

Summary of the State of the Art Technologies in Emission Control and Monitoring for the Manufacture of Fluoropolymers Utilised by the Members of the Manufacturing Programme

AIR EMISSIONS

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29 September 2026

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Glossary

Terms used

Definition

Adsorption	a heterogeneous reaction in which molecules or ions from a gas or liquid phase are retained on a solid or liquid surface that prefers specific compounds to others and thus removes them from effluent streams.
Aerosol	a suspension of fine solid or liquid particles in a gas
BAT	refers to EU best available technique, in this report it refers to PFAS abatement techniques
Breakthrough	is the point at which the adsorbent is no longer able to adsorb new molecules. The PFAS removal efficiency is reduced and targeted substances may “breakthrough” the adsorbent. It is at this point that the targeted substance concentration in the treated water reaches an unacceptable level and must be replaced by fresh adsorbent or be reactivated to remove the targeted substances and restore removal efficiency of the treatment bed.
BREF	EU Best Available Techniques reference document per EC Industrial Emissions Directive
Channeled emissions	waste stream that is ducted, more feasible for abatement. Channeled emissions of chemical constituents occur through emission point such as a stack.
CMR	carcinogen, mutagen or reproductive toxin, per Global Harmonized Classification System (GHS) or the Classification Labelling and Packaging Directive (CLP) in the EU.
COD	chemical oxygen demand
Condensation	is a technique used to remove solvent vapors from a waste gas stream by reducing its temperature below its dew point. When the vapor pressure of a substance falls below its partial pressure in the gas stream, the substance condenses into a mist or droplets, which are collected and appropriately treated.
Continuous measurement	is a measurement using an automated measuring system permanently installed on site.
Cross media effects	are unintentional impacts to one form of environmental media due to application of abatement technology to another environmental media. For example, minimizing emissions to air but shifting the impact from air to waste streams dealing with used filters.
CWW	Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector
Differential absorption LIDAR (DIAL)	is a light detection and ranging method. Two laser wavelengths are emitted: one that is absorbed by the target emission (on-resonance) and one that is not absorbed (off-resonance). The difference in the backscattered lights from

	these two wavelengths is measured to determine the concentration of the target gas.
Diffuse emissions	are non-ducted or non-channeled emissions to air including fugitive and non-fugitive emissions. Diffuse emissions are less feasible for abatement.
Diffusion	captures tiny particles exhibiting random motion
Electrostatic attraction	traps electrically charged particles on oppositely charged filter fibers
Emission factor	is a characteristic value that relates to the quantity of a substance released into the atmosphere to an activity associated with that release. These factors are usually calculated by dividing the weight of the substance emitted by a unit weight, volume, distance or interval of the activity emitting the substance.
Flue gas	is the mixture of gases exiting an incinerator via a pipe or flue.
Fluoropolymers	are a distinct type of polymeric per- and polyfluoroalkyl substances (PFAS) with high molecular weight and fluorine atoms directly attached to their carbon-only backbone.
FTIR	is Fourier Transform Infrared spectroscopy
Fugitive emissions	are non-channeled emissions to air caused by loss of tightness of equipment which is designed or assembled to be tight. Fugitive emissions can arise from moving equipment, such as agitators, compressors, etc., and/or static equipment, such as flanges and other connections, open-ended lines, sampling points, etc.
GAC	granular activated carbon
HCl	hydrochloric acid
HF	hydrofluoric acid
IED	EU Industrial Emissions Directive
IER	ion exchange resin
Inertial impaction	occurs when larger particles deviate from the flow path due to inertia and collide with the filter fibers
Interception	occurs when particles adhere to the filter fibers as they follow the streamlines
LC-MS/MS	or liquid chromatography – mass spectrometry/mass spectrometry is a powerful analytical technique allowing for the effective separation and identification of complex liquid mixtures.
LDAR	is leak detection and repair
Limit of detection (LOD)	is the smallest measure and concentration which can be detected, but not quantified, in the experimental conditions described by the method.

Limit of quantification (LOQ)	is the smallest measured concentration which can be quantified, in the experiment conditions described for the method.
Long chain PFAS	PFAS perfluoroalkane carboxylic acids/carboxylates with 8 or more total carbon atoms, and perfluoroalkane sulfonic acids/sulfonates with 6 or more carbon atoms
Maintenance threshold	a predefined concentration of a substance which, when detected triggers maintenance or repair action in the facility.
Mass balance	is a principle in which the total mass of substance entering the abatement system equals the total mass leaving the system.
MCERTS compliant	devices that have been certified by the UK Environment Agency's Monitoring Certification Scheme (MCERTS) to meet the required performance standards for emissions monitoring. These analyzers are designed to provide accurate and reliable measurements of volatile organic compounds (VOCs) in compliance with international standards such as EN12619.
Media	refers to environmental media such as air, water, soil, sediment, waste streams
Microparticle	is a particle less than 5 mm (5,000 µm) in diameter (per EC 2023)
Mist	liquid droplets suspended in a gas
NH ₃	ammonia
Non-fugitive emissions	are diffuse emissions other than fugitive emissions. Non-fugitive emissions may arise from, for example atmospheric vents, bulk storage, loading/unloading systems, vessels and tanks (an opening), open gutters, sampling systems, tank venting, waste, sewers and water treatment plants.
Non-targeted analyses	are analytical techniques that explore unknown compounds using mass spectrometry by identifying a peak in a chromatogram. Typically, a nontargeted method allows for detection of known and unknown chemicals. However, not all chromatographic peaks will be identified. Techniques can be specific to the matrix (air, water, soil, sediment, etc.) and type of PFAS of interest (non-polymeric or polymeric, polyfluoroalkyl versus perfluoroalkyl, etc.).
Normal cubic meter (Nm ³)	is a gas volume referenced to defined normal temperature and pressure conditions. Using a normal cubic meter standard allows for comparison across different systems, conditions or industries. Standard temperature and pressure (STP) definitions differ between agencies. Some use 5°C, others 10 or 15 °C. Using Nm ³ allows for a common, unambiguous unit of concentration for comparison.
NO _x	oxides of nitrogen
Optical gas imaging (OGI)	is a technology that uses infrared cameras to detect and visualize gas leaks invisible to the naked eye. The thermal

	contrast between gas emissions and their surroundings is captured. It can be calibrated for specific gas types.
Particle	is a very small piece of matter
Per- and polyfluoroalkyl substance	abbreviated, PFAS, is a fluorinated organic substance that contains at least one fully fluorinated methyl or methylene carbon atom (without any H/Cl/Br/I atom attached to it), per OECD 2021.
Periodic measurement	is a measurement at specified time intervals using manual or automated methods.
PM	particulate matter, solid or liquid droplets, usually followed by a mean particle diameter in micrometers, such as PM 2.5.
Particulate matter	refers to the mass of the particulate matter / substances per unit volume in the waste gas stream that the scrubber is designed to remove. This determines the efficiency of the scrubber in capturing those substances.
Recuperative thermal oxidation	uses the heat of the waste gases by indirect heat transfer.
Refreshing rate	in a fibrous packing scrubber, refers to the rate at which substances are removed from the gas stream. The higher the refreshing rate, the better the scrubber performance as it is more effectively removing substances from the waste gas stream.
Regenerate	is the restoration of an adsorbent like granular activated carbon after it has reached its breakthrough capacity. PFAS compounds are extracted from the adsorbent for example through solvent, chemical, thermal or other processes that remove or destroy adsorbed substances thereby restoring the adsorptive capacity of the adsorbent.
Residence time	refers to the time materials spend within the incineration chamber during the combustion process. The duration of time is a critical factor in achieving complete mineralization of PFAS, along with temperature and oxygen content.
Short chain PFAS	PFAS carboxylates with fewer than 8 carbons and sulfonates with fewer than 6 carbons are referred to as short chain PFAS.
Solar occultation flux (SOF) method	is a remote sensing technique used to quantify fugitive hydrocarbon emissions from industrial sources by measuring infrared intensity spectral of the sun from a moving vehicle. This allows for the determination and quantification of emissions of specified gases. It is recognized as Best Available Technology (BAT) in Europe for refineries and the chemical industry.
Spent	when an adsorbent, such as granular activated carbon, is no longer able to adsorb new molecules, the adsorbent is referred to as "spent" and its PFAS removal efficiency is reduced allowing targeted substances to "breakthrough" into the

	treated water. The adsorbent must either be replaced by fresh adsorbent or be reactivated (by removing the targeted substances) in order to restore removal efficiency.
Targeted analysis	is an analytical approach by which the analyst is looking only for specific chemicals. The mass spectra and retention times for each compound are known and all targeted chemicals above the noise level will be detected by this approach. The determination is typically optimized for sensitivity and selectivity and subsequently reduced by limiting the number of analytes.
Thermal oxidation	is an air emissions abatement technology in which combustible compounds in the waste gas stream are heated in a combustion chamber above the auto-ignition temperature and maintained at high temperature long enough to oxidize them completely to carbon dioxide and water.
Tracer correlation methods	are involved in the controlled release of a tracer gas and simultaneous measurement of the source gas concentration. They are useful for two-dimensional mapping of concentrations and leak searches on industrial sites.
Ultra-short chain PFAS	are PFAS with two or three carbon atoms
Vapor	is a substance in a gaseous phase
Venturi scrubber	is an air emissions control technology used primarily to control particulate matter by accelerating the waste gas stream through a “throat” section built into the duct. A scrubbing liquid is sprayed into the gas flow leading to droplet-particle interaction, followed by particle capture within the liquid and separation of gas and particulate.
VITO	is the Flemish Knowledge Centre for Best Available Techniques
WG	Waste Gas Treatment/Management Systems

1. Introduction

This report outlines state-of-the-art technologies used by the members of the Manufacturing Programme to prevent and reduce PFAS emissions to air from fluoropolymer manufacturing. It draws on publicly available information and current technical insights, and forms part of a series of technical documents covering abatement technologies for air and water, as well as PFAS waste management in fluoropolymer manufacturing.

