# Waters™

#### Application Note

# Extending PFAS Coverage and Sensitivity in a Direct Injection UPLC-MS/MS Method for Water Matrices Based on EU and UK Drinking Water Regulations

Jenny Davies, Stuart Adams, Simon Hird, Kari L. Organtini, Kenneth J. Rosnack

Waters Corporation

#### Abstract

This application note describes a direct injection method to fulfil the requirements of a list of 47 per-and polyfluoroalkyl substances (PFAS) by the UK Drinking Water Inspectorate (DWI) and the 20 PFAS contained in the 2020 EU Drinking Water Directive (DWD) totaling 48 analytes. The work was carried out using an ACQUITY™ Premier UPLC System coupled to the XEVO™ TQ Absolute Tandem Quadrupole Mass Spectrometer using a UniSpray™ ion source. Sub-ng/L Method Detection Limits (MDLs) were achieved for all 48 analytes using a 50 µL injection volume. Method robustness was shown with validation batches analyzed over three days in drinking water, surface water and river water.

#### Benefits

Performing the direct injection on the XEVO TQ Absolute with UniSpray ion source allows:

A direct injection method, suitable for the detection and quantification of a wide panel of PFAS covering both
 EU DWD and UK DWI regulations

- · Improved productivity from reduced sample volume and preparation time
- Enhanced sensitivity allowing sub ng/L level limits of detection to exceed typical drinking water regulatory requirements for PFAS

#### Introduction

PFAS has been detected in the environment all around the world and are known colloquially as "forever chemicals". They are derived from a wide range of consumer products and manufacturing processes. Some of their most common uses include water-resistant coatings on a variety of different products and firefighting foams. It is their widespread usage and toxicity, and potential to bioaccumulate that has led to their restriction.

For drinking water in the EU, a set of 20 PFAS are specified in Directive (EU) 2020/2184 on the quality of water intended for human consumption.<sup>1</sup> It imposes a quality-based parametric value (limit) of 0.1 µg/L for the sum of 20 specified PFAS which relates to a required limit of quantification for individual PFAS analytes of 5 ng/L and lower. For raw water sources that will ultimately be used for supplying drinking water, the Drinking Water Inspectorate (DWI) in England and Wales has outlined in a letter the requirements for the monitoring of 47 PFAS by water companies.<sup>2</sup> Maximum PFAS limits have yet to be determined in this case. The document refers to the DWI January 2021 published guidance for PFOS and PFOA in drinking water which states that water companies should use a tiered risk based approach, and test the analytes each to a level of 0.01 µg/L to ensure adequate quantification significantly below any trigger levels.<sup>3</sup> The assumption is that raw water sources will have permissible levels similar to drinking water levels or higher.

Direct injection methods are increasingly desirable to laboratories carrying out routine analysis of PFAS where analyte preconcentration is not deemed necessary or required. They have a simple sample preparation method, which not only reduces the opportunity for contamination and error but speeds up analysis time and the requirements for large volumes of samples. This can provide labs with a higher throughput of samples and lower analysis costs. To achieve these low levels of detection without sample preconcentration, an ACQUITY Premier UPLC was coupled to the Xevo TQ Absolute with a UniSpray source. The UniSpray source gives additional sensitivity benefits, and more detail on how it achieves this can be found in previously published literature.<sup>4</sup> UniSpray is an atmospheric ionization technique whereby the column effluent is nebulized as it exits a grounded capillary and then directed onto an impactor pin that is held at high voltage. This process creates smaller droplets compared to electrospray ionization (ESI), leading to an increased formation of gas phase ions and

improved ionization efficiency. Typically, PFAS have been seen to especially benefit from this type of ionization mechanism with improved response and signal to although the improvement amount varies between compounds. In order to comply with the current regulatory limits for drinking water in both the EU and England and Wales, and to ensure the method can cope with the likely lowering of those limits in the future, a target was set to achieve method detection limits (MDLs) for all the PFAS listed of 1 ng/L, in all water types.

## Experimental

#### **Background Contamination**

Due to the widespread nature of PFAS in many products, background contamination is one of the biggest challenges when tackling the analysis of PFAS. It is vitally important that meticulous care is taken at every stage from sample collection and preparation, through to analysis. Installing the Waters PFAS kit reduces the background interference from the chromatographic system and solvents. The kit is comprised of PFAS-free components that replace items such as the conventional PTFE coated solvent lines with PEEK tubing. Included is an isolator column which, when installed, helps to delay any residual background interferences from co-eluting with the analytical peak. Installation of both the kit and column is straightforward and quick.<sup>5</sup> A detailed account of the best practices for monitoring PFAS to avoid contamination can be found in the Waters™ White Paper.<sup>6</sup>

For the study samples of different types of drinking water (soft and hard) and two samples of raw water that is used to supply drinking water, were collected from sources around the UK and stored at 5 °C until analysis. Samples were prepared for analysis using the workflow found in Figure 1. Results were quantified using bracketed calibrations prepared in reagent water, with the use of internal standardized response. Internal standard concentrations in the final extract ranged from 5–50 ng/L, depending on the analyte. All the standards used were obtained from Wellington Laboratories. Information for 48 PFAS and 25 internal standards used in the application can be found in Appendix A.

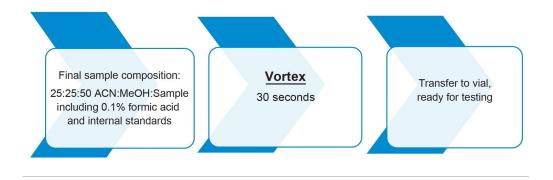


Figure 1. Preparation workflow for drinking water and environmental water samples.

# LC Conditions

LC system:	ACQUITY Premier UPLC with BSM and FTN  Sample Manager fitted with Waters PFAS kit and  Atlantis™ Premier BEH™ C18 AX 5 µm, 2.1 x 50 mm  isolator column (p/n: 186009407)
Vials:	Polypropylene 12 x 32 mm Screw Neck Vial, 700 $\mu$ L (p/n: 186005219), with pre-slit PTFE/Silicone septa (p/n: 186000305)
Column:	ACQUITY Premier CSH <sup>™</sup> C <sub>18</sub> , 1.7 μm, 2.1 mm X 100 mm (p/n: 186009461)
Column temperature:	40 °C
Sample temperature:	15 °C
Injection volume:	50 μL
Flow rate:	0.350 mL

N. 4 -   -   -   -   -   -   -   -   -   -	0 14	
Mobile phase A:	2 mM ammonium acetate in water:methanol 95:5	

(V/V)

Mobile phase B: 2 mM ammonium acetate in methanol

Purge solvent and seal wash: 50:50 methanol:water

Wash solvent: 90:10 methanol:water

#### **Gradient Table**

Time (min)	Flow (mL/min)	%A	%В	Curve
Initial	0.35	100	0	Initial
1	0.35	80	20	6
6	0.35	55	45	6
13	0.35	20	80	6
14	0.35	5	95	6
17	0.35	5	95	6
18	0.35	100	0	1
22	0.35	100	0	1

#### **MS Conditions**

MS system: Xevo TQ Absolute

Ionization mode: UniSpray, negative ion mode

Acquisition range: MRM

Impactor voltage: 0.9 kV

Desolvation temperature: 400 °C

Desolvation gas flow: 900 L/hr

Cone gas flow:	150 L/hr

Source temperature: 110 °C

**MRM Transitions** 

MRM parameters for each compound are listed in Appendix A.

#### Data Management

Informatics: waters\_connect™ for quantitation

#### Results and Discussion

#### Method Optimization

When simultaneously analyzing PFAS with a wide range of functionality (including carbon chain length), a careful balance of parameters is required to obtain maximum performance for all analytes. Two factors that can make a significant impact on performance are sample composition and desolvation temperature. In the following section different aspects to optimize the methods are discussed.

# Optimization of the Preparation of Samples for Analysis

The reduced solubility of long chain PFAS in water can result in precipitation of analytes or cause them to stick to the sides of vessels. To assess the recovery of analytes, samples were prepared using two different methods. For both methods the native analytes were spiked into water samples and homogenized. For method 1 an aliquot of the water was transferred into a centrifuge tube for sample preparation. For method 2 the water samples were not transferred and were prepared in the same container they were stored in. The mean recoveries, calculated using the concentration of six replicates of soft drinking water, for samples prepared using both methods are shown in Figure 2. The recovery of the longer chain analytes was found to be worse when samples were prepared using method 1. Whereas, by comparison, the recovery of the analytes from samples that were prepared using method 2, without any transferring, did not exhibit the same issues. It was determined that the

addition of organic solvent to the sample collection vessel assisted the solubility of analytes and washed any analytes from the sides of the container, resulting in improved recovery. When samples were prepared in this manner, they achieved recoveries between 83–124% for all 48 analytes.

