Application brief | 003941

Environmental

Out-of-the-box workflow for PFAS quantitation using a triple quadrupole approach with the TSQ Altis Plus mass spectrometer

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Keywords

PFAS, drinking water, surface water, groundwater, wastewater, European regulation, FTOH, FTAB, FTS, PFOS, PFOA, PFNA, PFHxS, diPAP, MRM, SRM, triple quadrupole

Application benefits

- Quantitation of a large panel of 61 PFAS compounds with performance and robustness proved with the applied analytical strategy.
- Designed to comply with current European regulations (0.1 µg/L sum of 20 PFAS; 0.5 µg/L total PFAS), and with many local regulations.
- The sensitivity of our method is compatible with major sample preparation techniques, including solid phase extraction (SPE). Limits of Quantification (LOQs) are achieved in solvent ranges from 50 ng/L for over 80% of targets to 500 ng/L for fewer than 5% of targets. Corresponding LOQs in matrices range from 0.1 ng/L to 1 ng/L with 500-fold concentration.
- Challenging PFAS (FTOH, FTAB) on the same method with a single HPLC separation.

Goal

To demonstrate the quantitation capabilities of the Thermo Scientific™ TSQ Altis Plus™ mass spectrometer for the analysis of PFAS in methanolic extracts. The analytical qualification of the method is presented with results on the limit of quantitation, linearity, reproducibility, and robustness. This method is applicable for the analysis of extracted water samples, including drinking water, surface water, groundwater, and wastewater.

Introduction

Per- and polyfluoroalkyl substances (PFAS) are a large group of synthetic chemicals known for their resistance to heat, water, and oil. Due to these properties, PFAS have been widely used in various industrial and consumer products. However, PFAS are often referred to as "forever chemicals" because they do not break down easily and can accumulate in the environment and in human and animal tissues over time. This persistence, along with their widespread use, has led to extensive environmental contamination, particularly in water sources.[1] As a result, analyzing PFAS in different matrices, especially drinking water, has become increasingly important. Analyzing PFAS is critical for understanding their distribution, concentration, and potential risks to human health and the environment.[2] To address these health risks, various governmental regulatory agencies have established validated methods to quantify individual or collective PFAS levels in drinking water.

Regulatory framework in Europe

In Europe, the main regulation governing drinking water quality is the Drinking Water Directive (2020/2184/EU), which sets two thresholds for PFAS:

- 0.1 µg/L for the sum of a group of 20 PFAS
- 0.5 µg/L for the totality of PFAS[3]

Some countries, such as Denmark and Italy, test additional compounds. In the United Kingdom, the testing is based on tiered results with different countermeasures depending on PFAS concentrations (Tier 1: <0.01 µg/L, Tier 2: 0.01 µg/L – 0.1 µg/L, Tier 3: >0.1 µg/L). Additionally, several European countries have established limits for the sum of four PFAS compounds to which the population has been most exposed: PFOA, PFNA, PFHxS, and PFOS.[4]

Regulations for natural waters and wastewater

Natural waters are regulated under directives such as the Water Framework Directive (WFD, 2000/60/EC), the Environmental Quality Standards Directive (EQSD, 2008/105/EC), and the Groundwater Directive (GWD, 2006/118/EC). Though no official European regulation applies to water matrices other than drinking water, proposals for surface water exist, listing compounds to analyze based on relative potency factors. EurEau's research finds that only long-chain PFAS chemicals, which are a minority, find their way into sewage sludge, while the rest enter the aquatic environment.

In October 2022, the Commission proposed quality standards for the sum of 24 PFAS, including PFOS, in surface water and groundwater, with a proposed standard of 4.4 ng/L (as PFOA equivalents). This was based on opinions from the European Food Safety Authority (EFSA) and the Scientific Committee on Health, Environment, and Emerging Risks. Wastewater discharges are regulated under directives mandating PFAS analysis from classified installations, with lists of regulated PFAS varying across Europe. For example, in France, the Order of June 20, 2023 mandates screening for eight additional emerging PFAS compounds in aqueous discharges from classified installations. However, the newly approved Urban Wastewater Treatment Directive (UWWTD) from November 2024 does not set binding limit values for treated wastewater.

Therefore, an exhaustive list of regulations, recommendations, and EPA methods[5] was used to define our list of PFAS included in the method, ensuring a comprehensive and adaptable approach that can evolve with changing legislation.

Analytical approach and methodology

Liquid chromatography coupled with mass spectrometry provides high sensitivity and specificity for detecting a wide range of PFAS compounds. In previous work, we demonstrated the ability to meet regulatory requirements for PFAS analysis using large volume injection and high-end triple quadrupole technology for drinking water analysis.[6] Nevertheless, other types of water need sample preparation, which is often critical, to concentrate PFAS from large volumes and to remove potential interferences.