There is currently no existing EU Best Available Techniques reference document (BREF) or best available technology (BAT) conclusions for the fluoropolymer manufacturing industry. The existing 2007 polymer BREF does not specifically address fluoropolymers. According to chemical/molecular structure, fluoropolymers are defined as a type of polymeric per- and polyfluoroalkyl substance (PFAS) (OECD 2021). Emissions control technology and fluoropolymer manufacture has evolved since 2007.

Though removal efficiencies vary between specific air abatement technologies, the technologies employed by the Manufacturing Programme Members remove PFAS monomers, long chain, short chain and ultra short chain PFAS and polymerization aids

This report does not address industries producing finished articles containing fluoropolymers or using fluoropolymers in operations.

1.1 Scope – Air Emissions

Emissions to air from the manufacture and processing of fluoropolymers generally may be in the form of solid particles, liquid droplets, aerosols, mists or vapors. This report addresses the state-of-the-art technologies used by the Manufacturing Programme member companies to manage PFAS emissions to air from fluoropolymer manufacturing (See sections 2-7).

This document on air emissions from fluoropolymer manufacturing addresses five technologies:

1. filtration,
2. scrubber,
3. activated carbon,
4. condensation and cryocondensation,
5. thermal oxidation

According to the Innovative and Collaborative Initiatives for the Transition to Elimination (INCITE) categorization used by the European Chemicals Agency (ECHA) and the EU's Committee for Socio-Economic Analysis (SEAC) reference documents, their relevance to these forms of air emissions technology is structured as follows:

1. basic information about the technology,
2. information on the current use of that section's technology in PFAS abatement systems,
3. the environmental performance of the technology,
4. cross media effects/ environmental co-benefits,
5. economics.

This air emissions report also contains a glossary of terms used herein and an overview of analytical techniques used with these technologies.

1.2 General BAT Reference Documents

The Industrial Emissions Directive (EU) 2024/1785, amending Directive 2010/75/EU, establishes the following key requirements for installations:

1. Prevent and control emissions through BATs
2. Take measures to ensure energy efficiency
3. Waste prevention and management
4. Resource conservation
5. Accident prevention and limiting their consequences
6. Compliance with integrated permits.

This report aims to address these key elements related to emissions to air.

Other BAT conclusions and reference documents which could be relevant for the activities covered in this document are the following:

- Common Waste Water and Waste Gas /Treatment/Management Systems in the Chemical Sector (CWW);
- Common Waste Gas management and treatment system in the chemical sector (WGC)
- Production of Polymers (POL);
- Monitoring of Emissions to Air and Water from IED Installations (ROM);
- Economics and Cross-Media Effects (ECM);
- Energy Efficiency (ENE).

These BAT conclusions apply without prejudice to other relevant legislation, e.g. on the registration, evaluation, authorization and restriction of chemicals (REACH), on classification, labelling and packaging of substances and mixtures (CLP).

In addition, companies producing fluoropolymers may become certified to the most widely recognized and adopted environmental management system (EMS) framework, ISO 14001:2026. The standard provides a framework for organizations to design and implement an EMS, and continually improve their environmental performance. By adhering to this standard, organizations can ensure they are taking proactive measures to minimize their environmental footprint, comply with relevant legal requirements, and achieve their environmental objectives. By adopting this standard, a commitment is made not only to regulatory compliance but also to continuous environmental improvement.

According to ISO 14001:2026: "The purpose of this International Standard is to provide organizations with a framework to protect the environment and respond to changing environmental conditions in balance with socio-economic needs. It specifies requirements that enable an organization to achieve the intended outcomes it sets for its environmental management system.

A systematic approach to environmental management can provide top management with information to build success over the long term and create options for contributing to sustainable development by:

- protecting the environment by preventing or mitigating adverse environmental impacts;
- mitigating the potential adverse effect of environmental conditions on the organization;

- assisting the organization in the fulfilment of compliance obligations;
- enhancing environmental performance;
- controlling or influencing the way the organization's products and services are designed, manufactured, distributed, consumed and disposed by using a life cycle perspective that can prevent environmental impacts from being unintentionally shifted elsewhere within the life cycle;
- achieving financial and operational benefits that can result from implementing environmentally sound alternatives that strengthen the organization's market position;
- communicating environmental information to relevant interested parties.”

The ISO 14001 requires the establishment of an environmental policy, identification of environmental aspects and impacts, setting environmental objectives and targets, implementing operational controls to minimize environmental impact, establishment of procedures to monitor environmental performance, and the review and updating of the environmental plan. Monitoring and measurement of environmental performance are requirements of the standard, as is training employees to the EMS and compliance with applicable environmental laws and regulations.

These principles and practices are also embodied in the general BATs in the Appendix.

1.3 Overview of Potential Air Emissions Relevant for Fluoropolymer Manufacturing

In 2021, the OECD defined per- and polyfluoroalkyl substances (PFAS) as fluorinated substances that contain at least one fully fluorinated methyl or methylene carbon atom (without any H/Cl/Br/I atom attached to it) (OECD 2021).

Fluoropolymers are polymeric PFAS with carbon-only polymer backbone and fluorine atoms directly attached to it. The OECD wrote a report outlining fluoropolymer production, use, degradation and environmental emissions from a life cycle perspective (OECD 2025).

All fluoropolymers begin with similar types of substances (e.g., monomers, initiators, chain transfer agents, reaction medium, inert gas stabilizer, pH adjuster, etc.). Some fluoropolymers require use of polymerization aids in their manufacture. The starting substances in fluoropolymers were assigned hazard, use, exposure controls and physical chemical properties when they were EU REACH-registered. This information is available for use by authorities setting permits for air emissions from fluoropolymer manufacturing.

The types of potential fluorinated air emissions from fluoropolymer manufacture are shown here.

- Monomers
- Ultra-short chain PFAS (with 2-3 carbons)
- Short chain PFAS (with 4-7 carbons)
- Long chain PFAS (with 8-21 carbons)

Not all of these substances are relevant for all fluoropolymer manufacturing facilities, therefore potential air emission composition will vary. Note also that detection of substances in air and reporting of emissions per government permits does not equate to noncompliance.

2. Filtration

2.1 Basic information about the technology

Filtration is an increasingly implementable solution used as pre-treatment component in current PFAS abatement systems, often integrated with other technologies to remove PFAS from air, water or waste streams. Filtration technology is a process designed to separate solid particles, liquid droplets, or aerosols from a gas or liquid stream. It is widely used across chemical industries for purposes such as emissions control, air purification, water treatment, and material recovery. The fundamental principle of filtration lies in the physical separation of particles using a filter medium, such as fabric, glass fibers, or synthetic materials, which acts as a barrier to trap substances of interest.

Filtration systems operate using several key mechanisms. Larger particles are physically blocked by the filter medium in a process known as sieving, while smaller particles are captured through interception, inertial impaction, diffusion, or electrostatic attraction. Interception occurs when particles adhere to the filter fibers as they follow the fluid streamlines, while inertial impaction takes place when larger particles deviate from the flow path due to inertia and collide with the filter fibers. Diffusion captures tiny particles exhibiting random motion, and electrostatic attraction traps electrically charged particles on oppositely charged filter fibers.

A critical aspect of filtration is the fluid dynamics involved, as systems are designed to allow the fluid (gas or liquid) to pass through the filter medium efficiently while minimizing pressure drops. The ability of filters to retain particles is evaluated based on particle size and removal efficiency. High-efficiency filters, such as High-Efficiency Particulate Air (HEPA) and Ultra-Low Penetration Air (ULPA) filters, are capable of capturing extremely small particles, down to 0.3 micrometers, with efficiencies exceeding 99.9%. Since microparticles are defined as < 5,000 micrometers in diameter, microparticles are effectively removed with this filtration technology. Minimizing particulate emission through filtration technology mitigates the risks of substances of concern potentially adsorbed to particles, such as non-polymeric PFAS, viruses, etc.

