considering the absence or presence of moisture. The materials with little to no reaction (i.e. sufficient chemical resistance) for all four cases (liquid chlorine dry, liquid chlorine wet, gaseous chlorine dry, gaseous chlorine wet) include:

- Asbestos
- Glass
- PTFE
- PVDF
- Resin, Chlorendic polyester
- Tantalum
- Viton (FKM)

The only elastomer on this list is FKM and the only other material suitable for gaskets is PTFE. Asbestos is banned in many countries because of its carcinogenic properties. Glass is not suitable for many applications due to its brittleness. Tantalum is a rather rare, very expensive metal, which limits its use in comparison with PFAS like PTFE or PVDF. Chlorendic polyester resin is used for lining larger tanks and vessels, limiting its use to a niche application.

Regarding non-fluorinated materials (polymers), the pamphlet assesses suitability for use with dry and wet liquid chlorine as follows. Chlorinated and unchlorinated PVC is said to have variable material integrity, depending on use conditions, with particular concerns about mechanical integrity. A similar assessment is made for EDPM (ethylene propylene diene monomer, and chlorosulphonated polyethylene. Contact with dry and wet liquid chlorine is said to 'jeapordise' the material integrity of neoprene, polyethylene, polypropylene, silicone, and natural and synthetic rubber.

[13] https://files.dep.state.pa.us/water/BPNPSM/WastewaterOperations_Assistance/WastewaterOperatorResources/CourseMaterials/RespCWProf_7122/Resources/Chlorine/Pamphlet164-Edition2-August2007.pdf

Chemical	Concentration (%)	Temp. °C	Temp. °F	PVC	CPVC	PP	PVDF	PTFE/PFA	VITON®	EPDM	FKM-C
Chlorine Dioxide ClO_2	14 gm/li	20	68	A	A	C	A	A	A*		A
		40	104	A	B	X	A	A			B
		60	140	B	B		A	A			
		80	176					A			
		100	212					A			
		120	248					A			
Chlorine Gas Cl_2	** Wet	20	68	A	A	X	A	A	X	X	A
		40	104	A	B		A	A			
		60	140	B	C		A	A			
		80	176				A	A			
		100	212				A	A			
		120	248				A	A			
Chlorine Gas (up to 150 ppm moisture) Cl_2	Dry	20	68	A	A	X	A	A	B	B	
		40	104	A	A		A	A	C	X	
		60	140	A	A		A	A	X		
		80	176				A	A			
		100	212				A	A			
		120	248				A	A			

Figure 6: Chlorine materials compatibility: Polymer supplier

The materials compatibility guidance issued by a polymer supplier, previously referenced (fn.10), supports this assessment, and indicates that the operating conditions which prevent PVC being a suitable material is higher temperature (see Figure 6). Non-fluorinated polymers are not recommended by this supplier for use at temperatures above 60°C. However, Table 2 indicates an operating range up to 70°C for Xylem's chlorination equipment. The chlorination process, specifically in the context of water treatment and disinfection, typically operates towards the top end of the 5-70°C (41-158°F) range for a number of reasons. For instance, higher temperatures lead to increased reaction rates, meaning faster and more cost-effective treatment. It might also be necessary to ensure treatment meets regulatory standards.

As with UV and ozone, forcing the use of non-fluorinated materials in chlorination through a ban on PFAS would mean lower treatment standards and higher treatment costs. Equipment would become shorter-lived, and more subject to breakdown and accidents.

3.2 Instrumentation and analytics

Xylem manufactures analytical monitoring and process control equipment that use PFAS components. Xylem's customers for this equipment include testing laboratories for environmental samples, water management offices, utilities in the drinking water and wastewater area (municipal and industrial) and authorities.

According to REACH Article 67(1), restrictions do not apply to the manufacture, placing on the market or use of substances in scientific research and development (SR&D). REACH Article 3(23) defines SR&D

as any scientific experimentation, analysis or chemical research carried out under controlled conditions in a volume less than one tonne per year. Article 67(1) also states that Annex XVII shall specify if a restriction shall not apply to product and process orientated research and development (PPORD). Article 3(22) defines PPORD as meaning any scientific development related to product development or the further development of a substance, on its own, in mixtures or in articles in the course of which pilot plant or production trials are used to develop the production process and/or to test the fields of application of the substance.

Thus, in principle it could be argued that Xylem's use of PFAS polymers in the production and supply of analytical equipment and instrumentation is exempt from the proposed restriction on the grounds that they are used for SR&D (and PPORD). However, this is subject to some uncertainty. In particular, despite the general exemption of SR&D in Article 67(1), the Dossier Submitters have proposed derogations for uses which appear to already be covered by this exemption,[14] so it is not clear how the definition of SR&D should be interpreted and where the exemption applies. In addition, the Dossier Submitters have not currently made a proposal to exempt PPORD, and under what conditions. Finally, there is no definition of controlled conditions in REACH and hence it is not possible to assess whether Xylem's uses of PFAS would class as such.

Thus, it is not currently clear that Xylem's uses of fluoropolymers in analytical equipment and instrumentation is exempt through the SR&D (and/or PPORD) exemption. Accordingly, Xylem is presenting the evidence and arguments around this application in this section with a view to establishing the case for exemption and/or derogation on other grounds.