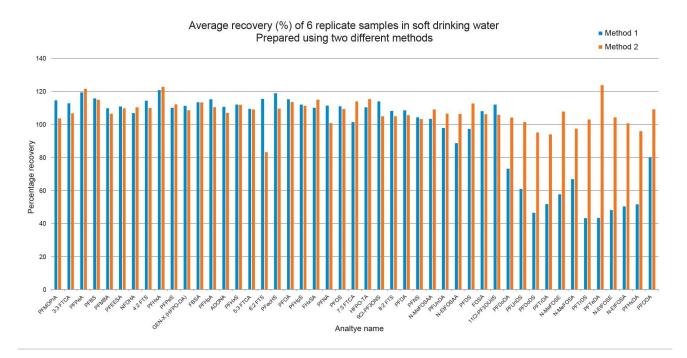


Figure 2. Average Mean recoveries (%) from six replicate samples prepared from soft drinking water by method 1 (blue) and method 2 (orange).

# Effect of Sample Composition on Peak Shape

Sample composition and preparation can yield substantial improvements in both response and chromatography. The reduced solubility of long chain PFAS (carboxylic and sulfonic acids with C10 and higher) in water, is highlighted with PFHxDA and PFODA, C16 and C18 respectively. Improvements can be seen with these compounds by diluting to a higher final organic content. However, increasing the organic content above 50% showed peak shape deterioration for short chain PFAS, and adds a further dilution to the sample, making it difficult to achieve the required low levels of detection.

A compromise of 50% organic solvent sample composition, with a ratio of 25:25:50 (v/v/v) of acetonitrile:methanol:water was chosen as the optimum blend of organic solvents to yield the best solubility and therefore performance of all analytes. The addition of formic acid to the sample at a concentration of 0.1%, saw

improvements in the peak shape of early eluting analytes.

Adding sufficient time to vortex mix the sample is another key detail in sample preparation that is essential for reproducible results, specifically for long chain PFAS. The solubility data of PFAS, shows as the PFAS carbon chain increases the solubility in water decreases. Therefore, these longer chain analytes can and have a tendency to precipitate and adhere to the sides of vessels. Ensuring the analytes are dissolved through vortex mixing during sample preparation can significantly improve the reproducibility of the analytes.

#### Comparison of the Response for PFAS When Using Electrospray and UniSpray

A direct comparison of electrospray and UniSpray was made by the analysis of 20 repeat injections of a 10 ng/L reagent water sample, using both ionization techniques. All 48 analytes showed improved response using UniSpray, gaining on average 2 to 7-fold increase in signal. These performance gains are particularly relevant with compounds that typically struggle with sensitivity, for example GenX and PFHxDA. Figure 3 contains chromatograms of these analytes analyzed using both methods of ionization. It can be seen that GenX and PFHxDA demonstrate a 7-fold increase in response, with additional 4-fold gains in signal-to-noise (S/N), through the use of the UniSpray ion source. Additional information and background can be found in Waters Application Note 720007413.<sup>7</sup>

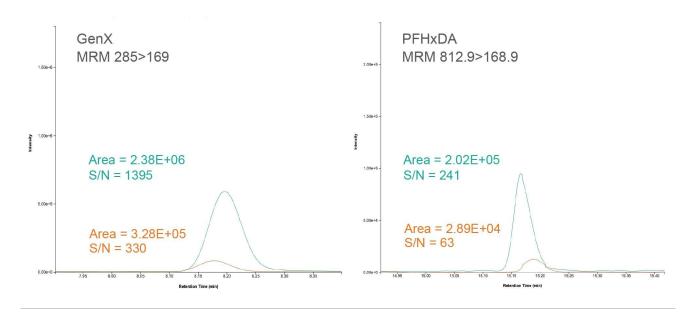


Figure 3. Signal to noise and peak response comparison of GenX and PFHxDA between electrospray (orange) and UniSpray (green) demonstrated at 10 ng/L in reagent water.

## Improving the Sensitivity of Labile Compounds

MRM parameters for compounds were optimized using the waters\_connect MRM optimization tool in System Control. This function automatically determines the fragment ions, cone voltage and collision energy for each compound through a direct infusion. This process is quick and simple and can significantly speed up time taken for method development.

Optimizing the desolvation temperature can yield to significant gains in response. Typically, labile PFAS favor low desolvation temperatures; this can be seen with GenX and HFPO-TA of which both are susceptible to in-source fragmentation. The overlaid chromatograms of different desolvation temperatures for four different analytes are shown in Figure 4. GenX and HFPO-TA have optimum desolvation temperatures of 350 °C, whereas the other more stable analytes favor higher temperatures. To accommodate all 48 PFAS, a compromise of 400 °C was chosen as the optimum temperature to gain the most method sensitivity overall.

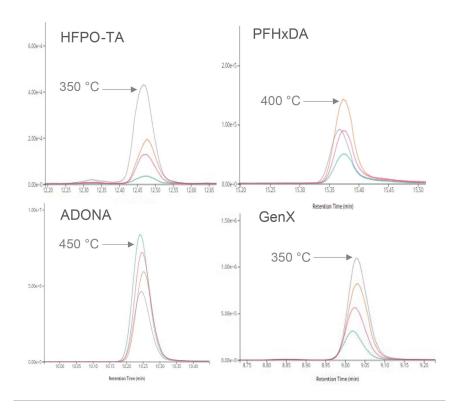


Figure 4. HFPO-TA, PFHxDA, ADONA and GenX at 350  $^{\circ}$ C (purple), 400  $^{\circ}$ C (orange), 450  $^{\circ}$ C (pink), and 500  $^{\circ}$ C (teal) Desolvation Temperatures.

#### Instrumental and Method Performance

Internally standardized reagent water bracketed calibrations were used throughout the whole study. Calibrations typically ranged from 0.5 ng/L to 50 ng/L, and full details can be found in Table 1. All analytes obtained  $R^2$  values above 0.99 and residuals <20%. Example calibration lines are shown in Figure 5, where the calibrations were bracketed between 20 samples.

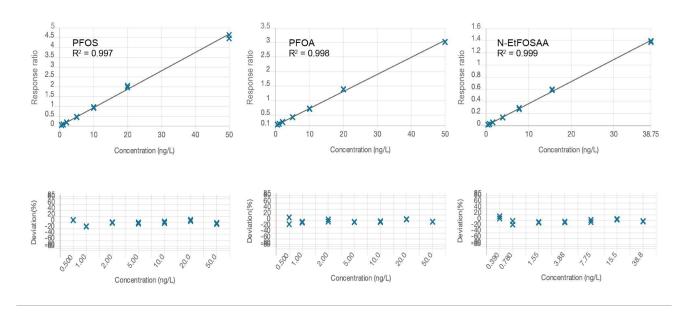


Figure 5. Bracketed calibration lines and residual deviation plots of PFOS, PFOA, and N-EtFOSAA.

#### Precision

To determine the precision of the method, in terms of retention time stability and repeatability of the response, an aliquot of each of the four water types was spiked at a concentration of 10 ng/L and homogenized and six replicate sub-samples prepared and analyzed each day for three days. The retention time for all the analytes shown to be stable, across the three days' of analyses (SD  $\leq$  0.03 min). The repeatability from the mean concentrations from all the measurements shows all but two analytes had %RSDs of <15%, with PFOS and PFOA achieving <7% in all water types. The repeatability for PFBA in river water was worse (18%RSD), which was attributed to the increased levels of this analyte in the methanol used for sample preparation adding variation to the results as different bottles of methanol were used over the course of the three days. PFODA was an outlier for both drinking waters and the river water repeatability was >20%RSD. This is likely to be related to its limited solubility in water causing variation in the sub-samples. The values for the repeatability (%RSD) for all analytes across the three days can be found in Figure 6.

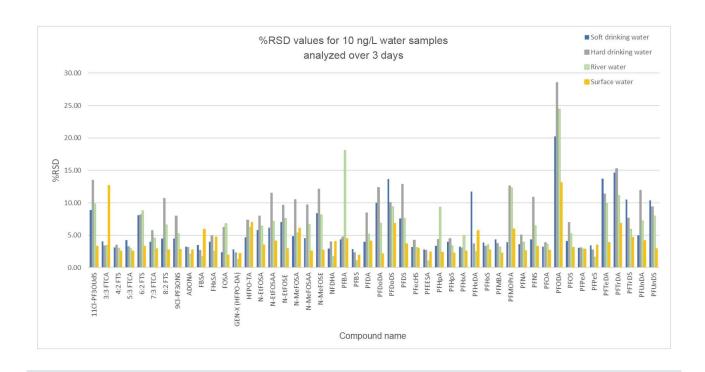


Figure 6. The repeatability (% RSD) for PFAS spiked into soft (blue) and hard (orange) drinking water, river water (green), and surface water (grey) at 10 ng/L (n=6) analyzed over three days.

# Sensitivity

A Method Detection Limit (MDL) study was performed to assess the sensitivity of the method, using twenty replicate injections of a 2 ng/L spiked sample in reagent water. The MDL was calculated using the equation from EPA 821-R-16-006<sup>8</sup>, detailed below;

$$MDL = SD \times t_{n-1}$$

SD = standard deviation of replicates and t<sub>n-1</sub> = student t value for n-1 samples

A minimum concentration of a tenth of the spiking level (0.2 ng/L) was applied to the dataset, all 48 compounds obtained sub ng/L MDLs.<sup>8</sup> This surpasses the original target and showing the method is suitable to check compliance with current regulatory requirements set out in the 2020 EU DWD. The full list of MDL values can be found in Table 1. To verify these levels are achievable in real water samples, various water types were spiked and analyzed at a concentration of 0.2 ng/L. The chromatograms of FOSA, PFNA, PFUnDA, and PFTrDS are displayed in Figure 7, and confirm good chromatography and significant response above blank levels allowing for

quantification at these concentrations.