Various filtration technologies have been developed to meet specific industrial and environmental needs. Absolute filters, such as HEPA and ULPA filters, are constructed from tightly woven glass cloth or synthetic fibers and are primarily used for high-efficiency removal of fine particles, dust, aerosols, and particulate-bound metals. Fabric filters (also known as bag filters) utilize porous woven or felted materials to trap particulates, achieving removal efficiencies of 95% to over 99.9%.

Mist eliminators are specialized devices designed to remove liquid droplets, aerosols, or mists from a gas or vapor stream. Their primary purpose is to ensure that the gas stream is free of liquid substances of interest before it is released into the environment or used in downstream processes. Mist eliminators, a standard technology for fluoropolymer manufacturers, are widely employed in industrial systems, such as cooling towers, scrubbers, evaporators, condensers, and distillation columns, where mist formation is common.

Mist formation occurs when liquid particles are entrained within a gas stream, typically due to turbulence, evaporation, or mechanical agitation. These droplets can range in size from large particles to submicron aerosols. Mist eliminators work by capturing and removing these liquid droplets. They rely on physical and mechanical principles to separate and collect the mist while allowing the gas to pass through. By doing so, mist eliminators help maintain process efficiency, comply with environmental standards, and prevent equipment degradation.

2.2 Information on the current use of the technology

These are the main ways in which filtration technology is applied to PFAS abatement technologies:

- Pre-Filtration to Reduce Dust: Pre-filtration systems, such as fabric filters or plate filters, are often installed to reduce dust concentrations before activated carbon filters. Dust can clog activated carbon filters, reducing their effectiveness. Plate filters, for example, can achieve dust concentrations as low as $<0.1 \text{ mg/m}^3$ and are suitable for temperatures up to 110°C . Effective pre-filtration ensures the longevity and capacity of activated carbon filters.
- Gas Washers with Mist Filters: In systems treating PFAS-containing gases, mist filters are used in conjunction with gas scrubbers (washers). These mist filters can remove particles larger than 0.1 microns with up to 99% efficiency, preventing PFAS-laden droplets or particles from reaching subsequent treatment stages like activated carbon filters. Such configurations are often found in industries like waste incineration or fluoropolymer production.
- Fabric Filters: Fabric filters (e.g., bag filters) are used to capture solid particles, including those potentially containing PFAS. These are typically employed in systems processing PFAS-containing air or gases.

Members of the Manufacturing Programme use filtration technology predominantly to remove particles/aerosols containing PFAS from air exhaust streams as pretreatment technologies to prevent fouling of subsequent adsorption technologies. Filtration is not effective for the removal of monomers, ultra-short, short or long-chain PFAS.

2.3 Environmental performance of the technology (key data)

The environmental performance of solid filtration technologies in PFAS abatement is primarily assessed by their ability to effectively capture PFAS particles from emissions and waste streams. Removal efficiency of the filter depends on particle size. For particles $>100 \text{ nm}$, a removal efficiency of 99% can be achieved.

Solid filtration technologies, such as fabric filters (e.g., bag or muffle filters) and plate filters, demonstrate high removal efficiencies for particulate-bound PFAS and PFAS powder (such as fluoropolymers).

Fabric filters can achieve general removal efficiencies of 99–99.9%, reducing dust concentrations in emissions to levels as low as $<10 \text{ mg/Nm}^3$. (See definition of Nm^3 .)

Plate filters can achieve even lower dust concentrations ($<0.1 \text{ mg/m}^3$), making them highly effective pre-filtration systems used to protect downstream treatment technologies like activated carbon filters.

While solid filters are highly effective for particulate-bound PFAS and PFAS powder (such as fluoropolymers), they are not suitable for capturing gaseous PFAS. Complementary technologies, such as activated carbon, gas washing systems or incineration, are needed for comprehensive treatment. See the water emissions document.

Solid filtration technologies provide effective environmental performance in particulate abatement in fluoropolymer manufacturing by capturing particulate (and therefore, particulate-bound PFAS) with high efficiency (for particles 100 nm removal efficiency is 99%) and minimizing emissions. However, their effectiveness is enhanced when used as part of an

integrated treatment system, addressing both particulate and gaseous forms of PFAS. Efficiency and effectiveness of filtration systems also depend on proper installation and ongoing routine maintenance. Proper waste management according to national, local regulations is also essential to ensure the long-term environmental benefits of these filtration technologies.

2.4 Cross media effects / environmental co-benefits

These filtration technologies often generate a solid and/or a liquid waste stream for subsequent management through complementary technologies, such as activated carbon, gas washing or incineration. See the water emissions document. Cross-media effects in solid filtration systems must be carefully managed to ensure the benefits of PFAS removal outweigh potential secondary impacts to other media (e.g. water, wastewater). This requires:

- Disposal and destruction of waste streams by incineration;
- Energy-efficient system designs;
- Continued innovation in filtration materials to minimize degradation and associated risks.

2.5 Economics

The economic considerations of using solid filtration technologies in PFAS abatement processes are multifaceted, involving both capital investment and operational costs. These considerations are influenced by the system design, the type and concentration of PFAS to be treated, and the scale of the operation. Below are the main economic aspects to consider: (per CWW BREF Brinkmann et al., 2016 tables 3.245 and 3.251 page 451)

- Equipment and installation costs (per 1,000 Nm³/h) €2,620 - 55,000
- Operating Costs (per 1,000 Nm³/h) €200-1500
- Waste Disposal Costs (cost per tonne substance treated) €44-397.

However, it should be noted that there are differences between manufacturing plants depending on production volumes, type of polymers and local regulations. Therefore, it is difficult to define costs related to filtration technologies.

3. Scrubber

3.1 Basic information about the technology

According to the BAT reference document for CWW, WG (Brinkmann et al., 2016) and CWG (Daginnus et al., 2023), absorption (or scrubbing) technique removes VOCs, NH₃, HCl, HF, NO_x, SO_x, and other inorganic gaseous compounds, in addition to dust/particulates. The scrubber is one of the technologies used to reduce channelled (ducted) emissions to air.

Scrubbers are air emission control systems used for the removal of particulate matter, aerosols, mists and certain gaseous components present in waste gas streams. The technology relies on contact between the waste gas and a liquid medium, usually water, allowing materials carried within the gas stream to be captured and removed before the treated gas is discharged (Daginnus et al., 2023; Vander Aa et al., 2024). In wet scrubber systems, particulate matter is captured by contact with a liquid stream. In some designs, centrifugal separation is subsequently used to remove particle-laden droplets from the gas stream.

A range of scrubber designs is available for industrial applications. The most appropriate configuration is determined by the energy needs, characteristics of the waste gas stream, the nature of the target substance present and the required level of emission reduction.

- Fibrous packing scrubber: This system is generally most suitable for the removal of gaseous components of interest and may also be effective for the collection of fine particulate matter, aerosols and mists. Scrubber application is more limited for waste gas streams containing significant quantities of coarse or insoluble particulate matter, as solids accumulation may reduce performance or cause blockage of the fibre bed. Depending on the design, periodic cleaning or regeneration may be required to maintain efficient operation.
- Plate scrubber: consist of a series of trays that promote repeated contact between the waste gas and the scrubbing liquid. This staged arrangement can provide stable operation over a range of gas flow rates and loading conditions while supporting the removal of particulate matter, aerosols and selected gaseous components. The primary application is the removal of particulate matter, including PFAS particles
- Spray towers: These systems introduce a washing liquid into the waste gas stream through spray nozzles, generating droplets within the tower. They are commonly used for the removal of highly soluble gaseous components and are also applied for the removal of small particulate matter (PM <10). Compared with packed-bed scrubbers, spray towers are generally less prone to fouling, although relatively high liquid-to-gas ratios (>3 l/m³) may be required for effective removal of fine particulate matter. Material removed from the gas stream is collected in the liquid phase and subsequently treated or managed as appropriate.
- Venturi scrubber utilises a narrowed section within the gas flow path that increases gas velocity as the waste gas passes through the unit. Scrubbing liquid is introduced into the system and dispersed within the high-velocity gas stream. These operating conditions support the removal of particulate matter and make Venturi scrubbers particularly suitable for the collection of fine particles, including submicron particle fractions.

Members of the Manufacturing Programme use scrubber technology for treatment of PFAS-containing air streams. The effectiveness of scrubber technology for removal of PFAS monomers, ultra-short, short- and long-chain PFAS depends on the water solubility of the PFAS component. Members confirm this technology efficiently captures ionic, non-polymeric short-chain and long-chain PFAS and removes them from the exhaust waste streams.

3.2 Information on the current use of the technology

According to the BREF (Daginnus et al., 2023), and VITO (Vander Aa et al., 2024), scrubbing is widely used in the chemical sector as a product recovery technique for the separation and purification of gaseous streams. It could be used in combination with other control devices, such as granular activated carbon (GAC) adsorbers or waste gas oxidizers.