Fluoropolymers are used in the following components in analytical equipment:

- Sealing tapes (PTFE)
- Valves, gaskets (e.g. PCTFE)
- Lubricants based on fluorinated compounds
- Membranes and foils (FEP, ETFE)
- Pistons in automatic titrators (PTFE)
- Tubing (ETFE)
- Electrical isolations (ETFE)

These components are used specifically in measuring instruments that serve applications in the environmental sector. This applies to the control of groundwater and drinking water, the monitoring of the chemical quality of rivers, lakes and seawater and the control of wastewater treatment plants. Measured variables include pH, oxygen content, conductivity, organic pollution (biological oxygen demand (BOD), chemical oxygen demand (COD)) and concentration of nutrients such as nitrate and phosphate. The instruments thus serve to ensure the supply of high-quality drinking water and the treatment of wastewater in accordance with regulations in order to prevent harmful emissions into the environment.

PFAS are of paramount importance in water analysis due to their unique material properties that set them apart from other compounds such as:

- chemical resistance (acids, alkalis (bases), organic chemicals, organic solvents)

[14] For instance, Paragraph 5(g) of the restriction proposal states that the restriction shall not apply to refrigerants in laboratory test and measurement equipment until 13.5 years after EiF.

- low adhesiveness (glueing requires that no chemical reactivity occurs under the conditions of use)
- low adsorption of measurands (improving analytical quality in respective instruments)
- high temperature resistance
- high electrical resistance
- extreme low friction and good gliding properties (no relevant difference between sliding friction and static friction)
- durability
- gas permeability (especially for oxygen, hydrogen, chlorine, ammonia etc.).

Their outstanding chemical resistance allows them to remain intact in environments with extremely acidic or basic pH, without reacting, which is essential for accurate and reliable analysis results and equipment reliability and durability. This is complemented by their high thermal stability that meets the requirements of numerous analytical methods, where temperature fluctuations are prevalent.

Moreover, the non-stick properties of PFAS significantly reduce the risk of sample loss or carry over due to adhesion, especially with sticky or viscous samples, which could lead to sample contamination and measurement error with other materials. Their low tendency for molecular adsorption ensures that trace contaminants in water samples can be precisely analysed without being compromised by undesirable adsorption effects. Finally, the chemical inertness of PFAS reduces the risk of cross contamination between samples, which is crucial in water analysis.

The proven long-term stability of PFAS materials, including their resistance to UV light, means that equipment using these materials can deliver consistent performance over extended periods e.g. most of Xylem's products have a 20 year life cycle. This is particularly important for applications like wastewater monitoring, where the location of instruments makes them difficult to access, hindering maintenance and repair, and where gradual deterioration of performance might be difficult to detect but could have significant consequences.

Xylem's analytical equipment is also used in detecting and measuring PFAS in environmental samples including water and groundwater, contaminated soil etc. This requires expensive instrumentation like High Pressure Liquid Chromatography (HPLC), mass spectrometry (MS), etc. which also require high-performance valves and tubing made of fluoropolymers because of their strong chemical resistance. For example, HPLC uses acetonitrile, methanol, phosphoric and trifluoracetic acids and operates at high pressure. Fluropolymers are used because they are able to offer these properties which enable the instruments to function.

There is in fact an urgent requirement for more sensitive and cheaper analytical instruments in future, for instance, to monitor emerging pollutants (including PFAS) in the environment and particularly in drinking water. Pollutant properties related to persistence, mobility and toxicity (PMT) are of increasing interest. The requirement for ultratrace (parts per trillion (ppt)) detection of PFAS is extremely challenging, due to the extreme potential for contamination, carry over, and chemical reactivity at such low concentrations. As a result, current methods require complex and specialized off-site equipment, effectively precluding the on-site monitoring of PFAS in distributed water infrastructures currently[15].

It is highly unlikely that systems that are required to operate in the ppt concentration range for the sampling and detection process itself will be possible without fluoropolymer parts. An example of

[15] *Concellón, Castro-Esteban, Swager; J. Am. Chem. Soc.* 2023, 145, 20, 11420–11430; DOI: 10.1021/jacs.3c03125

available technology that is used is the amplifying fluorescent polymers (AFPs) which are highly fluorinated and have poly(*p*-phenylene ethynylene) and polyfluorene backbones bearing pyridine-based selectors that react with acidic PFAS via a proton-transfer reaction. AFPs are available in thin-film and nanoparticle forms and can selectively detect PFAS concentrations of ∼1 ppb and ∼100 ppt, respectively and are not affected by the type of water being studied. Effective performance at these concentrations would simply not be possible with conventional materials.

The development and use of PFAS materials in analytical equipment has allowed progressive improvements in performance which allows for the detection and monitoring of a greater range of substances and concentrations much lower than were previously possible. Banning their use would force a return to old materials and old levels of performance.