We have previously demonstrated the capabilities of an automated dispersive liquid-liquid microextraction (DLLME) procedure using a Thermo Scientific™ TriPlus™ RSH SMART autosampler for the extraction and analysis of PFAS in drinking water.[7] The DLLME protocol offers advantages such as automation and the use of small sample and reagent volumes. However, the most common approach for PFAS extraction and pre-concentration is based on solid phase extraction (SPE)[8,9] and is compatible with our method.

Workflow method performance and package

This application brief describes our method for the quantitation of 61 PFAS in organic solvent, including those regulated at the EU level, additional targets monitored by specific EU countries, and emerging PFAS relevant for environmental and food safety. Method performance is presented based on limit of quantitation (LOQ), linear dynamic range, accuracy, precision, and robustness with real sample extracts.

For ease of use and training purposes, our workflow is fully documented and includes:

- A standard operating procedure (SOP) detailing hardware, capillary connections, consumables, and reagents.
- A software package with attached instrument method and processing methods, including view settings for guided, fast, and compliant data review and reporting using the Thermo Scientific™ Chromeleon™ 7.3.2 Chromatography Data System (CDS).
- A data set with examples and performance demonstrations.

Experimental

Instrument configuration and method

A Thermo Scientific™ Vanquish™ Flex Binary UHPLC pump with a Thermo Scientific™ Vanquish™ Duo Autosampler is used, coupled to a TSQ Altis Plus triple quadrupole mass spectrometer. The gradient uses a combination of water and methanol as the mobile phases. The hardware configuration schematics can be seen in Figure 1 and Table 1. A single combination of delay column/analytical column is used here. The second channel is kept for flexibility for additional or complementary applications. Table 2 recaps the main instrument parameters.

Method qualification results

To ensure that the method is adapted for the analysis of clean and wastewater samples, and to assess its robustness, an analytical qualification of the method was performed.