Water and alkaline solutions, such as sodium hydroxide (NaOH), may be used as scrubbing liquids, particularly for the treatment of acidic gaseous components, including certain non-polymeric PFAS such as perfluoroalkyl acids. In practice, multiple scrubber stages may be employed, with water used in the initial stages and alkaline scrubbing applied in a subsequent stage to enhance neutralisation of acidic components. Such arrangements are commonly used in thermal treatment systems, including waste incineration and afterburner applications.

Gas scrubbing can also be used for other waste gases with low concentrations, e.g. when extracting the work area, or for the treatment of the streams containing fluorosurfactant from polymer drying, coagulator blanketing, wastewater tank, etc.

The washing medium, containing the removed PFAS, will have to be further treated with other techniques. Refer to the wastewater emissions document.

This technology has been confirmed to be widely used in industrial applications, including fluoropolymer manufacturing.

3.3 Environmental performance of the technology (key data)

The effectiveness of gas scrubbers depends on both system design and operating conditions. Factors such as gas residence time, packing type, liquid-to-gas ratio (L/G), refreshing rate, water temperature and chemical dosing can influence overall performance. In applications involving particulate matter, dust scrubbers rely more heavily on gravity and centrifugal effects than gas scrubbers. The performance of wet dust scrubbing techniques is highly dependent on the size of the particulate matter and the aerosols to be collected.

According to the BREF, removal efficiency of organic compounds by absorption typically ranges from 50% to more than 99%. This approach is limited to water soluble PFAS and has proven to be effective for ultrashort-chain, short chain and long-chain PFAS. Venturi nozzle and scrubber is an abatement technology used by members of the Manufacturing Programme and is effective at removing short chain PFAS from the gas stream.

The abatement efficiency of a Venturi scrubber ranges from 70% to more than 99% for dust and PM₁₀ removal. Members of the Manufacturing Programme report wet scrubber efficiency of >90%. According to the BREF, the typical particulate matter loading of a fibrous packing is less than 11 g/Nm³. (Since the substance loading of the fibrous packing is the mass of substance per unit volume gas that the scrubber is designed to remove, 11 g/Nm³ is very high. In comparison, the US standard for particulate matter is typically set at 0.00015 g/m³.) As substance loading increases, the ratio of liquid to gas must increase to maintain the same collection efficiency. Higher substance loading results in increased solids content in the recycled scrubbing liquid. To maintain the solids content, a greater volume of scrubbing liquid must be bled from the system as waste and replaced with a greater volume of clean scrubbing liquid. Increased substance loadings increase the operating costs of the system due to higher pumping requirements, increased scrubbing liquid consumption, and greater waste liquid disposal volumes. Applications with high PM loadings also require more maintenance, as particles can cause plugging of orifices and wear to parts such as nozzles and fans.

3.4 Cross media effects / environmental co-benefits

The BREF reports that the main benefits of this technology are the removal of substances from the gaseous streams and that it is a robust technology.

Scrubbing transfers non-polymeric PFAS to the liquid phase, that needs additional abatement to remove/destroy components. See the wastewater emissions document for details.

3.5 Economics

Absorption is relatively inexpensive in comparison with some other techniques, e.g. thermal oxidation.

The BREF (Brinkmann et al., 2016, Table 3.237 page 441) reports an investment cost of:

- €460 – 1,380 for 1,000 Nm³/h for a fibrous packing scrubber
- €5,000 – 7,000 for 1,000 Nm³/h for a Venturi scrubber
- €1,390 – 7,480 for 1,000 Nm³/h for a plate scrubber

Per members of the Manufacturing Programme, running cost of the Venturi nozzle and scrubber is <0.001 €/Nm³. According to the BREF, the cost-effectiveness ranges from 31 to €2,460 per ton per year of emissions abated.

4. Activated Carbon

4.1 Basic information about the technology

According to the BAT CWW and WGC, activated carbon is one of the technologies used to reduce channelled emissions of organic compounds to air.

As described in the BREF and VITO, adsorption is a process in which substances present in a gas stream are retained on the surface of an adsorbent material. The adsorbent selectively retains certain substances, allowing them to be removed from the gas stream. Activated carbon is a highly porous carbon material with a large internal surface area, typically ranging from 700 to 1,500 m²/g. These characteristics make it suitable for the adsorption of a wide range of gaseous substances.

During operation, the waste gas stream passes through the activated carbon bed, where substances of interest are retained by the carbon. Over time, the available adsorption capacity decreases and the activated carbon must be replaced or regenerated/reactivated to maintain effective performance.

To minimise the potential for PFAS breakthrough, activated carbon systems are commonly configured using multiple units arranged in either series (lead-lag configuration) or parallel. In a series configuration, the first unit is removed from service when breakthrough of one or more target PFAS components is detected. The remaining units are then advanced within the treatment train and a new unit is installed at the final position in the series. In a parallel configuration, one unit must be replaced before or as soon as PFAS breakthrough occurs and the gas flow may be diverted to an alternative unit while the saturated unit is replaced, regenerated or reactivated.

Once removed from service, spent activated carbon may be managed through regeneration, reactivation, recovery or disposal. In many applications, the material is returned to a specialist supplier for treatment and reuse. Where regeneration is undertaken, PFAS components and other adsorbed substances are removed from the activated carbon under controlled conditions before further treatment or management.

To regenerate spent GAC, it is usually sent to a facility where it is heated to very high temperatures to destroy or remove (desorb) the adsorbed substances. Following desorption, these substances are generally present at a higher concentration and can either be recovered or managed through appropriate disposal routes. The spent GAC is tested to determine if it can be disposed of as non-hazardous waste in a suitable landfill. An alternative to landfill disposal is reactivation, which involves use of a specialised high-temperature furnace to volatilize most adsorbed substances (which are subsequently treated using appropriate abatement techniques) and restore the original pore structure of carbon. Another disposal

technique is the use of spent carbon as a fuel source in a cement kiln. The spent carbon has a high recoverable fuel value and is destroyed in the process.

The effectiveness of activated carbon technology depends on the type of substances being removed, the type of activated carbon used, and the temperature and humidity of the flue gases. Lower temperature, moisture content and dust levels generally improve the performance of activated carbon.

Activated carbon is a simple and robust technology, and suitable for continuous and discontinuous processes.

GAC technology is used by members of the Manufacturing Programme to capture non-polymeric PFAS, PFAS monomers and short chain PFAS. GAC is used to treat off-gas streams containing fluorosurfactants and fluorinated monomers originating from storage tanks.

4.2 Information on the current use of the technology

This technology is widely used in fluoropolymer manufacturing.

According to the BREF and VITO, activated carbon is widely used in the chemical sector and the typical configurations are 1 to 2 or more beds in series or in parallel. With 2 or more beds, when one bed is saturated, it is necessary to use another one to guarantee the continuity of the abatement of emissions.

4.3 Environmental performance of the technology (key data)

As described previously, activated carbon is a simple, robust and versatile technology. The efficiency depends on the type of chemicals of interest, the type of activated carbon used, and the temperature and humidity of the flue gases. Generally activated carbon has an efficiency of >90%, but efficiency decreases for fluorine components as the chain length decreases.

This activated carbon technology generally has an efficiency of >50%-99%, which is comparable to that described in the BREF and VITO. This approach has proven effective for PFAS monomers, non-polymeric, short chain and long-chain PFAS. Though removal effectiveness of GAC for ultra-short and long chain PFAS remains to be confirmed, members report operational experience of >90% and >95% effectiveness for removal of PFAS monomers and short chains, respectively.

4.4 Cross media effects / environmental co-benefits

The BREF reports that the main benefits of this activated carbon technology are the removal of target substances from gaseous streams and that it is a powerful, multipurpose and versatile abatement technology.

Steam regeneration produces wastewater with relatively high loads of chemical constituents which has to be discharged to wastewater treatment. When there is no regeneration, the adsorbent has to be disposed of, normally transferred to incineration. Regeneration and/or disposal of adsorbent can also be done by external companies.

The following environmental benefits of the activated carbon technology are of note:

- the technology can remove a wide spectrum of PFAS
- all other components in the waste stream could be adsorbed by the activated carbon;
- activated carbon may be regenerated with steam.

4.5 Economics

The CWW BREF (Brinkmann et al 2016) reports in table 3.168 page 361 an investment cost of €10,000–50,000 for 1,000 Nm³/h and a low operating cost and energy consumption. However, it should be noted that there are differences between manufacturing plants depending on production volumes, type of polymers and local regulations. Therefore, it is difficult to define costs related to activated carbon technologies. The initial investment in this technology depends on the type of system installed (e.g., fixed regenerable beds, disposable/rechargeable canisters, moving bed adsorbers, fluid-bed adsorbers), purchased equipment costs (adsorber vessel, fans, pumps, decanter, instrumentation, piping), plus installation, site preparation, buildings (construction), startup and performance tests. Operating costs include energy, operator labour, maintenance, GAC replacement and cooling water. Members of the Manufacturing Programme report costs of <0.001 €/Nm³.

5. Condensation and Cryocondensation

5.1 Basic information about the technology

According to the CWW and WGC BREFs, condensation is a technology used to remove gaseous substances from waste gas streams and may also be applied where recovery of valuable materials is desired.