3.3 Pumps

Xylem manufactures pumps that use fluoropolymer-based seals and gaskets to contain, move, and measure fluids at high temperature and high pressure. Xylem provides pumping solutions for drinking water and wastewater transfers that reduce energy use, minimise water losses, and save water resources. Xylem provides pumps that are used in various industries including but not limited to municipal drinking water distribution, municipal wastewater handling, agriculture (e.g., irrigation), industrial applications including food and beverages and chemicals, aquaculture, and commercial and residential buildings. The components in pumps made of fluoropolymer include sealings, bearings, cable sheaths, coatings, pump inserts and membranes (see Figure 7).

Fluoropolymer materials in pumps offer the required combination of chemical resistance (e.g strong cleaning agents in food and beverage industries), abrasion and wear resistance which can improve efficiency and prolong the life of the pump. Temperature stability, PFAS materials can maintain their properties at extreme temperatures, both high and low, making them suitable for pumps that operate in environments with temperature variations, ensuring consistent performance under challenging conditions, such as chemical processing plants. which makes fluoropolymer containing materials the preferred option. Examples of specific uses of Xylem pumps across various applications are:

- Water Supply and Treatment:
  - Municipal water supply: Xylem pumps are used to transport water from source locations (e.g., wells, rivers, lakes) to municipal water treatment plants and distribution systems.
- Wastewater Management:
  - Wastewater treatment plants: Xylem provides pumps for sewage and wastewater treatment facilities, including those used for lifting, aeration, and moving wastewater through treatment processes.
  - Stormwater management: Xylem pumps help manage stormwater runoff, preventing flooding in urban areas.

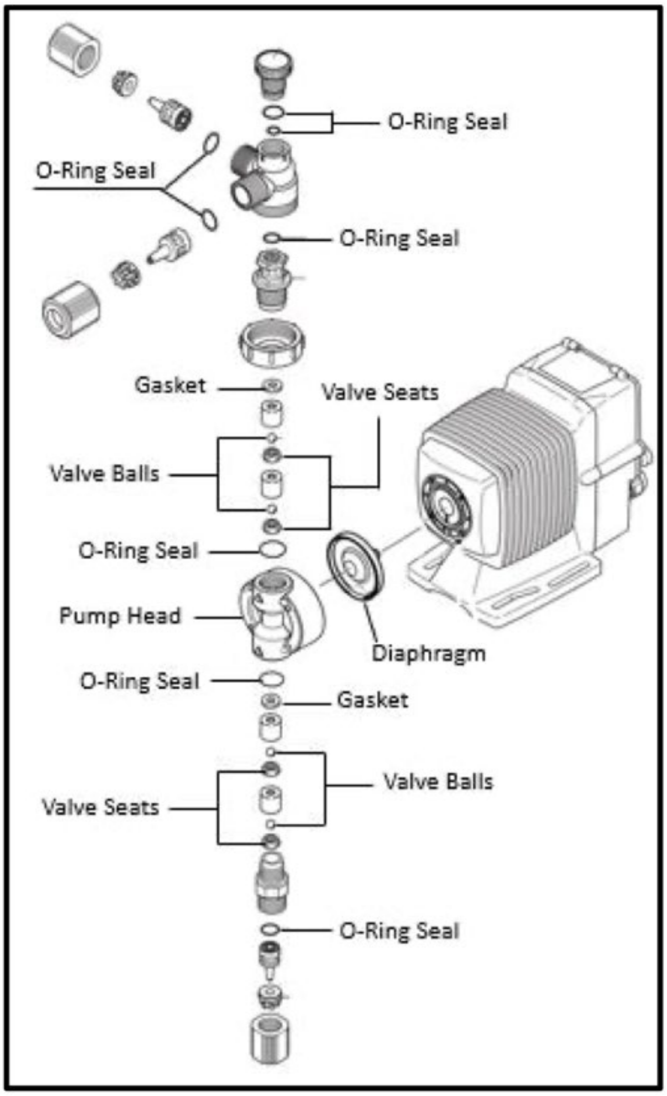

Figure 7: Pump components that are made using fluoropolymers[16]

- Agriculture:
    - Irrigation: Farmers use Xylem pumps to distribute water for crop irrigation, helping to improve agricultural yields.
- Industrial Applications:
    - Industrial processes: Xylem pumps are used in various industrial processes to move fluids, chemicals, and slurries.
    - Manufacturing: Xylem provides pumps for manufacturing applications, including those involving cooling, heating, and material handling.
    - Mining: Xylem pumps are used in mining operations for dewatering, slurry transfer, and other critical tasks.
- Commercial Buildings:

[16] https://europump.net/uploads/EUROPUMP_Position%20Paper%20PFAS_FINAL.pdf

- HVAC systems: Xylem pumps play a vital role in heating, ventilation, and air conditioning (HVAC) systems in commercial buildings.
  - Fire protection: Xylem offers fire protection pumps for sprinkler systems in commercial and industrial facilities.
- Marine and Offshore:
  - Marine applications: Xylem provides pumps for marine vessels, including those used for ballast water management, bilge pumping, and wastewater treatment.
  - Offshore oil and gas: Xylem pumps are used in offshore oil and gas operations for various applications, including water injection and subsea boosting.
- Mining and Construction Dewatering:
  - Construction sites: Xylem pumps are used in construction projects to manage groundwater and prevent flooding in excavations and foundations.
  - Mining: Xylem offers specialized dewatering pumps for mining operations to remove excess water from pits and tunnels.
- Environmental Remediation:
  - Groundwater remediation: Xylem pumps are used in environmental cleanup efforts to extract and treat contaminated groundwater.
- Aquaculture:
  - Fish farming: Xylem pumps are utilized in aquaculture for water circulation, aeration, and water quality management in fish farms.