Analyte name	Calibration range (ng/L)	Spike (ng/L)	MDL (ng/L)	Analyte name	Calibration range (ng/L)	Spike (ng/L)	MDL (ng/L)
11Cl-PF3OUdS	0.5-50	2	0.2	PFDoDA	0.5-50	2	0.2
3:3 FTCA	0.1–10	0.4	0.2	PFDoDS	0.5-50	2	0.2
4:2 FTS	0.5-50	2	0.2	PFDS	0.5-50	2	0.2
5:3 FTCA	0.5-50	2	0.2	PFecHS	0.5-50	2	0.2
6:2 FTS	0.5-50	2	0.2	PFEESA	0.5-50	2	0.2
7:3 FTCA	0.5-50	2	0.2	PFHpA	0.5-50	2	0.2
8:2 FTS	0.5-50	2	0.3	PFHpS	0.5-50	2	0.2
9CI-PF3ONS	0.5-50	2	0.2	PFHxA	0.5-50	2	0.2
ADONA	0.5-50	2	0.2	PFHxDA	0.5-50	2	0.2
FBSA	0.5-50	2	0.2	PFHxS	0.5-50	2	0.2
FHxSA	0.5-50	2	0.2	PFMBA	0.5-50	2	0.2
FOSA	0.5-50	2	0.2	PFMOPrA	0.5-50	2	0.2
GEN-X (HFPO-DA)	0.5-50	2	0.2	PFNA	0.5-50	2	0.2
HFPO-TA	0.5-50	5	0.8	PFNS	0.5-50	2	0.2
N-EtFOSA	0.05-5	0.2	0.2	PFOA	0.5-50	2	0.2
N-EtFOSAA	0.5-50	2	0.2	PFODA	0.5-50	2	0.2
N-EtFOSE	0.5-50	2	0.2	PFOS	0.5-50	2	0.2
N-MeFOSA	0.05-5	0.2	0.2	PFPeA	0.5-50	2	0.2
N-MeFOSAA	0.5-50	2	0.2	PFPeS	0.5-50	2	0.2
N-MeFOSE	0.5-50	2	0.2	PFTeDA	0.5-50	2	0.5
NFDHA	0.5-50	2	0.2	PFTrDA	0.5-50	2	0.2
PFBA	0.5-50	2	0.3	PFTrDS	0.5-50	2	0.2
PFBS	0.5-50	2	0.2	PFUnDA	0.5-50	2	0.2
PFDA	0.5-50	2	0.2	PFUnDS	0.5-50	2	0.2

Table 1. Method detection limits (MDLs) for all analytes calculated using the standard deviation of 20 replicate injections of a 2 ng/L standard in reagent water.

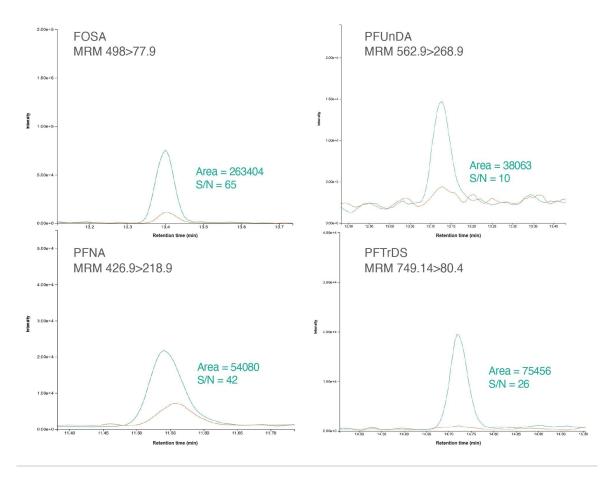


Figure 7. The overlaid chromatograms of 0.2 ng/L spiked samples (green) of FOSA and PFNA in river water and PFUnDA and PFTrDS in surface water with their associated blank samples (orange).

The ability to resolve and quantify branched and linear forms of PFAS at low concentrations is shown in Figure 8, whereby a chromatogram of a reagent water sample containing 0.73 ng/L linear and 0.20 ng/L branched PFOS demonstrates that at sub ng/L concentrations, the linear and branched forms are quantifiable and clearly resolved from each other.

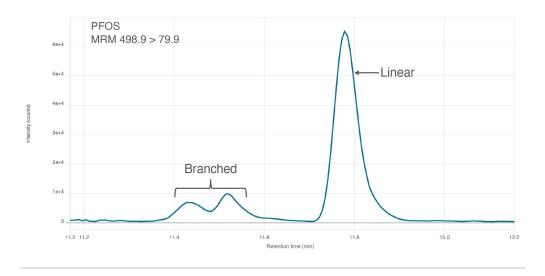


Figure 8. Detection of branched and linear forms of PFOS spiked into a reagent water sample at concentrations of 0.73 ng/L and 0.20 ng/L, respectively.

#### Conclusion

New regulations drive the demand for more sensitive methods with greater analytical scope to cope with extended lists of PFAS of interest. The work carried out here showed the required sensitivity gained by using Xevo TQ Absolute fitted with the UniSpray ion source can be used to check compliance with current regulations, using direct injection without the use of any preconcentration steps. The method performance study in various types of drinking and raw water from across the United Kingdom demonstrates a robust analytical method delivering repeatable results, with consistent retention of all analytes to meet and exceed regulatory requirement.

The optimized method concluded that;

- All 48 analytes achieved sub ng/L MDLs, showing that the method is suitable for checking compliance with current regulations including the EU Drinking Water Directive 2020/2184.
- Enhanced sensitivity was demonstrated through improved peak area response and S/N compared to ESI through using the UniSpray ion source.
- · Reduction in overall systemic background with the use of the PFAS kit and special isolator column, allowing

trace level detection of PFAS.	

Appendix A. MRM transitions of the a and respective isotopically labelled in standards.		