Condensation operates by cooling a waste gas stream so that selected gaseous components change from the vapour phase into a liquid phase. The condensed material can then be collected for recovery, treatment or disposal, depending on its composition and the requirements of the process. A range of condensation systems is available, including:

- coolant condensation, for operating temperatures down to approximately 25 °C;
- refrigerant condensation, for operating temperatures down to approximately 2 °C;
- brine condensation, for operating temperatures down to approximately -10 °C;
- ammonia brine condensation, for operating temperatures down to approximately -40 °C (single-stage) or -60 °C (two-stage);
- cryogenic condensation, for operating temperatures down to approximately -120 °C, although operation is commonly within the range of -40 °C and -80 °C;
- closed-cycle inert gas condensation.

Condensation systems may be designed using either direct cooling, where the cooling medium comes into contact with the gas stream, or indirect cooling, where heat is removed through a heat exchanger. Indirect cooling is generally preferred because it avoids the need for an additional phase-separation step between the cooling medium and the condensed liquid. For PFAS, condensation is commonly used as a pre-treatment to recover PFAS or reduce the amount of PFAS entering subsequent treatment systems, to decrease the load of the final treatment stage (e.g. GAC adsorption or incineration).

Cryogenic condensation employs very low operating temperatures to promote the condensation and recovery of gaseous components from waste gas streams. In many systems, liquid nitrogen is used as the cooling medium, with the resulting nitrogen gas often serving as an inert blanketing gas. The technology can be applied to a broad range of VOCs and volatile inorganic compounds, and can achieve high removal efficiencies. Due to the low operating temperatures involved, the incoming gas stream is typically required to contain

minimal moisture to prevent ice formation within the system. Cryogenic condensation can accommodate variations in gas flow and component loading and may be used to recover a wide range of volatile substances. Members of the Manufacturing Programme use this technology for the recovery of PFAS monomers, ultra-short, short and long-chain PFAS and the reduction of waste generated by the use of GAC. It is also used by members in the recovery of fluorinated solvent.

5.2 Information on the current use of the technology

According to the BREF, condensation is used to remove target substances from gaseous streams by lowering the temperature of the gas stream, enabling condensable components to transition to the liquid phase. The condensate, containing the condensed chemical constituents such as PFAS, may require further treatment using additional abatement techniques. When the coolant does not contact the waste gas stream, these substances are not transferred to the cooling liquid in surface condensers, allowing the coolant to be recycled in a closed-loop system. Surface condensers allow for direct recovery of VOCs from the gas stream (US EPA Air Pollution Control Cost Manual).

5.3 Environmental performance of the technology (key data)

The efficiency of this technique is considerably dependent on gas flow rate and composition. For example, cryogenic condensation is capable of achieving high removal efficiency, which may exceed 99%.

According to the BREF, typical removal efficiencies are around 98% for condensation and adsorption, compared with greater than 99% for cryogenic condensation.

5.4 Cross media effects / environmental co-benefits

As reported by the BREF, condensation is used to reduce concentration of target substances in a gaseous stream. The condensed substances, such as VOCs and/or PFAS, will require further treatment, (e.g. adsorption, or incineration).

Wastewater generation from condensation systems is linked to the amount of condensate collected. The quantity of condensate produced varies according to the moisture content of the gas stream and the cooling temperature applied. For VOC condensation, typical condensate concentrations are reported to range between 200 and 1,000 mg/L COD (Brinkmann et al., 2016). Cryogenic condensation systems operate at extremely low temperatures and therefore require appropriate safety measures. Exposure to cryogenic liquids, such as liquid nitrogen, or to recovered material released during a leak may present risks to personnel. Cryogenic condensation is suitable for the treatment of a wide range of VOCs and volatile inorganic compounds. The very low operating temperatures can provide high condensation efficiencies, making the technology suitable for applications requiring a high degree of emission reduction. To avoid ice formation, the gas stream is generally required to be substantially free of water prior to treatment. Condensation and cryocondensation have the following environmental benefits:

- Condensation significantly reduces the concentration of fluorosurfactant in the gas stream thereby reducing the need for active carbon thermal incineration externally.;
- The coolant in surface condensers can be recovered and recycled in a closed-loop system. VOCs and non-polymeric PFAS can be condensed for removal while preventing their entry into the cooling liquid.

This approach has proven effective for PFAS monomers, ultrashort-chain, short chain and long-chain PFAS as well as recovering of fluorinated solvents.

5.5 Economics

The CWW BREF (Brinkmann et al 2016) reports in table 3.162 page 351 that condensation has an investment cost of about €7,000 – 15,000, while the cryocondensation has a higher cost of about €400,000. Members of the Manufacturing Programme report operating costs of between <0.1 €/Nm³ to <1 €/Nm³ for condensers and cryocondensers, respectively. However, it should be noted that there are differences between manufacturing plants depending on production volumes, type of polymers and local regulations therefore it is difficult to define costs related to condensation and cryocondensation technologies.

6. Thermal Oxidation

6.1 Basic information about the technology

Thermal oxidation is considered an air emission control technology in which combustible components present in waste gas stream are converted to carbon dioxide and water through oxidation in the presence of air or oxygen at elevated temperatures. For PFAS-containing waste gas streams, thermal oxidation can also result in the formation of hydrogen fluoride (HF). Consequently, downstream treatment systems commonly incorporate alkaline scrubbing or other neutralisation technologies to control acid gases and minimise corrosion. The treatment is carried out within a combustion chamber designed to provide the operating conditions necessary to achieve the required degree of oxidation.

It is stated by Vander Aa et al. that the performance of thermal oxidation is influenced by a range of operating conditions including temperature, residence time, and characteristics of the combustion environment. The BREF reports typical operating temperatures of approximately 800 °C-1000 °C. Gehrmann et al. (2024), reported PFAS destruction efficiencies exceeding 99.99% under optimised conditions, including temperatures above 860 °C and a residence time of 2 s. The high thermal stability of perfluorinated substances is associated with the strength of carbon-fluorine bonds, resulting in higher energy requirements for degradation compared with many other organic compounds. Certain fluorinated compounds, including CF₄, are particularly resistant to thermal decomposition. Thermal oxidation generally performs most efficiently when treating waste gas streams containing higher concentrations of organic compounds.

In the abatement of air emissions the Manufacturing Programme members apply thermal oxidation treatment combined with water and gas scrubbing towers. Use of scrubbers alone or in combination with other waste gas treatment techniques is considered a BAT absorption technique that removes water-soluble organic and inorganic compounds as well as dust. According to the BREF, absorption using wet scrubbers is the principal technique for the removal of gaseous fluorides from waste gas streams. Alkaline scrubbers are commonly applied for the treatment of acid gases, such as hydrogen fluoride. Packed-bed scrubbers and spray towers are among the most frequently used scrubber configurations for these applications.

Members of the Manufacturing Programme currently use thermal oxidation for the destruction of PFAS and report removal efficiencies exceeding 99% for PFAS monomers and ultra-short

chain PFAS. Under optimized operating conditions, destruction efficiencies greater than 99.99% can be achieved.

6.2 Information on the current use of the technology

According to the BREF, thermal oxidation is widely used in the chemical sectors for channelled emissions to air (Daginnus et al., 2023). The implementation of recuperative and regenerative thermal oxidation to existing plants may be limited by site-specific design and operational considerations. Vander Aa et al. (2024) report that thermal oxidation is used by PFAS producers and other chemical manufacturers for the destruction of PFAS contained in waste gas streams. Members of the Manufacturing Programme currently use this technology for destruction of PFAS.

6.3 Environmental performance of the technology (key data)

For PFAS-containing waste gas streams Vander Aa et al. (2024) indicated that thermal oxidation performance is influenced by several operating parameters, including temperature, residence time, and combustion conditions. Reported industrial data include degradation efficiencies of 93.7 % for CF₄ at temperatures between 1200 °C and 1400 °C and a residence time of 1 s, while concentrations of other measurable PFAS components were reported below the quantification limit, corresponding to degradation efficiencies greater than 99 %.

According to the BREF, abatement efficiencies of organic compounds treated by thermal oxidation typically ranges from 95 % to more than 99.99 %. Under optimised operating conditions (>860 °C and 2 s residence time), PFAS destruction efficiencies greater than 99.99% have been reported.

6.4 Cross media effects / environmental co-benefits

The BREF reports that the thermal oxidizer technique benefits from reduction of emissions to air and possible energy recovery. Vander Aa et al indicates that the most important benefit of this technique is the removal or degradation of the PFAS present.

Use of thermal oxidation technique results in the following environmental benefits:

- Reduction in VOC
- Mineralisation of all types of PFAS (with appropriate conditions)

6.5 Economics

The CWW BREF (Brinkmann et al 2016) reports in table 3.206 page 407 that thermal oxidation is more expensive in comparison with other techniques. Thermal oxidation combined with water scrubbing tower technology has a variable energy and water cost. Generally, the waste stream gas first passes through the first (of two) hot ceramic bed heating the stream (and cooling the ceramic bed) to its ignition temperature. The hot gases then react (releasing energy) in the combustion chamber. While passing through the second ceramic bed, the hot gases heat it to the combustion chamber outlet temperature. When the temperature of the outlet ceramic reaches a set temperature, the process flows are reversed with inlet gas fed into the second and then the first ceramic bed, where it exits.