These examples demonstrate the versatility of Xylem pumps, which are designed to meet the specific needs of various industries and applications, helping to address critical water and fluid management challenges worldwide.

A specific example where fluoropolymers are used in Xylem is in manufacture of PVDF dosing pumps. PVDF used in chemical dosing pumps is a critical component to maintain a safe water supply, safe and efficient food production and to protect the public from water borne pathogens. PVDF dosing pumps are preferred for their ability to dose precise amount of chemicals, even in varying process conditions, and customers select PVDF versions of dosing pumps only for their most demanding and critical applications. About one in four dosing pumps sold is a PVDF pump and customers have standardised processes based on these pumps, also to help end-users meet regulatory demands in terms of precision and documentation of the chemicals added.

PVDF dosing pumps are used because of the following:

- Chemicals are usually dosed from high stock solutions with high concentrations
- Typical chemicals are strong acids and bases, strong oxidants, organic acids, ferric chlorides, etc.
- PVDF dosing heads are exposed to hundreds of pressure cycles per day (typical to 8 or 16 bar), thus material integrity is essential to ensure efficacy in use of the chemical and safety of the plant operator
- All materials need to be globally certified for use in food and beverage, municipal water supply, pharma, etc., which limits ability to readily switch supplier.

Example of applications where the PVDF pumps are used include but not limited to:

- Disinfection (chlorination) of drinking water to ensure safe public water supplies
- Chemicals used for drinking water treatment (e.g. pH adjustment, chemical cleaning of water filters, fluoride addition (US))
- Oxidation of organic substances in drinking water and wastewater treatment

- Disinfection of treated wastewater, preventing pathogens entering rivers, lakes and oceans
- Water treatment for reuse (requires more chemicals for treatment & disinfection)
- Preparation of chemical solutions to clean process equipment in food production (dairies, meat industry, breweries and many other)
- Disinfection of surfaces in food and beverage, health care facilities, etc.
- Treatment of food with disinfectants to improve storage duration for fruits, meat, etc.
- Treatment of animal feed water to improve productivity and reduce the use of antibiotics
- Biocide treatment for heating and cooling, to reduce energy consumption
- Disinfection of pool water for public pools, spas, etc.
- Legionella control in larger buildings (hotels), retirement homes, hospitals, sports centers, public water features, cooling towers etc., to prevent outbreaks of Legionnaires' disease
- Biofouling and legionella control in cooling towers for commercial buildings

Therefore, it can be seen that fluoropolymer materials are used in pumps to improve functionality and achieve higher performance and safety. Service life of components and products has been increased and maintenance intervals reduced which improve overall resource efficiency. No currently available alternative material guarantees the same performance, safety and lifetime.

Xylem supports the analysis and conclusions of the European Association of Pump Manufacturers, Europump, where a non-exhaustive list of fluoropolymer uses and functionality in pumps was detailed in Contribution 4245, this includes gaskets, seals, and bearings and that the use of PFAS materials should remain possible for these applications, where no alternatives are available and are not foreseeable in the next years.

4 Specific examples of PFAS use by Xylem

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5 The PFAS lifecycle in Xylem applications

The use of fluoropolymers in industrial and professional uses in the water industry can be effectively managed to ensure that the risks from their use are appropriately controlled throughout their lifecycle. They do not need to be banned.

Such an approach to risk management would ensure that the critical functions of fluoropolymers are not permanently lost to EU society, jeopardizing the functioning of the EU water industry and sectors and firms which rely on effective water and wastewater treatment. To this extent, a derogation for continued use of fluoropolymers in applications where alternatives do not exist or where the alternatives do not meet the technical and safety requirements in the water industry should be granted, provided the risks are appropriately managed. This section elaborates the rationale for such a conclusion.

In the Annex XV report, the DSs note that the main emission of fluoropolymers from the use phase is linked to dispersive applications. This is not applicable to industrial and professional uses in the water industry since fluoropolymers are typically incorporated into the products in the form of seals, O-rings, membranes, valves and electrical insulators. The high stability of fluoropolymers over time implies very limited degradation, which in turn implies that fluorinated emissions resulting from the use of fluoropolymer-containing applications are very limited as well. Thus, during their use phase (including article service life), there is no risk to address. This is recognised by the DSs who estimate emissions from the use of fluoropolymers to be minimal,

The DSs noted that the end-of-life phase is a concern and potential contributor of PFAS emissions, primarily through incomplete incineration. (Emissions from landfilling of fluoropolymers are considered by the DSs to be minimal.) However, Xylem argues that a restriction based on a requirement to ensure appropriate waste management of fluoropolymers would ensure that risks are controlled and would be more cost-effective and proportionate than a ban on fluoropolymers altogether.