PFBA   213.0   169.0   10   10   10   10   10   10   10		Darent	Product	Cone	Callinian	Potontion
PFBA 213.0 19.0 10 10 3.42   9°C <sub>4</sub> -PFBA 217.0 172.0 7 8 3.42   PFMOPRA 228.9 84.9 13 10 4.25   3:3FTCA 241.0 177.0 13 8 5.55   PFPPA 262.9 218.9 10 10 5.70   PFPBA 262.9 218.9 10 10 5.70   PFBBA 262.9 218.9 10 10 5.70   PFBBA 278.9 85.0 15 12 6.41   PFBB 299.1 99.1 15 27   80.1 15 27   99.1 15 27   6.44   99.1 15 27   6.44   99.1 15 27   7.81   80.1 34 28   6.50   PFEESA 314.9 85.0 15 20   7.31   135.0 15 20   7.31   NFDHA 294.9 85.0 5 20   7.66   80.9 42 27   7.81   135.0 15 20   7.81   185.0 15 20   7.81   185.0 1 15 20   7.81   185.0 1 15 20   7.81   185.0 1 15 20	Analyte name	Parent ion	Product ion	Cone voltage	Collision energy	Retention time
19.0   10   14   14   15   16   17   17   17   18   3.42   17   17   13   10   4.25   13   10   10   5.50   15   10   10   5.70   15   12   6.41   13   15   27   6.44   15   27   27   27   27   27   27   27   2	PERA		169.0			
PFMOPrA 228.9 84.9 13 10 4.25  3:3 FTCA 241.0 77.70 13 8 5.55  PFPBA 262.9 218.9 10 10 5.70  □C <sub>5</sub> -PFPBA 268.0 223.0 11 7 5.83  PFMBA 278.9 234.9 15 6 6.41  PFBS 299.1 15 27 6.44  □C <sub>5</sub> -PFBS 301.9 99.1 15 27 6.44  □C <sub>5</sub> -PFBS 301.9 99.1 15 27 6.44  □C <sub>5</sub> -PFBS 301.9 99.1 15 20 7.31  PFEESA 314.9 135.0 15 20 7.31  NFDHA 294.9 201.0 5 10 7.66  4:2 FTS 326.9 80.9 42 18 7.81  □C <sub>5</sub> -PFHXA 318.0 120.0 10 18 80.9 14 21 88.9 14 21 88.9 16 88.9 14 21 88.9 14 21 88.9 16 88.9 14 21 88.9 16 88.9 14 21 88.9 16 88.9 14 21 88.9 16 88.9 14 21 88.9 16 88.9 18 18 18 18 18 18 18 18 18 18 18 18 18						
3.3 FTCA  241.0						
PFPeA   262.9   218.9   10   10   5.70						
PFMBA 278.9 85.0 15 12 6.41  PFMBA 278.9 85.0 15 12 6.41  PFBS 299.1 99.1 15 27 6.44  PFBS 301.9 99.1 15 27 6.44  PFESA 314.9 83.0 15 20 7.31  NFDHA 294.9 201.0 5 10 7.66  4:2 FTS 326.9 80.9 42 27 7.81  "C₂-VFEXA 318.0 120.0 10 18 7.99  PFHXA 312.9 268.9 5 10 7.99  PFPES 348.9 98.9 32 25  "C₃-HFPO-DA 287.0 168.9 10 18 8.50  GEN-X (HFPO-DA) 285.0 119.0 12 7 78.0 25 25 8.60  PFHA 362.9 318.9 15 10 9.61  "C₃-PFHA 362.9 318.9 15 10 9.61  "C₃-PFHA 362.9 318.9 15 10 9.61  "C₃-PFHXA 376.9 25 15 15 9.61  "C₃-PFHXA 376.9 25 15 15 9.61  "C₃-PFHXA 376.9 25 25 15 9.61  "C₃-PFHXA 376.9 322.0 16 7 9.81  "C₃-PFHXA 376.9 39.1 10 30 9.81  "C₃-PFHXA 376.9 38.9 99.1 10 30 9.81  "C₃-PFHXA 398.9 99.1 10 30 9.87  PFHXA 398.9 99.1 10 30 9.87  PFHXA 398.9 99.1 10 30 9.87  PFHXA 398.9 99.1 10 30 9.87  PFECHS 460.9 380.9 44 22 10.73  PFECHS 460.9 380.9 44 22 10.73  PFECHS 460.9 380.9 44 22 10.73  PFECHS 460.9 380.9 44 22 10.77  PFECHS 460.9 380.9 44 22 10	3:3 FTCA	241.0		13	8	5.55
PFMBA 278.9 234.9 15 6 6 .41  PFBS 299.1 99.1 15 6 6 .44  **Box 299.1 99.1 15 27 6.44  **PFESA 301.9 99.1 34 22 6.50  **PFESA 314.9 135.0 15 20 7.31  **NFDHA 294.9 85.0 5 20 7.66  **A:2FTS 326.9 80.9 42 27 7.81  **Box 297.0 14 18 7.81  **Box 297.0 14 18 7.81  **Box 297.0 10 18 7.99  **PFHXA 312.9 18.9 5 22 7.99  **PFPS 348.9 98.9 32 25 10  **PFPS 348.9 10 18 8.50  **Box 297.9 118.9 5 22 7.99  **Box 348.9 10 18 8.50  **Box 348.9 10 10 18 8.50  **Box 348.9 10 10 18 8.50  **Box 348.9 10 10 35 8.50  **Box 348.9 15 15 9.61  **Box 348.9 15 15 10 9.61  **Box 348.9 15 15 10 9.61  **Box 348.9 15 15 15 15 15 9.61  **Box 348.9 15 9.61  **Box 348.9 15 9.61  **Box 348.9 15 9.61						
PFMBA 278.9 PFBS 299.1 80.1 15 27 6.44 PFBS 299.1 99.1 15 27 6.44  "C <sub>2</sub> -PFBS 301.9 99.1 34 28 6.50 PFEESA 314.9 135.0 15 20 7.31  NFDHA 294.9 85.0 5 20 7.66  4:2 FTS 326.9 306.9 42 18 7.81  "C <sub>2</sub> -4:2 FTS 329.0 80.9 14 18 7.81  "C <sub>2</sub> -PFHXA 318.0 120.0 10 18 7.99 PFHXA 312.9 268.9 5 10 7.99 PFPeS 348.9 98.9 32 25 7.99 PFPeS 348.9 98.9 32 25 8.35  "C3-HFPO-DA 287.0 168.9 10 8 8.50  GEN-X (HFPO-DA) 285.0 169.0 12 7 8.50 PFHPA 362.9 318.9 15 10 8 8.50  PFHPA 362.9 318.9 15 10 9.61  "C <sub>3</sub> -PFHXA 362.9 318.9 15 10 9.61  ADONA 376.9 84.9 12 22 9.61  PFHXS 398.9 99.1 10 30 9.61  "C <sub>3</sub> -PFHXS 402.0 16 15 9.61  "C <sub>3</sub> -PFHXS 398.9 99.1 10 30 9.81  "C <sub>3</sub> -PFHXS 402.0 16 13 38 9.81  "C <sub>4</sub> -PFHXS 398.9 99.1 10 30 9.81  "C <sub>5</sub> -PFHXS 402.0 172.0 16 15 9.61  PFHXS 398.9 10 10 30 9.81  "C <sub>5</sub> -PFHXS 402.0 172.0 16 15 9.61  PFHXS 398.9 10 10 30 9.81  "C <sub>5</sub> -PFHXS 402.0 172.0 16 15 9.61  "C <sub>5</sub> -PFHXS 402.0 172.0 16 15 9.61  "C <sub>5</sub> -PFHXS 402.0 99.1 13 30 9.81  "C <sub>5</sub> -PFHXS 402.0 99.1 13 30 9.81  "C <sub>5</sub> -PFHXS 402.0 12 10 18 11 10 18 11 10 18 11 10 18 11 10 10	¹³C₅-PFPeA	268.0				5.83
PFBS   299.1   99.1   15   27   6.44   11	PFMBA	278.9				6.41
99.1 15 27  10C <sub>3</sub> -PFBS 301.9 99.1 34 24 6.50  PFEESA 314.9 83.0 15 20 7.31  NFDHA 294.9 201.0 5 10 7.66  4:2 FTS 326.9 80.9 42 27 7.81  10C <sub>3</sub> -4:2 FTS 329.0 80.9 14 18 7.81  10C <sub>3</sub> -4:2 FTS 329.0 80.9 14 21 7.81  10C <sub>3</sub> -PFHXA 318.0 273.0 10 6 7.99  PFHXA 312.9 118.9 5 22 7.99  PFPeS 348.9 98.9 32 25 10  10C <sub>3</sub> -HFPO-DA 287.0 168.9 10 18 8.50  GEN-X (HFPO-DA) 285.0 169.0 12 7 8.50  FBSA 297.9 118.9 25 15 8.60  PFHpA 362.9 361.0 12 7 7 8.60  PFHPA 362.9 168.9 15 10 18 8.50  PFHPA 362.9 168.9 15 10 18 8.50  PFHPA 362.9 168.9 15 15 15 9.61  10C <sub>4</sub> -PFHPA 367.0 172.0 16 15 15 9.61  10C <sub>5</sub> -PFHXS 402.0 99.1 10 35 8.9  PFHXS 398.9 99.1 10 30 9.81  10C <sub>3</sub> -PFHXS 402.0 99.1 13 30 9.81  10C <sub>3</sub> -PFHXS 402.0 99.1 13 30 9.81  10C <sub>3</sub> -PFOA 412.9 80.1 12 32 10.73  PFECHS 460.9 369.0 10 18 13 18 15 10  10C <sub>5</sub> -PFHX 398.9 99.1 10 30 9.81  10C <sub>5</sub> -PFHX 402.0 99.1 10 30 9.81  10C <sub>5</sub> -PFHX 402.0 99.1 10 30 9.87  PFECHS 409.0 48 27 10.73  PFECHS 409.0 48 27 10.73  PFECHS 409.0 48 27 10.73  PFECHS 409.0 309.0 40 18.81  PFHPS 448.9 98.9 15 35 10.92  PFHPS 448.9 98.9 15 35 10.92  PFHRS 398.0 10 10 18 10.81  PFHRS 398.0 10 10 18 10.81  PFECHS 409.0 48 27 10.73  PFECHS 409.0 406.9 12 22 10.73  PFECHS 409.0 300 25 11.70  PFHRS 398.0 10 10 18 10.81  PFHRS 398.0 15 35 10.92  PFHRS 398.0 15 35 10.92  PFHRS 398.0 15 35 10.92  PFECHS 409.0 408.0 15 13 36 34 11.88  PFOS 498.9 98.9 30 40 40 11.88  PFOS 498.9 99.1 36 34 11.88  PFOS 498.9 99.1 36 34 11.88	DEDO	0004				0.44
PFESA 314.9 99.1 34 24 6.50  PFESA 314.9 135.0 15 20 7.31  NFDHA 294.9 85.0 5 20 7.66  201.0 5 10 7.66  4:2 FTS 326.9 306.9 42 27 7.81  329.0 306.9 42 18 7.81  329.0 14 18 7.81  329.0 10 14 18 7.81  329.0 10 10 18 7.99  PFHXA 312.9 268.9 5 10 7.99  PFPES 348.9 79.9 32 31 8.35  32-3 10 10 18 8.50  PFPES 348.9 10 18 8.50  GEN-X (HFPO-DA) 285.0 168.9 10 8 8.50  FBSA 297.9 118.9 25 15 8.60  PFHDA 362.9 318.9 15 15 9.61  362.4 PFHDA 367.0 172.0 16 15 9.61  370.4 PFHDA 370.9 172.0 16 15 9.61  384.9 12 22 9.75  PFHXS 398.9 80.1 10 35 9.81  396.7 PFHXS 402.0 99.1 13 30 9.81  310.5 FTCA 340.9 237.0 13 26 9.87  PFECHS 460.9 99.1 13 30 9.81  310.5 FTCA 340.9 237.0 13 26 9.87  PFECHS 460.9 12 12 10 9.75  PFECHS 460.9 12 22 10.73  PFECHS 460.9 12 22 10.73  PFECHS 460.9 99.1 13 30 9.81  310.9 PFHXS 489.9 44 22 10.77  PFECHS 460.9 12 22 10.73  PFECHS 460.9 10 18 18 10 10 18 10 10 18 10 11 10 11 10 10 10 10 10 10 10 10 10	PFB2	299.1	99.1	15	27	6.44
PFEESA 314.9 83.0 15 20 7.31  NFDHA 294.9 85.0 5 20 7.66  4:2 FTS 326.9 80.9 42 27 7.81  "C₂-4:2 FTS 329.0 80.9 42 18 7.81  "C₂-7 FFHXA 318.0 120.0 10 6 7.99  PFHXA 312.9 268.9 5 10 7.99  PFPES 348.9 98.9 32 25 8.35  "C3-HFPO-DA 287.0 184.9 10 18 8.50  GEN-X (HFPO-DA) 285.0 119.0 12 35 8.50  PFHpA 362.9 118.9 25 15 8.60  PFHpA 362.9 168.9 15 10 9.61  "C₄-PFHpA 367.0 172.0 16 15 9.61  "C₄-PFHXS 398.9 99.1 10 30 9.81  "C₃-PFHXS 402.0 99.1 13 30 9.81  PFECHS 460.9 12 22 10.73  PFECHS 460.9 12 10 30 9.81  PFHX 398.9 99.1 10 30 9.81  PFHX 400.9 12 22 10.77  PFECHS 460.9 99.1 44 22 10.77  PFECHS 460.9 99.9 15 35 35 10.92  PFECHS 460.9 99.9 15 35 35 10.92  PFECHS 460.9 99.9 15 35 35 10.92  PFECHS 460.9 99.9 15 30 40 40 11.88  PFECHS 460.9 99.9 30 40 40 11.88	<sup>13</sup> C <sub>3</sub> -PFBS	301.9				6.50
NFDHA						
NFDHA 294.9 201.0 5 10 7.66 201.0 5 10 7.66 201.0 5 10 7.66 201.0 5 10 7.66 201.0 5 10 7.66 201.0 5 10 7.66 201.0 5 10 7.66 201.0 5 10 7.66 201.0 5 10 7.66 201.0 5 10 7.66 201.0 5 10 7.66 202.0 80.9 42 18 7.81 7.81 7.81 7.81 7.81 7.81 7.81 7.	PFEESA	314.9		200		7.31