However, it should be noted that there are differences between manufacturing plants depending on production volumes, type of polymers and local regulations therefore it is difficult to define costs related to thermal oxidation technologies.

7. Monitoring of air emissions

There are no standardized European measurement methods for air emissions of PFAS but there are validated methods to measure air emissions of PFAS (Vander Aa et al 2024). VITO (the Flemish Institute for Technological Research) established a method (Hofman et al., 2025) for quantifying PFAS air emissions (LUC/VI/003), which came into force in Flanders in 2024.

The choice of measurement method is dependent on the volatility of PFAS, PFAS chain length and type of analysis required (screening vs targeted). Validated methods include LUC/VI/003 (LC-MS/MS method used to determine a concentration of PFAS in a guided gas stream, with sampling train based on EPA's OTM-45 method) in addition to EPA's OTM-45 method. LUC/VI/003 method can be complemented with canister sampling followed by GC-MS analysis of the most volatile PFAS compounds (see EPA, 1999) (Vander Aa et al, 2024). The LUC/VI/003 method has been revised (June 2025).

PFAS analyses may be targeted or non-targeted. Targeted analyses look for a defined list of substances using certified authentic reference standards (for identification of detected substances). They most often employ liquid chromatography-mass spectroscopy/mass spectroscopy (LC-MS/MS) with triple quadrupole instruments. Non-targeted analysis screens for all detectable compounds using high resolution mass spectroscopy (HRMS). It has the capacity to detect many PFAS. Many detected substances may not be identified because of the lack of reference standards, or the degree of confidence in the substance identification varies.

7.1. Monitoring of stack emissions

7.1.1. Basic information about the technology and information on the current use of the technology

Channelled emissions to air refer to emissions released through a defined emission point such as a stack, vent or pipe. According to European BREF (Official Journal of European Union, 2022; Daginnus et al, 2023) monitoring of channelled emissions to air is usually performed using periodic or continuous measurement methods that are based on EN standards or when such standards are not available to ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality. Continuous measurement is a measurement using an automated measuring system permanently installed on site while periodic measurement is a measurement at specified time intervals using manual or automated methods.

Members of the Manufacturing Programme use a variety of technologies to monitor PFAS emissions to air. Monitoring can be conducted periodically and/or continuously using online techniques. Members of the Manufacturing Programme match the specific PFAS measured with the most appropriate analytical method for detection, identification, and quantitation. Techniques utilised by members are presented below.

7.1.1.1. Fourier transform infrared spectroscopy (FTIR)

Continuous air monitoring for PFAS monomers levels is conducted using FTIR-based equipment. FTIR, the preferred method of infrared spectroscopy, passes IR radiation through the sample, some of which is absorbed by the sample and some of it is passed through (transmitted). This results in a spectrum representing the molecular absorption and transmission of the sample creating a molecular fingerprint. Each molecular fingerprint is

unique and allows for the identification of substances within a sample, the consistency of the sample and the amount of components in a mixture.

7.1.1.2. Gas Chromatography (GC) and Mass Spectroscopy (MS)

The Manufacturing Programme members perform stack monitoring using Gas Chromatography (GC) and Mass Spectroscopy (MS). Gas chromatography is also used to continuously monitor major non-polymeric PFAS expected to be found in the off gas from Granulated Activated Carbon (GAC) air abatement technology. Monitoring of the non-polymeric PFAS in the off gas from GAC air abatement technology is also performed using offline targeted GC.

Gas chromatography is an analytical technique that separates and analyses volatile, thermally stable compounds within a mixture. It utilises an inert mobile phase to transport vaporized samples through a stationary phase-coated column separating components based on their volatility and interaction with the stationary phase. A mass spectrometer, often combined with a GC, allows for identification and quantification of the unknown compounds. MS operates by ionizing samples to create charged particles, accelerating them, and separating them based on their mass-to-charge ratio using electric or magnetic fields.

7.1.1.3. Volatile Organic Compounds (VOC) monitors

Whilst not PFAS specific, off gases from GAC air abatement technology can be also continuously monitored using MCERTS compliant VOC analyser.

7.1.1.4. Liquid Chromatography- tandem Mass Spectrometry (LC-MS/MS)

Liquid Chromatography combined with tandem mass spectrometry (LC-MS-MS) combines the separating power of liquid chromatography with selective mass analysis capability of triple quadrupole mass spectrometry. It is a targeted analytical method that is utilised by the Manufacturing Programme members to analyse PFAS in the exhaust of channeled emissions to air and to monitor the abatement technologies (e.g. carbon beds) for a moment of breakthrough.

One of the methods for sampling and analysing of PFAS is, for example, the US EPA OTM 45 method. OTM-45 is the US EPA's Other Test Method for the measurement of selected PFAS, from stationary sources. The method relies on traditional offline gas-phase sampling, which involve collecting samples onto filters and sorbents for later analysis. They require lengthy collection periods and primarily focus on known compounds. OTM-45 method can be used to measure up to 50 specific semi-volatile and condensable PFAS air emissions from stationary sources. It can be also used to collect and recover ionic and covalent PFAS for non-targeted analysis of PFAS compounds. OTM-45 method sampling train uses adsorbent modules such as XAD-2 to capture PFAS compounds that are then analysed on LC-MS/MS (EPA, 2025). XAD4/ORBO modules are also known to be utilised.

7.1.1.5. Mass balances

The Manufacturing Programme members perform periodic mass balances to monitor their emissions. Mass balances are one of the BAT techniques for estimating fugitive and non-fugitive emissions. They allow understanding of processes on a site and to develop improvement strategies.

According to the BAT review by Vander Aa et al. (2024), a mass balance of the total air emissions can be drawn up if sufficiently accurate information is known about presence of PFAS in the process, which components and in what concentrations, the properties of the PFAS components present, e.g. volatility/vapour pressure, including possible formation of

micelles and/or adsorption to particulate matter, the properties of the matrix in which the PFAS components are located, e.g. whether or not PFAS have a strong tendency to bind, process conditions, e.g. temperature, turbulence, air velocities, etc., and process steps that can lead to guided and/or diffuse PFAS emissions.

7.1.2 Environmental performance of the technology (key data)

As described in the European BREF (Daginnus et al., 2023) although monitoring has no direct environmental benefit, it is the prerequisite for corrective action. Ad hoc sampling, online continuous monitoring by FTIR, GC, GC-MS and external monitoring offer the ability to screen and monitor for a number of non-polymeric PFAS.

The PFAS analytical monitoring used by the members of the Manufacturing Programme utilize mass spectroscopy which is very sensitive often resulting in limits of detection (LOD) and quantification (LOQ) one or more orders of magnitude below other less sensitive analytical methods. The environmental matrix in which the PFAS analysis is conducted, the presence of other organic compounds, laboratory interferences, and other analytical factors can influence the achievable LODs and LOQs for PFAS. Verification of the efficiency of abatement technology by continuous monitoring by Gas Chromatography (GC) and Mass Spectroscopy (MS) could be limited by the analytical detection limit. For the abatement technologies frequency of sampling needs to be considered as it is dependent on the type of the abatement technology. For example, activated carbon beds need to be sampled with a frequency that will indicate the moment of breakthrough.

All of the techniques separately and combined allow for the information to be obtained on the presence and emissions of specific non-polymeric PFAS as well as information on the efficiency of emission reduction technologies.

7.1.3. Cross media effects / environmental co-benefits

The Manufacturing Programme members report that LC-MS/MS technique is very versatile and can be used for different analytical procedures.

No other cross-media effects or other environmental co-benefits have been reported by members.

7.1.4. Economics

All of the techniques may require initial investment in the equipment, ongoing maintenance and running costs. External analysis costs also need to be considered.

The members of the Manufacturing Programme report that implementation of LC-MS/MS may require high investment cost but running costs are low in comparison. For the easily quantifiable aspects, sampling and analysis can cost €2,000-4,000 up to €10,000 or €100,000 per year for analysis. Extraction from XAD/ORBO can cost €100-200 per sample.

According to the European BREF (Daginnus et al., 2023), mass balances require additional costs due to measurements and staff time. All monitoring techniques require initial investment in equipment, ongoing maintenance and operating costs. External analytical costs also need to be considered.