At the end of their lifecycle, PFAS-containing components from industrial and professional uses are typically disposed of according to the Industrial Emissions Directive (2010/75/EU) and existing national legislations in the Member States. For example, in Germany, according to the "Kreislaufwirtschafts-/abfallgesetz (KrWG)" ("closed substance cycle waste management"), waste disposal is only allowed if material or thermal recycling is not possible, due to technical, economic or ecological reasons. PTFE and other fully fluorinated fluoropolymers may not be used as substitute fuel for thermal incineration if its caloric value is below 11.000 kJ/kg (required according to §8 KrWG). This is mainly the case with PTFE waste as its caloric value amounts to approximately 5.500 kJ/kg. If the caloric value exceeds 6.000 kJ/kg incineration of this waste is required. In this case it has to be ensured that the incineration plant chosen is equipped with an acid scrubber and the combustion temperature is above 800 °C[17].

While there is a need to recycle fluoropolymers due to their high value and stability, recycling of fluorinated polymers from industrial or commercial applications is technically challenging. The majority of fluoropolymer uses in Xylem products are distributed across a wide range of uses in complex applications. The quantity of fluoropolymers used in our applications is often low and

[17] https://www.pro-kunststoff.de/assets/Mekblätter%20und%20Co/FP%20TM-10-Recycling-of-fluoropolymers.pdf

therefore dedicated collection and recycling would be very costly and logistically challenging. For this reason, the most effective way of managing the end-of-life of fluoropolymers is through incineration at high temperatures. Currently, this is done through municipal incinerators. Nevertheless, additional conditions to ensure the effectiveness of the incineration of fluoropolymers could be considered.

Additional incineration conditions can be adopted similar to those in the RAC opinion on PFAS in firefighting foams[18] which recommended that hazardous waste containing more than 1% of halogenated organic substances should be incinerated at elevated temperatures (above 1,100°C), and in accordance with the relevant best available technologies (BAT) reference documents. This would ensure that PFAS waste is degraded (mineralised) to carbon dioxide and hydrogen fluoride. By mandating effective incineration of fluoropolymers (i.e., conditions that lead to the complete mineralisation and degradation of fluoropolymers), as a condition of their continued use, industrial incineration according to BAT will ensure that the risks posed by the use and disposal of fluoropolymers are effectively managed. As such, a total ban of fluoropolymers in water and wastewater applications is not the least burdensome means to address the identified risk and would, therefore, be disproportionate.

[18] RAC opinion on proposed restriction of PFAS in firefighting foams, available on ECHA website at https://echa.europa.eu/documents/10162/9a785928-3fbd-a230-cffa-7b8590240d69

6 Impacts of a ban

The Annex XV report only assesses the options of a full ban with or without time-limited derogations. Derogations were identified by the DSs based on sector-specific assessment of the use of fluoropolymers.

The water industry as a sector was not assessed in the Annex XV report and, as a result, sector-specific derogations for the water industry were neither considered nor proposed. According to the current proposal, therefore, use of PFAS in the water sector will be subject to a complete ban 18 months after entry into force of the restriction. We believe that the failure to consider options other than a ban and the lack of assessment of impacts on the water industry will result in disproportionate impacts to society, given the extensive use of fluoropolymers in water and wastewater applications and their critical function for these uses in society. We contend that a ban is not the most appropriate measure to address the concerns raised by the DSs. For instance, it needs to be taken into account that the use of fluoropolymers has been assessed and approved in various legislative areas to be used in drinking water services.

Fluorinated polymers serve a vital role in various industrial applications, particularly in environments where extreme temperatures, harsh chemicals, and high-pressure conditions are prevalent. One of the primary advantages of using PFAS is their exceptional combination of chemical resistance and durability. They can withstand exposure to corrosive chemicals, acids, and bases, making them indispensable in any industry where such conditions occur. This is for instance the case in chemical processing, oil and gas, pharmaceutical manufacturing and in water treatment. Fluoropolymer based components such as seals and gaskets maintain their full integrity over time, assuring a reliable leak-free service, reducing the need for frequent replacements and thereby minimising downtime and maintenance costs. The higher unit cost of fluoropolymers seals and gaskets is as such compensated by the lower life cycle cost for the systems in which these polymers are used.

6.1 Prospects for substitution

One significant challenge in finding alternatives to fluoropolymers lies in replicating their unique combination of properties. Traditional, typically cheaper materials, such as rubber and silicone, generally lack the same level of chemical resistance and durability that PFAS provide. Additionally, alternatives that are chemically resistant are not able to withstand the same range of temperatures or pressures, limiting their applicability in demanding industrial settings. Researchers and industries are always working to develop alternative materials with similar capabilities, but it should be recalled that PFAS were developed in direct response to the fundamental weaknesses of traditional materials. Replacing PFAS can hardly be expected to occur through the refinement of these traditional materials, but must depend on science being able to identify new materials with the performance of PFAS but without the drawbacks (e.g. environmental persistence). This is not a short-term task, and in the meantime, PFAS continue to be the preferred choice for critical sealing and gasket applications where no suitable substitutes exist. It is essential to be able to continue using these PFAS materials without compromising performance in these crucial industrial applications while ongoing research and innovation efforts work to find environmentally preferable alternatives.