201.0 5 10 80.9 42 27 306.9 42 18 7.81  10 C <sub>3</sub> -4:2FTS 329.0 80.9 14 21 118.1 7.81  118.2 7.81  118.2 7.81  118.3 7.81  118.4 11 18 7.81  118.5 7.81  118.9 5 22 7.99  118.9 5 22 7.99  118.9 10 18 8.50  119.0 12 35 8.50  119.0 12 35 8.50  119.0 12 35 8.50  119.0 12 35 8.50  119.0 12 77 118.9 25 15 8.60  119.0 12 77 118.9 25 15 8.60  119.0 12 77 118.9 25 15 8.60  119.0 12 77 118.9 25 15 8.60  119.0 12 77 118.9 25 15 8.60  119.0 12 77 110.0 16 110.0 16 110.0 16 110.0 16 110.0 170.0 17	NEDUA	204.0				7.00
## 12F1S   326.9   306.9   42   18   7.81   ## 12	NEDHA	294.9	201.0	5	10	7.00
111	4:2 FTS	326.9				7.81
**C <sub>2</sub> -4:2FTS 329.0 80.9 14 21 7.81  **C <sub>5</sub> -PFHXA 318.0 10 6 6 7.99  PFHXA 312.9 268.9 5 10 7.99  PFPeS 348.9 79.9 32 31 8.35  **C3-HFPO-DA 287.0 168.9 10 8 8.50  GEN-X (HFPO-DA) 285.0 119.0 12 35 8.50  FBSA 297.9 78.0 25 25 25 8.60  PFHpA 362.9 168.9 15 15 9.61  **C4-PFHpA 367.0 168.9 15 15 9.61  **ADONA 376.9 251.0 12 10 9.75  PFHXS 398.9 99.1 10 35 9.81  **S2-PFHXS 402.0 99.1 10 30 9.81  **S2-FFHXS 427.0 406.9 12 22 10.73  **PecHS 460.9 380.9 48 27  PFOA 412.9 99.1 10 18 10.73  **PecHS 460.9 15 15 10 9.61  **C5-PFOA 412.9 168.9 10 10 18 10.81  **PerPRS 448.9 99.1 10 10 10 10 10 10.81  **PerPRS 448.9 99.1 10 10 10 10.81  **PerPRS 448.9 99.9 15 35 10.92  **PerPRS 448.9 99.9 10 10 10 10.81  **PerPRS 448.9 99.9 15 35 10.92  **PerPRS 448.9 99.9 15 35 35 10.92  **PerPRS 448.9 99.9 15 36 34 11.88  **PerPRS 448.9 99.9 10 10 10 11.88  **PerPRS 448.9 99.9 10 10 10 10 11.88  **PerPRS 448.9 99.9 10 10 10 10 11.88  **PerPRS 448.9 99.9 30 40 11.88						
PFHXA 318.0 273.0 10 6 7.99  PFHXA 312.9 268.9 5 10 7.99  PFPeS 348.9 79.9 32 31 8.35  PFPeS 348.9 99.9 32 25  PGS-HFPO-DA 287.0 184.9 10 18 8.50  BGEN-X (HFPO-DA) 285.0 119.0 12 35 8.50  PFHA 362.9 119.0 12 7 78.0 25 25 15 8.60  PFHA 362.9 168.9 15 10 9.61  PFHA 362.9 168.9 15 15 9.61  PFHXS 398.9 99.1 10 35 9.81  PFHXS 398.9 99.1 10 35 9.81  PG-₂-PFHXS 402.0 99.1 13 30 9.81  PG-₂-E2FTS 429.0 10 13 26 9.87  PFOA 412.9 168.9 10 18 8.50  PFHAS 398.9 99.1 10 30 9.81  PFHAS 398.0 15 10 35 9.81  PFECHS 460.9 217.0 13 26 9.87  PFOA 412.9 168.9 10 18 10.73  PFHXS 398.9 99.1 10 30 9.81  PFOA 412.9 168.9 10 18 10.81  PFHAS 398.0 44 22 10.77  PFOA 412.9 168.9 10 18 10.81  PFHXS 398.0 10 10 10 10 10.81  PFHXS 398.0 10 10 10 10 10.81  PFHXS 398.0 15 35 10.92  PFHXS 398.0 15 35 10.92  PFHXS 448.9 99.1 10 18 10.81  PFHXS 398.0 10 18 10.81  PFHXS 398.0 10 10 10 10 10.81  PFHXS 398.0 15 35 10.92  PFNX 462.9 418.9 10 10 10 11.81  PFNX 462.9 418.9 10 10 10 11.81  PFNX 462.9 418.9 10 10 10 11.81  PFNX 462.9 418.9 10 10 10 10 11.81  PFNX 498.9 98.9 30 40 11.88  PFOS 498.9 98.9 30 40 11.88	<sup>13</sup> C <sub>2</sub> -4:2FTS	329.0				7.81
PFHXA 312.9 118.9 5 22 7.99  PFPeS 348.9 5 10 7.99  PFPeS 348.9 79.9 32 31 8.35  PC3-PFHA 367.0 172.0 16 15  ADONA 376.9 251.0 12 10 9.75  PFHXS 398.9 99.1 10 35 9.81  PFHXS 402.0 99.1 10 35 9.81  PFPC4-FFF 448.9 99.1 10 35 9.87  PFPCA 412.9 168.9 15 15 9.61  PFPCA 412.9 168.9 15 15 10 9.81  PFPCA 412.9 168.9 16 15 9.81  PFPCA 412.9 168.9 16 16 15 9.81  PFPCA 412.9 168.9 172 22 10.73  PFPCA 412.9 168.9 10 18 10.81  PFPCA 412.9 168.9 10 18 10.81  PFPCA 448.9 99.1 10 10 10 10  PFPCA 412.9 168.9 10 18 10.81  PFPCA 448.9 99.9 15 35 10.92  PFPCA 448.9 99.9 15 36 34 11.88  PFPCA 498.9 99.9 30 40 11.88  PFPCA 498.9 99.9 30 40 11.88	IIO DELL'A	210.0	1			7.00
PFHXA 312.9 268.9 5 10 7.99  PFPeS 348.9 79.9 32 31 31 8.35  168.9 10 8 8.50  IEAN-X (HFPO-DA) 287.0 119.0 12 35 8.50  FBSA 297.9 78.0 25 25 25 8.60  PFHpA 362.9 168.9 15 15 9.61  322.0 16 7 9.61  ADONA 376.9 251.0 12 10 9.75  PFHXS 398.9 99.1 10 35 9.81  10.3°C <sub>3</sub> -PFHXS 402.0 99.1 13 30 9.81  10.3°C <sub>3</sub> -PFHXS 402.0 99.1 13 30 9.81  10.3°C <sub>3</sub> -6:2FTS 427.0 406.9 12 22 10.73  PFECHS 460.9 380.9 48 27  PFOA 412.9 168.9 10 18  10.7°C <sub>8</sub> -PFOA 421.0 172.0 6 16  PFHXS 398.9 99.1 44 22  10.77  PFHXS 408.9 12 22 10.73  PFECHS 460.9 380.9 48 27  PFOA 412.9 168.9 10 18  10.77  PFHXS 398.9 99.1 44 22  10.77  PFHXS 460.9 99.1 44 22  10.77  PFOA 412.9 168.9 10 18  10.81  PFHXS 398.9 15 35 10.92  PFNA 462.9 448.9 10 10 10 11.81  PFNS 498.9 98.9 30 40 11.88  PFOS 498.9 98.9 30 40 11.88	™C₅-PFHXA	318.0	120.0	10	18	7.99
PFPeS 348.9	PFHxA	312.9				7.99
PFPeS   348.9   98.9   32   25   8.35						
¹³C3-HFPO-DA         287.0         168.9         10         8         8.50           GEN-X (HFPO-DA)         285.0         169.0         12         7         8.50           FBSA         297.9         118.9         25         25         25         8.60           PFHPA         362.9         318.9         15         10         9.61         9.61           ¹³C4-PFHPA         367.0         172.0         16         7         9.61         9.61           ADONA         376.9         251.0         12         10         9.61         9.61           ADONA         376.9         251.0         12         10         9.75         9.61           PFHxS         398.9         99.1         10         30         9.81         9.81           ¹³C5-PFHXS         402.0         99.1         13         30         9.81         9.81           ¹³C5-PFHXS         402.0         99.1         13         30         9.87         9.81           ¹³C5-PFHXS         402.0         99.1         13         30         9.87         9.87           ¹³C7-PFHXS         402.0         99.1         13         30         9.87         10.73	PFPeS	348.9				8.35
GEN-X (HFPO-DA) 285.0 169.0 12 35 8.50 169.0 12 7 8.60 12 7 8.60 169.0 12 7 8.60 12 7 8.60 169.0 12 7 8.60 169.0 12 7 8.60 169.0 12 7 8.60 169.0 12 7 8.60 169.0 12 7 8.60 169.0 15 15 15 9.61 168.9 15 10 9.61 168.9 15 10 9.61 16 7 9.61 172.0 16 15 16 17 9.61 172.0 16 15 16 17 9.61 172.0 16 15 16 17 9.61 172.0 16 15 16 17 9.61 172.0 16 15 16 17 9.61 172.0 16 15 16 17 9.61 172.0 16 15 16 17 9.61 172.0 16 15 16 17 9.61 172.0 16 15 16 17 9.61 172.0 16 15 16 17 9.61 172.0 12 10 9.75 172.0 12 10 9.75 172.0 12 10 9.75 172.0 12 10 9.75 172.0 12 10 9.75 172.0 12 10 9.75 172.0 12 10 9.75 172.0 12 10 9.81 172 172.0 12 10 9.81 172 172.0 12 10 9.81 172 172.0 12 10 9.81 172.0 12 10 9.81 172.0 12 10 9.81 172.0 12 10 9.81 172.0 12 10 9.81 172.0 12 10 9.81 172.0 12 10 9.81 172.0 12 10 9.81 172.0 18 10.81 172.0 18 169.0 10 10 10 10 10 10 10 10 10 10 10 10 10						
FBSA   297.9   169.0   12   7   8.50	™C3-HFPO-DA	287.0	184.9	10	18	8.50
FBSA 297.9   18.9   25   25   8.60	GEN-X (HFPO-DA)	285.0				8.50
PFHPA  362.9  PFHPA  362.9  318.9  322.0  166.7  322.0  166.7  36.1  322.0  166.7  36.1  376.9  251.0  251.						
PFHPA 362.9 168.9 15 15 15 9.61  ***BC4-PFHPA 367.0 172.0 16 15 9.61  ***ADONA 376.9 84.9 12 22 9.75  PFHxS 398.9 99.1 10 30 9.81  ***BC5-PFHXS 402.0 80.1 13 38 9.81  ***STCA 340.9 217.0 13 26 9.87  6:2 FTS 427.0 80.1 12 32 10.73  ***BC5-6:2FTS 429.0 80.9 12 22 10.73  ***PFECHS 460.9 12 22 10.73  ***PFECHS 460.9 99.1 44 22 10.77  PFOA 412.9 380.9 48 27 10.73  ***PFPOA 412.9 369.0 10 18 10.81  ***BC5-PFOA 421.0 172.0 6 16 16 10.81  ***PFHPS 448.9 98.9 15 35 10.92  ***PFHXS 398.9 15 35 10.92  ***PFNA 472.0 172.0 7 18 10.81  ***PFNA 462.9 418.9 10 10 10 10 10 10 10 10 10 10 10 10 10	FBSA	297.9				8.60
318.9 15 10 322.0 16 7 172.0 16 15 36.1 172.0 16 15 372.0 16 15 372.0 16 15 372.0 16 15 372.0 16 15 372.0 16 15 372.0 16 15 372.0 16 15 372.0 12 10 375.0 12 10 375.0 12 10 375.0 12 10 375.0 12 10 375.0 13 38 38 9.81 38 9.81 38 9.81 39.1 13 30 38 9.81 39.1 13 30 38 9.81 39.1 13 30 38 9.81 39.1 13 30 38 9.81 39.1 13 30 38 9.81 39.1 12 22 37.0 13 13 13 38 9.87 380.1 12 32 370.0 13 13 13 38 9.87 380.1 12 32 370.0 13 13 13 38 9.81 39.87 380.1 12 32 370.0 13 13 13 38 9.81 39.87 380.1 12 32 32 10.73 406.9 12 22 10.73 406.9 12 22 10.73 409.0 48 21 10.73	DELI-A	202.0				0.01
367.0   172.0   16   15   9.61   15   9.61   15   15   15   15   15   15   15	РЕНРА	362.9	318.9	15		9.61
ADONA 376.9 84.9 12 22 9.75  PFHXS 398.9 99.1 10 30 9.81  30C <sub>3</sub> -PFHXS 402.0 99.1 13 30 9.81  5:3 FTCA 340.9 217.0 13 26 9.87  6:2 FTS 427.0 80.1 12 32 10.73  6:2 FTS 429.0 80.1 12 32 10.73  PFecHS 460.9 12 22 10.73  PFECHS 460.9 99.1 44 22 10.77  PFOA 412.9 80.9 48 27 10.73  PFOA 412.9 168.9 10 18 10.81  10C <sub>8</sub> -PFOA 421.0 172.0 6 16 16 10.81  PFHpS 448.9 99.9 15 35 10.92  FHXSA 398.0 169.0 30 25 11.70  11C <sub>8</sub> -PFNA 472.0 172.0 7 18 11.81  PFNA 462.9 418.9 10 10 15 11.81  PFNA 462.9 418.9 10 10 15 11.81  11C <sub>8</sub> -PFOS 507.0 99.9 30 40 11.88  PFOS 498.9 98.9 30 40 11.88  PFOS 498.9 98.9 30 40 11.88	¹³C₄-PFHpA	367.0				9.61