7.2. Monitoring of diffuse and fugitive emissions to air

7.2.1 Basic information about the technology and information on the current use of the technology

Diffuse emissions to air are releases that do not occur through dedicated ducts or stacks. They include fugitive and non-fugitive emissions (Daginnus et al, 2023). Fugitive emissions are caused by loss of tightness of equipment which is designed or assembled to be tight. Fugitive emissions can arise from moving equipment, such as agitators, compressors, pumps, valves (manual and automatic) and/ or static equipment, such as flanges and other connections, open-ended lines, sampling points. Non-fugitive emissions are diffuse emissions other than fugitive emissions. Non-fugitive emissions may arise from, for example, atmospheric vents, bulk storage, loading/unloading systems, vessels and tanks (on opening), open gutters, sampling systems, tank venting, waste, sewers and water treatment plants. Emissions arising from maintenance activities would also be considered non-fugitive emissions.

According to European BREF (Daginnus et al., 2023), diffuse VOC emissions to air should be monitored using recognised standards. Monitoring requirements depend on both the source type (fugitive or non-fugitive) and whether the VOCs are classified as CMR Category 1A or 1B. For most diffuse emission sources, monitoring is undertaken at least annually. For VOCs classified as CMR Category 1A or 1B, as well as non-CMR Category 1A or 1B from fugitive and non-fugitive sources monitoring should generally be undertaken at least annually. However, fugitive emissions of VOCs that are not classified as CMR Category 1A or 1B may be monitored in accordance with the frequency specified within the Leak Detection and Repair (LDAR) programme. In addition, the BREF recommends that fugitive and non-fugitive VOC emissions are estimated separately at least once per year by using one or a combination of techniques such as emission factors, mass balance or thermodynamic models. The uncertainty associated with the emission estimated should be also evaluated.

According to the European BREF, diffuse VOC emissions can be estimated by emission factors, mass balance, thermodynamic models, portable VOC analysers, optical gas imaging (OGI), differential absorption LIDAR (DIAL) method, solar occultation flux (SOF) method or tracer correlation methods (Daginnus et al, 2023).

Members of the Manufacturing Programme use a variety of technologies to monitor diffuse and fugitive emissions of PFAS emissions to air and take corrective action to control them. Monitoring can be either via external laboratory, online gas detection system in the workplace or outside the plant, as part of Leak Detection and Repair Programme (LDAR) and periodic mass balances.

7.2.1.1. Online continuous monitoring systems

The Manufacturing Programme members that have gas in their manufacturing plants have gas detection systems using online analysers for continuous monitoring throughout areas of the manufacturing plants inform of fugitive emissions. The system has been designed to identify potential sources of exposure and ensuring exposure standards are not exceeded. This monitoring provides alarms when set threshold concentration limit is detected. Air in the workplace can be monitored using online detectors for the purpose of processing and hygiene workplace air control. The results may have to be shared with authorities. Monitoring outside the manufacturing plant involves online continuous detection of gas.

7.2.1.2. Offline monitoring systems

Air in the workplace or outside of the plant of the Manufacturing Programme members is measured using periodic time weighted air monitoring with cartridge (active sampling) to check external air emission for polymerization aid and monomers (general population air exposure) shared with authorities.

One of the methods used to measure PFAS and for identifying sources of fugitive air emissions is, for example, the US EPA OTM 45 method that is based on LC-MS/MS technique.

7.2.1.3. Leak Detection and Repair Programme (LDAR)

The Leak Detection and Repair Programme described in the European BREF is a systematic approach for identifying, monitoring and reducing fugitive emissions to air (Daginnus, et al., 2023). An LDAR programme is typically over a period of one to five years, depending on the size, complexity, and operational characteristics of the installation. Key elements generally include:

- Development and maintenance of an inventory of equipment that may contribute to fugitive VOC emissions, using appropriate identification and screening techniques.
- Establishment of criteria for determining when equipment is considered to be leaking. These criteria may include concentration-based leak thresholds and/or the use of visual detection techniques such as optical gas imaging. The criteria selected depend on factors such as equipment accessibility and the properties of the substances released.
- Definition of maintenance and repair criteria, including thresholds that trigger corrective actions. These thresholds are typically equal to or higher than the leak threshold and may vary depending on the characteristics of the emission source and the substances involved.
- Periodic monitoring and measurement of fugitive VOC emissions from equipment included within the LDAR inventory.
- Implementation of maintenance and repair actions where required. Corrective actions are generally prioritised according to factors such as the significance of the emission source, the properties of the emitted substances and operational considerations. Follow-up monitoring may be undertaken to confirm the effectiveness of repairs after an appropriate period.

Maintenance of records and databases used to track identified emission sources, monitoring results and corrective actions undertaken as part of the LDAR programme. Members of the Manufacturing Programme apply LDAR for fugitive emissions in line with the BAT/BREF. The fluoropolymer manufacturing facilities of members of the Manufacturing Programme are periodically shut down for maintenance. Inspections of plant equipment and replacement of parts ensures appropriate functioning of equipment and prevents failures that may result in fugitive emissions.

7.2.1.4. Mass balances

Manufacturing Programme members perform periodic mass balances to monitor their emissions. Mass balances are an important tool for understanding on-site processes, estimating emissions and supporting the development of improvement strategies.

According to the European BREF (Daginnus, et al., 2023) mass balance approaches can provide an indication of overall site emissions but have limitations when used to quantify emissions accurately or to identify individual emission sources. According to Vander Aa et al. (2024), the preparation of a PFAS air-emission mass balance depends on the availability of

sufficiently detailed process information. This includes knowledge of the PFAS components present and their concentrations, their behaviour within the process (including volatility and interactions with particulate matter), characteristics of the process matrix, operating conditions such as temperature and airflow, and the process activities that may generate channelled or diffuse PFAS emissions. Environmental performance of the technology (key data)

Monitoring provides the basis for assessing performance, identifying deviations and informing corrective measures, although it does not directly result in emission reductions (Daginnus et al., 2023). All of the techniques separately and combined allow for the information to be obtained on the presence and emissions of specific non-polymeric PFAS as well as information on the efficiency of emission reduction technologies. Mass balances allow for monitoring of non-polymeric PFAS emissions not only to air but also to other compartments

7.2.2 Cross media effects / environmental co-benefits

The Manufacturing Programme members report that LC-MS/MS technique is very versatile and can be used for different analytical procedures.

No other cross-media effects or other environmental co-benefits have been reported by members.

7.2.3 Economics

All of the techniques may require initial investment in the equipment, ongoing maintenance and running costs. External analysis costs also need to be considered.

Costs for performing sampling and measurements by techniques such as OTM-45 utilising LC-MS/MS are presented in section 7.1.4. Members report that performing LDAR costs about €90,000 per year.

According to the European BREF (Daginnus et al., 2023), mass balances require additional costs due to measurements and staff time.

The following BAT provisions are reproduced from the BAT Conclusions for Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (Brinkmann et al, 2016),

8. Appendices

The following BAT provisions are reproduced from the BAT Conclusions for Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (Brinkmann et al, 2016).

8.1 General BAT 1

In order to improve overall environmental performance, best available techniques to elaborate and implement an environmental management system (EMS) incorporate all of the following features:

1. Commitment, leadership, and accountability of the management, including senior management, for the implementation of an effective EMS;
2. An analysis that includes the determination of the organization's context, the identification of the needs and expectation of interested parties, the identification of characteristics of the installation that are associated with possible risks for the environment as well as of the applicable legal requirements relating to the environment and human health;
3. Development of an environmental policy that includes the continuous improvement of the environmental performance of the installation;
4. Establishing objectives and performance indicators in relation to significant environmental aspects, including safeguarding compliance with applicable legal requirements;
5. Planning and implementing the necessary procedures and actions (including corrective and preventative actions where needed, to achieve the environmental objectives and avoid environmental risks;
6. Determination of structures, roles and responsibilities in relation to environmental aspects and objectives and provision of the financial and human resources needed;
7. Ensuring the necessary competence and awareness of staff whose work may affect the environmental performance of the installation (e.g., by providing information and training);
8. Internal and external communication;
9. Fostering employee involvement in good environmental management practices;
10. Establishing and maintaining a management manual and written procedures to control activities with significant environmental impact as well as relevant records;
11. Effective operational planning and process control;
12. Implementation of appropriate maintenance programmes;
13. Emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations;
14. When (re)designing a (new) installation or a part thereof, consideration of its environmental impacts throughout its life, which includes construction, maintenance, operation and decommissioning;
15. Implementation of a monitoring and measurement programme; if necessary, information can be found in the Reference Report on Monitoring of Emissions to Air and Water from IED Installations;
16. Application of sectoral benchmarking on a regular basis;
17. Periodic independent (as far as practicable) internal auditing and periodic independent external auditing in order to assess the environmental performance and to determine

- whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained;
18. Evaluation of causes of nonconformities, implementation of corrective actions in response to nonconformities, review of the effectiveness of corrective actions, and determination of whether similar nonconformities exist or could potentially occur;
 19. Periodic review, by senior management, of the EMS and its continuing suitability, adequacy and effectiveness;
 20. Following and taking into account the development of cleaner techniques.