Xylem has carried out internal research on the use of non-fluorinated materials in water treatment applications such as in water treatment devices using ozone. As discussed in Section 3.1.1, ozone is a very strong oxidizer and typically reacts with all organic and inorganic materials. It is this property which is sought in ozone-based water treatment equipment for the disinfection of water or for the removal of inorganic substances through oxidation. The results showed that the non-fluorinated materials were susceptible to attack by ozone and had shorter lifespans which significantly increased service (disassembly and seal or component replacement) requirements. This would result in increased maintenance costs, downtime costs and additional exposure of maintenance personnel to corrosive and toxic process liquids. Similarly, an internal analysis of alternatives done for fluoropolymer components in chlorination systems showed that substitution of PTFE and FKM in sealing O-rings resulted in significant additional effort for monitoring on the customer's part due to increased leakage risks, lower durability and shorter lifespans, higher maintenance costs as a result of the significant shorter maintenance cycles. (A more detailed analysis of alternatives in chlorination is given in Annex C.)

Furthermore, in the long term, the use of substitute products, even if possible, is only likely to be feasible in certain areas of use, and would still require major design changes. Spare and maintenance parts of existing plants could not be adapted in the field to substitute products without completely rebuilding or replacing the existing plants. This means that the impact is not only on the production of new functional and safe systems, but it would also lead to the premature retirement of already installed UV and ozone systems, for example. Their safe continued operation would no longer be guaranteed due to the absence of very relevant spare parts. Inevitably, many hundreds of thousands of installed ozone systems globally in public utility and industrial locations would be affected with significant effects on public health and environmental integrity.

One of the key properties of fluoropolymers used in drinking water service is the extremely low release of substances during their service life. This in combination with the ease of use and the high reliability in demanding services over long periods over time makes these kinds of polymers the material of choice for seals and gaskets in drinking water service. Substituting these polymers will require long test cycles to assure low release rates and reliability over long periods of time in demanding conditions. Numerous aspects must be considered, including, for instance, the formation of known or unknown by-products because of the exposure of substitute materials to chemicals such as ozone, or chlorine, or as a result to exposure to UV irradiation. These by-products can be formed at low concentrations even if the mechanical stability of the substitute products is not (significantly) reduced. This has, for instance, been observed in seals of ozone-water piping systems where alternative materials have been used. In this case, formed by-products of the seals can migrate to the ozone treated water lowering the quality of drinking water and posing health risks to consumers.

Even if new materials providing acceptable levels of performance could be found, it is expected that the process for qualification and validation of these new materials for use in the water industry would last, additionally, at least 10 years, taking also into account that these water treatment systems are available on a global market with local approval requirements for products to be used in drinking water service. In case of a ban, the lack of recognised alternatives would thus lead to regrettable substitution to alternatives that do not perform at the same specification as fluoropolymers, which may be potentially hazardous, less durable and as such would mean applications are unable to meet stringent safety and environmental standards.

Given the complexity and the wide-ranging use of PFAS, it is challenging to estimate the total societal cost for replacing all PFAS for Xylem uses. It would likely be a multi-billion-dollar effort to substitute over an extended period, on top of a recuring additional cost during the service life of the systems using the PFAS alternatives due to lower performance and higher maintenance cost. In any case the substitution would be complex involving collaboration between industries, government agencies, research institutions, and regulatory bodies.

6.2 Economic impacts

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A lack of replacement parts for these systems would result in early retirement and replacement with systems which are less effective and less efficient, consequently compromising the quality of water produced. A maintenance derogation should be considered for these systems due to the lack of feasible alternatives. A similar argument was used by the DSs to propose a derogation (5i) relating to the servicing of existing HVACR equipment using F-gases:

> *"Maintenance and refilling of existing HVACR equipment put on the market before [18 months after EiF] and for which no drop-in alternative exist, until 13.5 years after EiF"*

The DSs proposed this derogation because:

> *"the lack of drop-in alternatives means that equipment that would currently need servicing including some top up of refrigerant levels could not be repaired. Added costs would arise from the premature retirement of existing equipment, the early purchase of replacement equipment and added environmental burdens from disposal of equipment."*

Finally, it should be noted that, although Xylem is responding to this submission individually, the impacts of the proposed restriction will affect the broader water and wastewater treatment and analytics sectors. Xylem is a significant global supplier of the technologies covered in the submission, but it is by no means the only one. However, the technologies described in this submission, and their dependence on the use of PFAS, are common across all suppliers. Hence, impacts of the restriction on Xylem will be mirrored by similar impacts across all suppliers in the industry, and hence across all customers. The restriction would therefore have societal-level impacts through its impacts on the water and wastewater treatment and analysis sectors. We would encourage the DSs, RAC and SEAC to examine the critical use of PFAS in the applications described in this submission and to ensure that their societal value is reflected in their regulatory proposal.