ADONA 376.9 251.0 12 10 9.75  PFHXS 398.9 80.1 10 35 9.81  30C <sub>3</sub> -PFHXS 402.0 99.1 13 38 9.81  5:3 FTCA 340.9 217.0 13 26 9.87  6:2 FTS 427.0 80.1 12 32 10.73  6:2 FTS 429.0 80.1 12 32 10.73  PFecHS 460.9 12 22 10.73  PFOA 412.9 99.1 44 22 10.77  PFOA 412.9 168.9 10 18 20 10.81  10C <sub>8</sub> -PFOA 421.0 172.0 6 16 10 10.81  PFHPS 448.9 99.9 15 35 10.92  FHXSA 398.0 169.0 30 25 11.70  11C <sub>8</sub> -PFNA 472.0 172.0 7 18 11.81  PFNA 462.9 418.9 10 10 15 11.81  PFNA 462.9 418.9 10 10 10 11.81  11C <sub>8</sub> -PFOS 507.0 99.9 30 40 11.88  PFOS 498.9 98.9 30 40 11.88  PFOS 498.9 98.9 30 40 11.88	-4					
PFHXS         398.9         80.1         10         35         9.81           13C <sub>3</sub> -PFHXS         402.0         99.1         10         30         9.81           5:3 FTCA         340.9         217.0         13         26         9.87           6:2 FTS         427.0         406.9         12         22         10.73           6:2 FTS         429.0         409.0         48         21         10.73           PFecHS         460.9         380.9         44         22         10.77           PFOA         412.9         369.0         10         18         10.81           10**Ca-PFOA         421.0         172.0         6         16         10.81           PFHpS         448.9         98.9         15         35         10.92           FHXSA         398.0         169.0         30         25         11.70           10**Ca-PFNA         472.0         223.0         7         18         11.81           PFNA         462.9         418.9         10         10         11.81           10**Ca-PFOS         507.0         99.1         36         34         11.88           10**Ca-PFOS         507.0 <td>ADONA</td> <td>376.9</td> <td></td> <td></td> <td></td> <td>9.75</td>	ADONA	376.9				9.75
99.1 10 30 99.1 13 30 99.81  5:3 FTCA 340.9 217.0 13 26 99.87  6:2 FTS 427.0 406.9 12 22 10.73  406.9 12 22 10.73  PFECHS 460.9 380.9 48 27 10.73  PFOA 412.9 380.9 10 18 369.0 10 10 10 18 369.0 10 10 10 10 172.0 6 16 16 10.81  PFHPS 448.9 99.9 15 35 PFHXSA 398.0 169.0 30 25 FHXSA 398.0 169.0 30 25  FHXSA 398.0 169.0 30 25  FHXSA 398.0 169.0 30 25  FHXSA 398.0 169.0 30 25  11.70  172.0 7 18 11.81  PFNA 462.9 418.9 10 15 11.81  PFNA 462.9 418.9 10 10 172.0 7 18 11.81  PFNA 462.9 418.9 10 10 172.0 7 18 11.81  PFNA 462.9 418.9 10 10 172.0 7 18 11.81  PFNA 462.9 418.9 10 10 172.0 7 18 11.81  PFNA 462.9 418.9 10 10 172.0 7 18 11.81  PFNA 462.9 418.9 10 10 172.0 7 18 11.81  PFNA 462.9 418.9 10 10 172.0 7 18 11.81  PFNA 462.9 418.9 10 10 172.0 7 18 11.81  PFNA 462.9 418.9 10 10 172.0 7 18 11.81	DELLING	200.0		10	35	0.01
99.1 13 30 9.81  5:3 FTCA 340.9 217.0 13 26 9.87  80.1 12 32 10.73  406.9 12 22 10.73  406.9 12 22 10.73  PFecHS 429.0 80.9 48 21 10.73  PFOA 412.9 380.9 44 22 10.77  PFOA 412.9 168.9 10 18 10.81  10.62 PFOA 421.0 172.0 6 16 16 10.81  PFHpS 448.9 78.9 15 35 10.92  FHXSA 398.0 169.0 30 25 11.70  FHXSA 398.0 169.0 30 25 11.70  10.62 PFNA 472.0 7 18 11.81  PFNA 462.9 418.9 10 10 15 11.81  PFNA 462.9 418.9 10 10 15 11.81  PFOS 498.9 98.9 30 40 11.88  PFOS 498.9 98.9 30 40 11.88  7:3 FTCA 440.8 10.11 30 12.09	FFINS	390.9				9.01
5:3 FTCA 340.9 217.0 13 26 9.87  237.0 13 13 13  6:2 FTS 427.0 406.9 12 22 10.73  406.9 12 22 10.73  409.0 48 21 10.73  PFECHS 460.9 380.9 48 27  PFOA 412.9 168.9 10 18 10.81  2C <sub>8</sub> -PFOA 421.0 172.0 6 16 10 10.81  PFHps 448.9 98.9 15 35 10.92  FHXSA 398.0 169.0 30 25  FHXSA 398.0 169.0 30 25  11.70  2C <sub>9</sub> -PFNA 472.0 223.0 7 18 11.81  PFNA 462.9 418.9 10 10 15 11.81  PFNA 462.9 418.9 10 10 10  3C <sub>6</sub> -PFOS 507.0 99.1 36 34 11.88  PFOS 498.9 98.9 30 40 11.88  PFOS 498.9 98.9 30 40 11.88	13C <sub>3</sub> -PFHxS	402.0				9.81
340.9   237.0   13   13   9.87						
6:2 FTS	5:3 FTCA	340.9				9.87
## A06.9   12   22   22   409.0   48   21   10.73   48   27   10.73   48   27   10.73   48   27   10.73   48   27   10.75   48   27   10.77   44   22   10.77   48   10   10   10   10   10   10   10   1	6-2 ETS	427.0		12	32	10.73
PFECHS 429.0 80.9 48 27 10.73  PFECHS 460.9 99.1 44 22 10.77  PFOA 412.9 168.9 10 18 10.81  369.0 10 10 10 10.81  376.0 6 8 10.81  PFHpS 448.9 79.9 15 35 10.92  PHXSA 398.0 78.1 30 25 11.70  10C <sub>s</sub> -PFNA 472.0 7 18 11.81  PFNA 462.9 418.9 10 10 15 11.81  PFNA 462.9 418.9 10 10 10  10C <sub>s</sub> -PFOS 507.0 99.1 36 34 11.88  PFOS 498.9 98.9 30 40 11.88  PFOS 498.9 98.9 30 40 11.88	0.2 F13	727.0				10.73
PFECHS         460.9         99.1         44         22         10.77           PFOA         412.9         168.9         10         18         10.81           10Cs-PFOA         421.0         376.0         6         8         10.81           PFHPS         448.9         78.9         15         35         10.92           FHXSA         398.0         78.1         30         25         11.70           169.0         30         25         11.70           169.0         30         25         11.70           172.0         7         18         11.81           PFNA         462.9         218.9         10         15           418.9         10         15         1.81           18Cs-PFOS         507.0         80.1         36         34         11.88           PFOS         498.9         99.9         30         40         11.88           7:35TCA         440.8         316.9         18         20         12.09	<sup>13</sup> C <sub>2</sub> -6:2FTS	429.0				10.73
PFOCHS 460.9 380.9 44 22 10.77  PFOA 412.9 168.9 10 18 10.81  369.0 10 10 10 10  172.0 6 16 16 10.81  PFHpS 448.9 79.9 15 35 10.92  FHXSA 398.0 169.0 30 25 11.70  172.0 7 18 11.81  PFNA 472.0 7 18 11.81  PFNA 462.9 418.9 10 10  182.8 PFOS 507.0 80.1 36 34 11.88  PFOS 498.9 98.9 30 40 11.88  733.FTCA 440.8 316.9 18 20 12.09						
PFOA 412.9 369.0 10 10 10.81  376.0 6 8 10.81  PFHpS 448.9 79.9 15 35 10.92  FHxSA 398.0 78.1 30 25 11.70  169.0 30 25 11.70  172.0 7 18 11.81  PFNA 462.9 418.9 10 15  172.0 7 18 11.81  PFNA 462.9 418.9 10 15  172.0 7 18 11.81  PFNA 462.9 418.9 10 15  173.6 PFOS 507.0 80.1 36 34 11.88  PFOS 498.9 98.9 30 40 11.88  PFOS 498.9 98.9 30 40 11.88	PFecHS	460.9				10.77
10   10   10   10   10   10   10   10	PEOA	412.9				10.81
PFHpS 448.9						
PFHpS 448.9 79.9 15 35 10.92  FHxSA 398.0 78.1 30 25 11.70  169.0 30 25 11.70  172.0 7 18 11.81  PFNA 462.9 218.9 10 15 15 11.81  169.0 30 25 11.70  172.0 7 18 11.81  181.81 11.81  PFNA 462.9 48.9 10 15 11.81  181.81 36 34 11.88  PFOS 498.9 99.9 30 40 11.88  73.5 FCA 440.8 316.9 18 20 12.09	13C <sub>8</sub> -PFOA	421.0				10.81
PFHpS 448.9 98.9 15 35 10.92  FHxSA 398.0 78.1 30 25 11.70  169.0 30 25 11.70  172.0 7 18 11.81  PFNA 462.9 218.9 10 15 15 11.81  169.0 30 40 11.88  PFOS 498.9 99.9 30 40 11.88  PFOS 498.9 98.9 30 40 11.88  73.5 FCA 440.8 316.9 18 20 12.09						
PFNSA 398.0 169.0 30 25 11.70 11.70 11.81	PFHpS	448.9				10.92
169.0 30 25 172.0 7 18 11.81  PFNA 462.9 218.9 10 15 418.9 10 10 10 11.81  11.82  11.84  11.85  11.81	FHxSA	398.0				11.70
PFNA 472.0 223.0 7 18 11.81 11.81    PFNA 462.9 218.9 10 15 11.81    3C <sub>8</sub> -PFOS 507.0 80.1 36 34 11.88    PFOS 498.9 99.1 36 34 11.88    PFOS 498.9 30 40 98.9 30 40 11.88    7:3 FTCA 440.8 316.9 18 20 12.09						
PFNA 462.9 218.9 10 15 11.81  13C <sub>e</sub> -PFOS 507.0 80.1 36 34 11.88  PFOS 498.9 79.9 30 40 98.9 30 40  98.9 30 40 11.88  7:3 FTCA 440.8 316.9 18 20 12.09	<sup>13</sup> C <sub>9</sub> -PFNA	472.0				11.81
PFNA 462.9 418.9 10 10 11.81  13C <sub>8</sub> -PFOS 507.0 <b>80.1</b> 36 34 11.88  PFOS 498.9 99.9 30 40 11.88  7:3 FTCA 440.8 316.9 18 20 12.09						
PFOS 498.9 9.1 36 34 11.88 98.9 30 40 11.88 98.9 30 40 11.88 98.9 30 40 11.88	PFNA	462.9				11.81
99.1 36 34 79.9 30 40 99.9 30 40 11.88 7:3 FTCA 440.8 316.9 18 20 12.09	13Co-PFOS	507.0				11,88
PFOS 498.9 98.9 30 40 11.88 7:3 FTCA 440.8 316.9 18 20 12.09	2,1100	227.0			1000	
7:3 FTCA 440.8 316.9 18 20 12.09	PFOS	498.9				11.88
7:3 FTCA 440.8 12.09	705-5					40
	7:3 FTCA	440.8				12.09

