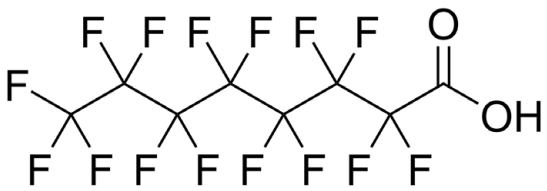
Method Guide for PFAS Analysis

A Survey of Existing PFAS Testing Methods and Guidelines from Around the World

PFAS are increasingly prevalent in our daily lives. They can be found in numerous places, including non-stick metal cookware, spill-resistance sprays, firefighting foams (anti-film forming foam, [AFFF]), and even some drinking water sources. While many countries have banned the use and manufacture of certain per- and polyfluoroalkyl substances because of their adverse health effects and extreme persistence in the environment, newly modified PFAS compounds are registered constantly, and manufacturing sites have relocated to where there are fewer restrictions.

The main structure of these compounds consists of covalent bonds between carbon and fluorine atoms (Figure 1). The covalent bond between carbon and fluorine is one of the strongest bonds in nature, which makes PFAS highly resistant to breaking down and enables their very long lifetimes. This is why PFAS are frequently called "forever chemicals."

Figure 1: Structure of PFOA (perfluorooctanoic acid).



Early movements in establishing PFAS testing methods began in 2009 with U.S. EPA Method 537 and ISO 25101:2009 method targeting select compounds in water—the most common and direct exposure pathway for humans. Since then, multiple government agencies and scientific communities have collaboratively been working together around the world and have developed several PFAS testing standards. A list of currently available testing standards is provided, along with information about their scope, in Table I.

For laboratories starting PFAS testing or for those staying up to date on existing, global testing methodologies, this table can be helpful for selecting or improving a workflow. Labs setting up new PFAS testing methods should research whether there are any PFAS manufacturing facilities in the region where their samples are from. Any specific compounds made in that region should be cross-referenced with the compounds covered by a given method because the list of target analytes vary from method to method. It is always a good idea to refer to any available regional guidelines and regulations for testing.

Due to their ubiquitous application and the frequency of daily encounters with PFAS, testing will continue to expand from environmental samples to food, consumer goods, and even air. As an example, methods ISO 23702-1:2018 and U.S. EPA OTM 45 were specifically developed for leather and air, respectively. It can be challenging for labs to keep up and keep track of new methods, but resources like this article can help you find a successful PFAS testing method for the samples you work with. If you have any questions or need some help with your PFAS analysis, contact your local Restek sales representative.

Table I: ISO PFAS Testing Methods and Guidelines.e

Standard Name	ISO 25101:2009	ISO 21675:2019	ISO 23702-1:2018
Title of Standard	Water quality — Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) — Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry.	Water quality — Determination of perfluoroalkyl and polyfluoroalkyl substances (PFAS) in water — Method using solid phase extraction and liquid chromatography-tandem mass spectrometry (LC-MS/MS)	Leather — Organic fluorine — Part 1: Determination of the non-volatile compound content by extraction method using liquid chromatography/tandem mass spectrometry detector (LC-MS/MS)
Year published (revised)*	2009	2019	2018
Sample Matrix	Water	Water	Leather
Sample Preparation	SPE (WAX, HLB, C18. Refer to Table A.1 in Annex A)	WAX (weak anion exchange) solid phase extraction	Solvent extraction (MeOH)
Detection Technique	LC-MS/MS	LC-MS/MS	LC-MS/MS
Analyte List	• PFOS • PFOA	• PFOS • PFOA • N-EtFOSAA • N-MeFOSAA • PFBS • PFDA • PFDoDA[1] • PFHpA • PFHxS • PFHxA • PFNA • PFTeDA[1] • PFTrDA[1] • PFUnDA[1] • HFPO-DA • PFBA • PFPeA • PFDS • PFHpS • FOSA • 6:2 FTSA[1] • 8:2 FTSA[1] • 8:2 FTUCA[1] • 8:2 diPAP • N-MeFOSA • N-EtFOSA • PFHxDA • PFOcDA • 9Cl-PF3ONS • DONA[1]	• PFOS[2] • PFOA[2] • PFDoDA[1,2] • PFHxS[2] • PFNA[2] • PFTeDA[1,2] • PFTrDA[1,2] • PFUnDA[1,2] • PFBS[3] • PFDA[3] • PFHpA[3] • PFHxA[3] • PFBA[3] • PFPeA[3] • PFOSA[1,3]

Table II: U.S. EPA PFAS Testing Methods and Guidelines.