7 Conclusions

PFASs form a critical component of the technologies which underpin water and wastewater treatment, water quality monitoring and analysis, and the transport of aggressive liquids in a wide range of industries and sectors. PFASs offer a unique combination of properties which enables them to operate at extremes of temperature and pH, over extended periods, with minimal degradation, whilst offering low friction, low contamination and other advantageous performance characteristics. They therefore contribute benefits to society which far exceed their physical dimensions, by enabling high levels of water quality, pollution control and transport of liquids, accurately, safely and cost-effectively. PFASs have been developed and adopted in direct response to the inherent weaknesses of traditional materials. Therefore, forcing the re-adoption of these materials by banning PFASs would inevitably lead to losses of function, lower reliability and higher costs, in turn leading to lower standards of water quality, environmental quality and safety. A ban of these uses of PFAS would therefore be disproportionate from a societal point of view. In their Annex XV dossier, the DSs recognise that emissions of PFAS from the use of fluoropolymers are minimal, and that any losses from the waste stage are similarly low and can be controlled completely with appropriate waste management. A regulatory approach which more directly targets the sources of risks associated with fluoropolymers would be more effective and would enable the high societal benefits of their use to be maintained and enhanced. Xylem encourages the DSs, RAC and SEAC to reject a ban, and consider alternative approaches to achieving their regulatory objectives.

8 Annexes

Annex A: List of Xylem brands

Water and wastewater treatment	
Essence of Life	Unique hybrid value chain partnerships delivering a compelling suite of innovative rural and peri-urban water management solutions.
Evoqua Water Technologies	Evoqua's products enable customers to dramatically improve the way water and wastewater is used, managed, conserved, re-used and returned to nature.
Flygt	Xylem's Flygt brand provides customers with a complete range of products and solutions for moving water and wastewater.
Leopold	Xylem's Leopold brand is a leader in rapid gravity media filtration and clarification solutions for the water and wastewater industry.
MJK	MJK Automation develops, manufactures and supplies water instrumentation for control of drinking water, sewage water and industrial water treatment.
Sanitare	Xylem's Sanitaire brand provides complete biological wastewater treatment solutions for public utility and industrial applications.
Wedeco	Xylem's Wedeco brand manufactures reliable, chemical-free, and environmentally-friendly water and wastewater treatment technologies.

Instrumentation and analytical products	
Aanderaa	Aanderaa designs, manufactures and sells sensors, instruments and systems for measuring and monitoring in demanding environments.
Bellingham + Stanley	Bellingham + Stanley is one of the world's leading manufacturers of Refractometers and Polarimeters used throughout the world's food, drinks, pharmaceutical, chemical and petroleum industries.
ebro	ebro provides temperature measurement and data-logging technologies for the measurement of temperature, pressure, humidity and other physical parameters.
HYPACK	HYPACK is a leading provider of hydrographic survey data acquisition, processing, and visualization software for ocean, coastal and surface water applications.
OI Analytical	Offers analytical instruments that detect, measure, analyze and monitor chemicals in liquids, solids and gases and products used to digest, extract and separate components of chemical mixtures.
PureHM	PureHM solutions for regulated inspections of pipelines that carry energy products provide actionable data to identify problem areas, reduce unnecessary pipeline repairs, and prolong asset life.
Pure Technologies	Pure Technologies is a world leader in the development and application of innovative technologies for inspection, monitoring and management of critical infrastructure

Instrumentation and analytical products	
Royce Technologies	A global producer of monitoring and control instrumentation and sensors specifically designed for municipal and industrial wastewater treatment applications.
Sensus	Sensus helps public service providers to reach farther by responding to evolving business needs with innovation in sensing and communications technologies, data analytics and services.
SI Analytics	The manufacturer of titrators, viscosity measuring systems, extensive line of glass capillary viscometers, high-performance laboratory and process electrodes.
SonTek	SonTek manufactures rugged, reliable acoustic Doppler instrumentation for the measurement of water velocity, flow, discharge, currents, and waves.
WTW	Offers robust analysis products for the measurement of pH, dissolved oxygen, conductivity, total dissolved solids and specific ions.
YSI	Manufactures sensors, instruments, software and data collection platforms for environmental and coastal water quality monitoring and testing.

Pumps, Valves and Plumbing accessories	
AC Fire	AC Fire Pump Systems design and custom build a wide range of fire pump products and turnkey systems for commercial and industrial applications, including prefabricated packages and house units.
Bell & Gossett	Bell & Gossett is a leading manufacturer of pumps, valves, heat exchangers and accessories for plumbing, wastewater and HVAC - including steam and heat transfer -applications.
Flojet	Flojet is a leading global supplier of small pumps, motors and dispensing pumps for a variety of industries, including the beverage dispensing market.
Godwin	Godwin is a global leader in the manufacture and supply of fully automatic self-priming pumps.
Goulds Water Technology	Centrifugal and turbine pumps, controllers, variable frequency drives, and accessories for agricultural, building trades, commercial and light industrial water and wastewater applications
Jabsco	Jabsco is a worldwide leading manufacturer of products for the recreational marine market and also offers industrial pumps for various applications including hygienic, fluid transfer in chemical processing, paint processing, and construction
Lowara	Lowara is leading in pumps and drives, offering complete solutions for water supply, wastewater, HVAC and fire protection in agricultural, building services, commercial and industrial applications.
Rule	Rule is a worldwide leading manufacturer of pumps, switches, and various accessories for the recreational marine market that are available globally at local marine dealers and marine retailers.