Analyte name	Parent ion	Product ion	Cone voltage	Collision energy	Retention time
		119.1	40	42	
HFPO-TA	494.7	184.9	40	12	12.09
001 0500110	504.0	82.9	14	25	40.00
9CI-PF3ONS	531.0	351.0	14	22	12.39
13C 9:2ETC	529.0	509.0	20	27	12.62
<sup>13</sup> C <sub>2</sub> -8:2FTS	529.0	80.9	20	37	12.02
8:2 FTS	526.9	80.9	28	37	12.62
0.2113	320.9	506.9	28	26	12.02
PFNS	548.9	80.1	20	40	12.66
	0.000	99.1	20	40	
<sup>13</sup> C <sub>6</sub> -PFDA	519.0	473.9	25	7	12.66
•		219.0	25	13	
PFDA	512.9	218.9	15	18	12.66
		468.9	15	10	
N-MeFOSAA	569.9	168.9	36	30	12.95
		418.9	36	22	-
d3-N-MeFOSAA	573.0	418.9	17	18	13.05
		515.0 <b>80.1</b>	17 25	18 50	
PFDS	598.9	99.1	25	46	13.35
		268.9	25	20	
PFUnDA	562.9	518.9	25	10	13.37
		524.9	9	8	
<sup>13</sup> C <sub>7</sub> -PFUnDA	569.9	273.9	9	14	13.37
		418.9	34	15	
N-EtFOSAA	584.0	525.9	34	18	13.37
		418.9	24	17	
d5-N-EtFOSAA	589.0	482.9	24	13	13.37
		77.9	40	30	
FOSA	498.0	83.0	40	30	13.60
13C <sub>8</sub> -FOSA	506.0	77.9	13	28	13.60
4401 05001110		82.9	30	30	
11CI-PF3OUdS	631.0	450.9	30	26	13.72
120 DED-DA	045.0	569.9	23	10	10.05
<sup>13</sup> C <sub>2</sub> -PFDoDA	615.0	168.9	23	22	13.95
PFDoDA	612.9	168.9	30	25	13.97
FFDODA	012.9	568.9	30	12	13.97
PFUnDS	649.1	80.0	40	55	13.98
FTOIDS	043.1	99.0	40	55	13.30
PFTrDA	662.9	168.9	5	30	14.50
	OOLIO	218.9	5	20	11100
PFDoDS	699.1	80.0	40	55	14.51
		99.0	40	55	
d7 N-MeFOSE	623.0	59.1	18	13	14.75
		168.9	18	30	
N-MeFOSE	615.9	59.1	23	14	14.81
N-MeFOSA	511.8	168.9	38	26	14.83
		219.0	38	26	
d-N-MeFOSA	515.0	168.9	34	21	14.83
		218.9 <b>80.0</b>	34 40	55	
PFTrDS	749.1	99.0	40	55	14.94
		168.9	18	25	
13C <sub>2</sub> -PFTeDA	715.0	219.0	18	25	14.96
		168.9	14	30	
PFTeDA	712.9	668.8	14	14	14.96
		169.0	38	28	
N-EtFOSA	525.8	219.0	38	26	15.05
JON ESCOP	0000	59.1	18	13	45.40
d9 N-EtFOSE	639.0	188.9	18	76	15.12
N E+FOCE	6300	59.1	18	13	15 10
N-EtFOSE	630.0	605.0	18	13	15.12
d-N-EtFOSA	531 C	168.9	15	25	15.17
U-IN-E(FUSA	531.0	218.9	15	23	15.17
PFHxDA	812.9	168.9	22	28	15.38
FFIIXUA	012.9	218.9	22	22	13.36
<sup>13</sup> C <sub>2</sub> -PFHxDA	814.8	769.9	23	15	15.38
O2-11-11ADA	014.0	169.0	23	32	13.30
PFODA	912.9	169.2	34	35	15.59
	01210	868.9	34	15	13.33