Standard Name	US EPA 537.1	US EPA 533	US EPA 8327	US EPA OTM45	EPA 1633 (2nd Draft)
Title of Standard	Determination of Selected Per- and Polyfluorinated Alkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)	Determination of Per- and Polyfluoroalkyl Substances in Drinking Water by Isotope Dilution Anion Exchange Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry	Per-and Polyfluoroalkyl Substances (PFAS) Using External Standard Calibration and Multiple Reaction Monitoring (MRM) Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)	Other Test Method 45 (OTM-45) Measurement of Selected Per- and Polyfluorinated Alkyl Substances from Stationary Sources	Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS
Year published (revised)*	2018 (2019)	2019	2019	2021	2021 (2022)
Sample Matrix	Drinking water	Drinking water	Non-potable water	Air	Aqueous, soil, biosolids, sediment, tissue
Sample Preparation	S-DVB solid phase extraction	WAX (weak anion exchange) solid phase extraction	Direct injection	Sampling train with XAD resin and impingers	WAX (weak anion exchange) solid phase extraction Cleanup by bulk carbon
Detection Technique	LC-MS/MS	LC-MS/MS	LC-MS/MS	LC-MS/MS	LC-MS/MS
Analyte List	• PFOS • PFOA • N-EtFOSAA • N-MeFOSAA • PFBS • PFDA • PFDoA • PFHpA • PFHxS • PFHxA • PFNA • PFTA[1] • PFTrDA[1] • PFUnA[1] • HFPO-DA • 9Cl-PF3ONS • ADONA[1] • 11Cl-PF3OUdS	• PFOS • PFOA • PFBS • PFDA • PFDoA • PFHpA • PFHxS • PFHxA • PFNA • PFUdA[1] • HFPO-DA • PFBA • PFPeA • PFHpS • PFPeS • 4:2 FTS • 6:2 FTS[1] • 8:2 FTS[1] • 9Cl-PF3ONS • ADONA[1] • PFEESA • NFDHA • PFMPA • PFMBA • 11Cl-PF3OUdS	• PFOS • PFOA • N-EtFOSAA • N-MeFOSAA • PFBS • PFDA • PFDoA • PFHpA • PFHxS • PFHxA • PFNA • PFTeDA[1] • PFTrA[1] • PFUdA[1] • PFBA • PFPeA • PFDS • PFHpS • PFPeS • FOSA[1] • 4:2 FTS[1] • 6:2 FTS[1] • 8:2 FTS[1] • PFNS	• PFOS • PFOA • EtFOSAA • MeFOSAA • PFBS • PFDA • PFDoA • PFHpA • PFHxS • PFHxA • PFNA • PFTeDA[1] • PFTrDA[1] • PFUnDA[1] • HFPO-DA • PFBA • PFPeA • PFDS • PFHpS • PFPeS • FOSA[1] • 4:2 FTS[1] • 6:2 FTS[1] • 8:2 FTS[1] • 10:2 FTS[1] • 8:2 FTUCA or FOUEA[1] • MeFOSA[1] • EtFOSA[1] • PFHxDA • PFODA • 9Cl-PF3ONS • ADONA[1] • PFNS • PFecHS • 3:3 FTCA[1] • 5:3 FTCA[1] • 6:2 FTCA or 6:2 FHEA[1] • 7:3 FTCA or FHpPA[1] • 6:2 FHUEA[1] • PFEESA • NFDHA • PFMPA • PFMBA • 11Cl-PF3OUdS • N-MeFOSE • N-EtFOSE • Perfluorododecane sulfonate (PFDoS)[4] • Sodium perfluoro-1-dodecanesulfonate (PFDoS)[4] • 8:2 FTA or FOEA[1] • 10:2 FDEA[1]	• PFBA • PFPeA • PFHxA • PFHpA • PFOA • PFNA • PFDA • PFUnA • PFDoA • PFTrDA • PFTeDA • PFBS • PFPeS • PFHxS • PFHpS • PFOS • PFNS • PFDS • PFDoS • 4:2FTS • 6:2FTS • 8:2FTS • PFOSA • NMeFOSA • NEtFOSA • NMeFOSAA • NEtFOSAA • NMeFOSE • NEtFOSE • HFPO-DA • ADONA • PFMPA • PFMBA • NFDHA • 9Cl-PF3ONS • 11Cl-PF3OUdS • PFEESA • 3:3FTCA • 5:3FTCA • 7:3FTCA

Table III: ASTM PFAS Testing Methods and Guidelines.

Standard Name	ASTM D7979-19	ASTM D7968-17a
Title of Standard	Standard Test Method for Determination of Per- and Polyfluoroalkyl Substances in Water, Sludge, Influent, Effluent, and Wastewater by Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS)	Standard Test Method for Determination of Polyfluorinated Compounds in Soil by Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS)
Year published (revised)*	2017 (2019)	2014 (2017)
Sample Matrix	Water Sludge Influent Effluent Wastewater	Soil
Sample Preparation	Direct Injection	Direct Injection
Detection Technique	LC-MS/MS	LC-MS/MS
Analyte List	• PFOS • PFOA • PFBS • PFDA • PFDoA • PFHpA • PFHxS • PFHxA • PFNA • PFTreA[1] • PFTriA[1] • PFUnA[1] • PFBA • PFPeA • FOUEA[1] • PFecHS • FHEA[1] • FOEA[1] • FDEA[1] • FHpPA[1] • FHUEA[1]	• PFOS • PFOA • PFBS • PFDA • PFDoA • PFHpA • PFHxS • PFHxA • PFNA • PFTreA[1] • PFTriA[1] • PFUnA[1] • PFBA • PFPeA • FOUEA[1] • PFecHS • FHEA[1] • FOEA[1] • FDEA[1] • FHpPA[1] • FHUEA[1]

Table IV: DIN PFAS Testing Methods and Guidelines.

Standard Name	DIN 38407-42:2011
Title of Standard	German standard methods for the examination of water, waste water and sludge
Year published (revised)*	2011
Sample Matrix	Water
Sample Preparation	WAX (weak anion exchange) solid phase extraction
Detection Technique	LC-MS/MS
Analyte List	• PFOS • PFOA • PFBS • PFDA • PFHpA • PFHxS • PFHxA • PFNA • PFBA • PFPeA

1. Analyte acronyms may appear differently in various test standards but may refer to the same compounds. For example, DONA and ADONA are the same compound. For accurate analyte list and naming, please refer to the original published documents and the compound's CAS #.
2. Regulated compounds in ISO 23702-1:2018
3. Non-regulated compounds in ISO 23702-1:2018
4. Two different CAS numbers for PFDoS. Sodium Perfluoro-1-dodecanesulfonate is in salt format.

* U.S. EPA methods are publicly available at www.epa.gov and other methods are available for purchase from relevant agency's website.

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