Smith-Blair	Smith-Blair is a leading global manufacturer of fittings that join, repair, restrain, tap and cap pipes for the water, wastewater, gas, oilfield and industrial markets.

Accessories e.g Electrical components (control panels, switches etc)	
CentriPro	Motors, repair parts, controls, panels, switches, and other accessories designed to work with Bell & Gossett, Goulds Water Technology, Marlow Pumps, and Red Jacket products and systems.
McDonnell & Miller	A leader in engineering and manufacturing boiler and liquid level controls, low-water cutoffs, and flow switches for steam and hot water boilers in industrial, commercial and building applications.
Standard Xchange	Standard designs and manufactures heat exchanger products for the chemical, pulp and paper, biofuels, sugar processing, petroleum, power generation, mining and general industrial markets.
Services	
Sentec	Sentec- Supporting customers in all stages of product development, from initial concept through to product launch by inventing, developing, assessing or cost reducing a wide variety of technologies, products or processes.
Wachs Water Services	Wachs Water helps utilities optimize control of their aging water distribution infrastructures, which reduces the consequences of failure and improves water quality.

Annex B: Fluoropolymer uses in Xylem

Category	Article	Uses	Sector	Business Unit	Properties
Sealing applications	Seals O-rings Gaskets Sealing tapes	UV reactor Ozone system Chlorine disinfection Measuring device e	Water treatment Analytical Gas Electric	Wedeco XAG Evoqua Leopold AWS Sensus Pure Technologies	• Excellent **chemical resistance** to many highly aggressive liquids (Cl2, ClO2, Hypochlorite, acids). • **Resistant to UV-irradiation** of high dose and over time. • Maintain their **elasticity** and **sealing** properties at **temperatures** where other elastomers will harden
Valves	Valve block Valve from Kalrez *Switching valves for Analyzers*	Measuring device Ozone/UV systems Chlorine disinfection	Water treatment Analytical	Wedeco Evoqua XAG Sensus	• Chem resistance (ClO2, Hypochlorite, acids) Optimum hardness
Lubricants & Greases	Lubricant grease (also used in conjunction with valves-	Measuring device Ozone/UV systems	Water treatment Analytical	XAG Wedeco AWS Sensus Pure Technologies	• Long period operation • High temperatures • Low friction, low wear • Good gliding properties • Resistant to aggressive chemicals and reagents e.g., Valve parts must be lubricated with PFAS lubricants as otherwise they are not tight and aggressive fluid will leak
Membranes and foils/film	Membrane for Teflon vacuum			Leopold	• Chemical resistance • Gas permeability

Category	Article	Uses	Sector	Business Unit	Properties
	pump Membrane pump Sensor membranes (Oxygen, Ammonia, Hydrogren, Chlorine, CO2)	Measuring device Ozone/UV systems Chlorine disinfection	Water treatment Analytical Electric Gas	Evoqua XAG Wedeco (sensors) Pure Technologies Sensus	• Diffusion coefficient
Pistons		Measuring device	Analytical	XAG	• Chemical and thermal resistance • Elasticity, sliding and abrasion properties
Tubing	Analyzers	Measuring device Ozone/UV systems Chlorine disinfection Pipe inspection	Water treatment Analytical	Wedeco XAG Evoqua Leopold Pure technology	• Chemical stable over a wide acidity-alkalinity range • High temperatures over a long period of time
Electric/electronic articles	Cables Sockets Insulation Adapters LED Lithium Batteries	Measuring device Ozone/UV systems Proprietary electronic comp.	Water treatment Analytical	Wedeco XAG Sensus Pure technologies AWS	• Long period operation • High temperatures • Coatings (non-disclosed materials by third party vendors)
Bushing/bearing/Plugs	Connectors	Measuring device	Analytical	XAG Leopold AWS Sensus Pure Technologies	

Category	Article	Uses	Sector	Business Unit	Properties
Pumps	Mechanical seals Rings (o-rings, quenching casting rings, sealing rings, guide wire o-rings) Coatings for fasteners	Measuring device Ozone/UV systems Chlorine disinfection (Pumping and circulating clean or contaminated water or chemicals)	Water treatment Analytical	Wedeco Evoqua XAG Lowara AWS Sensus	• Chem resistance (ClO2, Hypo, acids) Optimum hardness • Maintain elasticity and sealing properties at high temperatures
Accessory material	Cleaner	Measuring device	Analytical meters	XAG Sensus Pure HM Pure Technologies	
	Teflon spray				
	Silicone spray				
Pressure Regulators Pressure Valves Heat Exchangers Glycol Make Up	TBD Fluids: Glycol Ethylene Glycol	Pressure and temperature regulation in Steam & Water Systems	AWS	Morton Grove Standard Exchange	• Pressurized solutions for closed loop heating, chilled water, process systems, snowmelt, and radiant heat • Heat and Thermal transfer

Annex C: Analysis of alternatives for fluoropolymers components in chlorine- based water treatment systems

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