#### References

- 1. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the Quality of Water Intended for Human Consumption (recast) [Online] https://eur-lex.europa.eu/eli/dir/2020/2184/oj < https://eur-lex.europa.eu/eli/dir/2020/2184/oj > .
- 2. Drinking Water Inspectorate (DWI) Information Letter, Requirements for Poly and Perfluorinated Alkyl Substances (PFAS) Monitoring by Water Companies in England and Wales 05/2021 [Online] https://dwi-content.s3.eu-west-2.amazonaws.com/wp-content/uploads/2021/10/04203217/Information-Letter-PFAS-Monitoring.pdf <a href="https://dwi-content.s3.eu-west-2.amazonaws.com/wp-content/uploads/2021/10/04203217/Information-Letter-PFAS-Monitoring.pdf">https://dwi-content.s3.eu-west-2.amazonaws.com/wp-content/uploads/2021/10/04203217/Information-Letter-PFAS-Monitoring.pdf</a>.
- 3. Drinking Water Inspectorate (DWI), Guidance on the Water Supply (Water Quality) Regulations 20161 Specific to PFOS (perfluorooctane sulphonate) and PFOA (perfluorooctanoic acid) Concentrations in Drinking Water, January 2021 [Online] https://cdn.dwi.gov.uk/wp-content/uploads/2021/01/12110137/PFOS-PFOA-guidance-2021.pdf <a href="https://cdn.dwi.gov.uk/wp-content/uploads/2021/01/12110137/PFOS-PFOA-guidance-2021.pdf">https://cdn.dwi.gov.uk/wp-content/uploads/2021/01/12110137/PFOS-PFOA-guidance-2021.pdf</a>.
- 4. S. Bajic. Waters UniSpray Ionization Source. Waters White Paper 720006009 
  https://www.waters.com/webassets/cms/library/docs/unispray\_ionization\_source\_white\_paper.pdf> , 2017.
- 5. PFAS Analysis Kit for ACQUITY UPLC Systems. Waters User Guide 715006386 < https://www.waters.com/waters/support.htm?lid=135047135> v01. Mar 2020.
- 6. ITRC (Interstate Technology & Regulatory Council). 2022. PFAS Technical and Regulatory Guidance Document and Fact Sheets PFAS-1, Table 4-1. Washington, D.C.: Interstate Technology and Regulatory Council, PFAS Team. https://pfas-1.itrcweb.org/ <a href="https://pfas-1.itrcweb.org/">https://pfas-1.itrcweb.org/</a> Accessed 21 Sept 2023.
- 7. Nicola Dreolin, Henry Foddy, Kari Organtini, Stuart Adams, Ken Rosnack, Peter Hancock. Best Practices for Monitoring PFAS Contamination in a Routine Shared-Space Commercial Laboratory, Waters White Paper 720007905 <a href="https://www.waters.com/webassets/cms/library/docs/720007905en.pdf">https://www.waters.com/webassets/cms/library/docs/720007905en.pdf</a> . April 2023.
- 8. Hannah Willmer, Kari L. Organtini, Stuart Adams. Routine Determination of Per- and Polyfluoronated Alkyl Substances (PFAS) in Drinking Water by Direct Injection Using UPLC-MS/MS to Meet the EU Drinking Water Directive 2020/2184 Requirements. Waters Application Note 720007413. Oct 2021.
- 9. US Environmental Protection Agency. Definition and Procedure for the Determination of the Method

Detection Limit, Revision 2. EPA 821-R-16-006. December 2016 [online] Definition and Procedure for the Determination of the Method Detection Limit, Revision 2; December 2016 (epa.gov) < https://www.epa.gov/sites/default/files/2016-12/documents/mdl-procedure\_rev2\_12-13-2016.pdf>.

10. Organtini K, Cleland G, Rosnack K. Large Volume Direct Injection Method for the Analysis of Perfluorinated Alkyl Substances (PFAS) in Environmental Water Samples in Accordance with ASTM 7979-17. Waters Application Note 720006329. Jan 2018.

#### **Featured Products**

ACQUITY Premier System <a href="https://www.waters.com/waters/nav.htm?cid=135077739">https://www.waters.com/waters/nav.htm?cid=135077739</a>

Xevo TQ Absolute Triple Quadrupole Mass Spectrometry <

https://www.waters.com/nextgen/global/products/mass-spectrometry-systems/xevo-tq-absolute.html>

waters\_connect for Quantitation <a href="https://www.waters.com/nextgen/global/products/informatics-and-software/waters\_connect-for-quantitation.html">https://www.waters.com/nextgen/global/products/informatics-and-software/waters\_connect-for-quantitation.html</a>

720008137, December 2023

© 2024 Waters Corporation. All Rights Reserved.

Termos de Uso Política de Privacidade Marcas comerciais Carreiras Avisos jurídicos e de privacidade Cookies Preferências de cookies