8.2 General BAT 2:

In order to improve the overall environmental performance, BAT is to establish, maintain and regularly review (including when a significant change occurs) an inventory of inputs and outputs, as part of the EMS (see BAT 1), that incorporates all of the following features:

1. Information about the production processes, including:
 - i. Simplified process flow sheets that show the origin of the emissions to air, water and soil;
 - ii. Descriptions of process-integrated techniques and waste water/waste gas treatment techniques to prevent or reduce emissions, including their performance (e.g., abatement efficiency);
 - iii. Information about the quantity and characteristics of raw materials and fuels used;
 - iv. Information about water consumption and usage (e.g., flow diagrams and water mass balances);
 - v. Information about energy consumption and usage;
 - vi. Information about the characteristics of the waste water streams, such as:
 1. Average values and variability of flow, pH, temperature and conductivity;
 2. Average concentration and mass flow values of relevant substances/parameters (e.g., total suspended solids, TOC or COD, metals, etc.) and their variability;
 - vii. Information about the quantity and characteristics of the process chemicals used:
 1. The identity and the characteristics of process chemicals, including properties with adverse effects on the environment and/or human health;
 2. The quantities of process chemicals used and the location of their use;
 - viii. Information about the characteristics of the waste gas streams, such as:
 1. Average values and variability of flow and temperature;
 2. Average concentration and mass flow values of relevant substances (e.g., dust, NO_x, SO_x, CO, etc.) and their variability;
 3. Presence of other substances that may affect the waste gas treatment system (e.g., oxygen, nitrogen, water vapour) or installation safety;
 4. Presence of substances classified as CMR 1A, CMR 1B or CMR 2; the presence of such substances may for example be assessed according to the criteria of Regulation (EC) No. 1272/2008 on classification, labelling, and packaging, (CLP);
 - ix. Information about the quantity and characteristics of residue generated.

Applicability

The level of detail and the degree of formalization of the inventory will generally be related to the nature, scale and complexity of the plant and the range of environmental impacts it may have.

8.3 General BAT 3:

In order to improve overall environmental performance, BAT is to elaborate and implement a chemicals management system (CMS), as part of the EMS, that incorporates all of the following features:

1. A policy to reduce the consumption of and risks associated with process chemicals, including a procurement policy to select less harmful process chemicals and their suppliers with the aim of minimising the use of and risks associated with hazardous substances and substances of very high concern as well as to avoid the procurement of an excess amount of process chemicals. The selection is based on:
 - a. the comparative analysis of their hazard classification and potential to be released into the environment in order to reduce emissions to the environment.
 - b. the pathways of the process chemical through the plant, potential release and level of exposure
 - c. the potential for recovery and reuse;
 - d. the regular analysis of the potential for substitution with the aim to identify potentially new available and safer alternatives that meet performance standards and socioeconomic feasibility;
 - e. the anticipatory monitoring of regulatory changes related to hazardous substances and substances of very high concern and the safeguarding of compliance with applicable legal requirements.

Applicability

The level of detail and the degree of formalization of the inventory will generally be related to the nature, scale and complexity of the plant and the range of environmental impacts it may have.

9. References

European Commission (EC), Integrated Pollution Prevention and Control Reference Document on Economics and Cross-Media Effects (ECM) July 2006. [Economics and Cross-media Effects | EU-BRITE](#)

European Commission (EC), Reference Document on Best Available Techniques for Energy Efficiency February 2009 (corrected version as of 09/2021) Energy Efficiency (ENE). [Energy Efficiency | EU-BRITE](#)

European Commission (EC), Reference Document on Best Available Techniques in the Production of Polymers, August 2007

Brinkmann, T., Both, R., Scalet, B., Roudier, S. and Delgado Sancho, L.. JRC Reference Report on Monitoring of Emissions to Air and Water from IED Installations - Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control), EUR 29261 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-86853-5, doi:10.2760/344197, JRC112164. (ROM),
<https://publications.jrc.ec.europa.eu/repository/handle/JRC112164>

Brinkmann, Thomas, Germán Giner Santonja, Hande Yükseler, Serge Roudier, Luis Delgado Sancho; Best Available Techniques (BAT) Reference Document for Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector; EUR 28112 EN; <https://data.europa.eu/doi/10.2791/37535>

Daginnus, K., Marty, T., Trotta, N. V., Brinkmann, T., Whitfield, A., Roudier, S. (2023). Best Available Techniques (BAT) Reference Document for Common Waste Gas Management and Treatment Systems in the Chemical Sector. JRC Policy for Science Report. Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) <https://data.europa.eu/doi/10.2760/220326>

Gehrmann, Hans-Joachim, Philip Taylor, Krasimir Aleksandrov, Philipp Bergdolt, Andrei Bologna, David Blye, Priyank Dalal, Priyanga Gunasekar, Sven Herremanns, Deepak Kapoor, Meg Michell, Vanessa Nuredin, Michael Schlipf, Dieter Stapf, Mineralization of fluoropolymers from combustion in a pilot plant under representative European municipal and hazardous waste combustor conditions, Chemosphere, Volume 365, 2024, 143403, ISSN 0045-6535, <https://doi.org/10.1016/j.chemosphere.2024.143403>

Hofman Jelle, Griet Jacobs, Bart Baeyens, Aline Reis De Carvalho, Wim Aerts, Stefan Voorspoels, Gill Van den Bergh, Masha Van Deun, Patrick Berghmans, Andres Van Brecht, Gert Otten, Quantifying per- and polyfluoroalkyl substances (PFAS) in air emissions: Lab & field experiences from a hazardous waste incinerator, Environment International, Volume 200, 2025, 109541, ISSN 0160-4120, <https://doi.org/10.1016/j.envint.2025.109541>

ISO 14001:2026 (en), Environmental management systems — Requirements with guidance for use

OECD (2021), Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance, OECD Series on Risk Management of Chemicals, OECD Publishing, Paris, <https://doi.org/10.1787/e458e796-en>.

OECD (2025), Synthesis report on understanding fluoropolymers and their life cycle, OECD Series on Risk Management of Chemicals, OECD Publishing, Paris, <https://doi.org/10.1787/35b035df-en>.

Official Journal of the European Union, L318, 12 December 2022 (2022) *Official Journal* L 318, 157. Commission implementing decision (EU) 2022/2427 of 6 December 2022 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for common waste gas management and treatment systems in the chemical sector.

https://eur-lex.europa.eu/eli/dec_impl/2022/2427/oj

U.S. Environmental Protection Agency (USEPA). (2023). Air Pollution Control Technology Fact Sheet: Fabric Filter Mechanical Shaker Cleaned Type and Cleaned Type with Sonic Horn Enhancement 2023, EPA-452/F-03-024

U.S. Environmental Protection Agency (USEPA). (2003). Air Pollution Control Technology Fact Sheet: [Fabric Filter - Reverse-Air/Reverse-Jet Cleaned Type with and without Sonic Horn enhancement, 2003](#)

U.S. Environmental Protection Agency (USEPA). (2003). Air Pollution Control Technology Fact Sheet: Fabric Filter - Pulse-Jet Cleaned Type, EPA-452/F-03-025.

U.S. Environmental Protection Agency (USEPA). (January 2002) Air Pollution Control Cost Manual [Cost Reports and Guidance for Air Pollution Regulations | US EPA](#) on line, in process update to EPA/452/B-02-001 EPA AIR POLLUTION CONTROL COST MANUAL Sixth Edition EPA/452/B-02-001/ .

U.S. Environmental Protection Agency (USEPA). (1999). Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Second Edition. Compendium Method TO-15: Determination of Volatile Organic Compounds (VOCs) In Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS). Center for Environmental Research Information Office of Research and Development U.S. Environmental Protection Agency Cincinnati, OH 45268. EPA/625/R-96/010b.

U.S. Environmental Protection Agency (US EPA). (2025). Other Test Method 45 (OTM-45) Measurement of Selected Per- and Polyfluorinated Alkyl Substances from Stationary sources. <https://www.epa.gov/system/files/documents/2025-01/other-test-method-45-rev1-final-1-14-25.pdf>

Vander Aa, S., Lescrauwaet, A., Goelen, T., Janssens, G. (2024). Beste beschikbare technieken (BBT) ter beperking van pfas luchtemissies (BAT study to reduce PFAS air emissions). Flemish Knowledge Centre for Best Available Techniques (VITO) on behalf of Flemish region. <https://emis.vito.be/nl/bbt/publicaties/bbtbref-en-andere-publicaties/pfas-emissies-lucht>

Contact:

Caroline Andersson, Director Fluoropolymers Product Group: caroline.andersson@plasticseurope.org
Tel: +32 2 7923 53, Mobile: +32 477 639165

About Fluoropolymers Product Group (FPG):

The FPG is part of Plastics Europe, the industry association representing European polymer producers. It operates in accordance with the Plastics Europe governance rules, including Competition Compliance Rules. Plastics Europe covers the EU, plus UK, Norway, Turkey and Switzerland.

About Fluoropolymers:

Fluoropolymers are advanced materials that provide unmatched durability, chemical and thermal resistance, and stability in extreme environments. Their unique set of properties makes them essential in many industries, from healthcare and renewable energy to transportation, aerospace and semiconductors