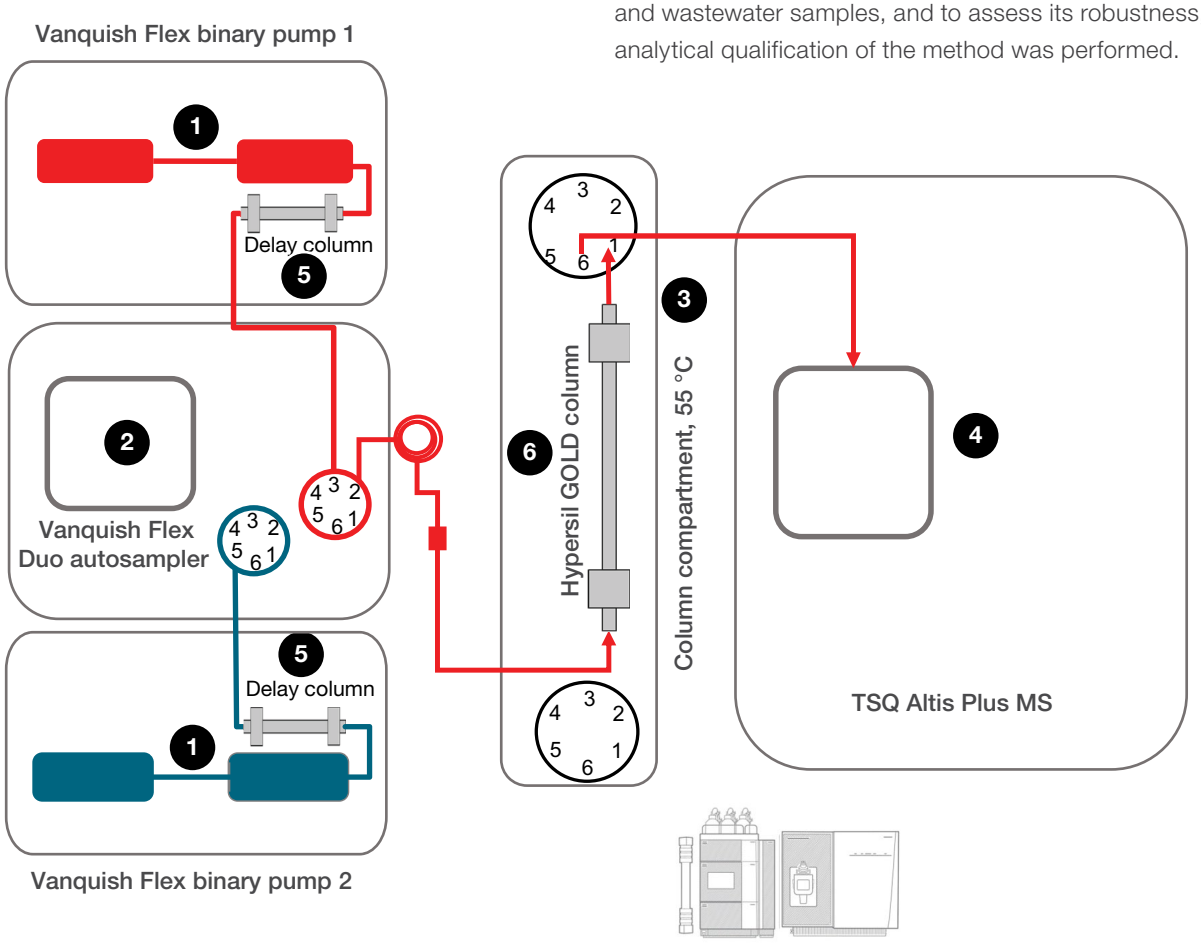


Figure 1. Hardware configuration for the analysis of PFAS in clean water

Table 1. References of configuration utilized for PFAS analysis

Reference	Part number	Instrument
1	VF-P10-A-01	2× Vanquish Flex Binary UHPLC Pump
2	VF-A40-A-02	Vanquish Dual Split Sampler
3	VH-C10-A-03	Vanquish Flex Column Compartment
4	TSQ03-10002	TSQ Altis Plus MS
5	25002-052130	Thermo Scientific™ Hypersil GOLD™ 50 × 2.1 mm, 1.9 µm column
6	25002-102130	Hypersil GOLD 100 × 2.1 mm, 1.9 µm column

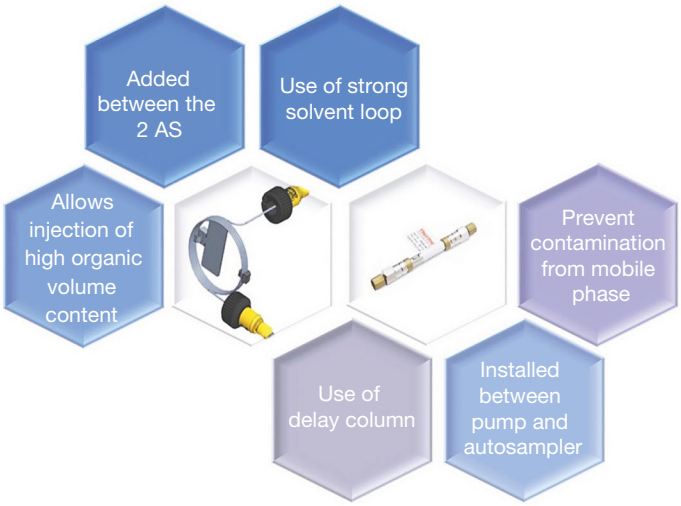


Figure 2. Tips and tricks for PFAS analysis hardware configuration. To prevent contamination and issues with high organic content, use a strong solvent loop between autosampler ports and analytical columns, and add delay columns.

Table 2. Instrument parameters

	Parameters
Delay column	Hypersil GOLD 50 × 2.1 mm, 1.9 µm
Column	Hypersil GOLD 100 × 2.1 mm, 1.9 µm
Mobile phase A	Water at 0.1 mM of ammonium fluoride
Mobile phase B	Methanol at 0.1 mM of ammonium fluoride
Total run time	13 min
Injection volume	10 µL
Acquisition type	2 MRM for targets, various dwell time priority, 1 min retention time window
Resolution	Q1 0.7 FWHM, Q3 1.2 FWHM
Source type	HESI
Polarity mode	Negative

Sample preparation

Calibration solutions were prepared in methanol with concentrations ranging from 25 ng/L up to 5,000 ng/L, with internal standard concentration at 500 ng/L. Spiking solutions of the 61 studied compounds were initially prepared in methanol at 1 ng/mL and 10 ng/mL. These solutions were then used for the preparation of calibration standards and a mix of 22 labeled internal standards dissolved in methanol was added to the samples to correct for any possible extraction and matrix effects.

Qualification tests

Linearity assessment, stability testing and method robustness

Linearity was assessed by injecting six calibration sets with varying parameters such as operator, day, and instrument. The limit of detection (LOD) and limit of quantitation (LOQ) were determined by checking for linearity and back-calculated concentrations at each level of concentration. Each LOQ was reproduced and measured for stability with 10 replicate injections. The method robustness was evaluated using quality control (QC) samples studied at LOQ concentrations (50–250 ng/L).

- QCs were injected every 10 injections of matrix samples (including SPE extracts of surface water, DLLME extracts of sewage water, groundwater, and effluent).
- A total of 40 matrix samples, a calibration curve, and 4 replicates of every LOQ were analyzed resulting in 12 QC injected for a period of 17 hours (70 injections).

The different parameters were tested, and their validation criteria are presented in Table 3.

Table 3. Qualification criteria

	Tested	Acceptamce criteria
Calibration and linearity	Calibration curve	≥5 levels, including blank
	Internal standard variation	RSD < 30% compared to the average area for the calibration curve
	Linearity	R^2 ≥ 0.990, back-calculated: ±20%, except LOQ ±40% (solvent calibration curve)
	Qualification	For at least 5 calibration curves validated
Sensitivity	LOQ RSD (%)	<20% for 10 injections
	LOQ bias (%)	<40% for 10 injections
	Blank injection	Area (LOQ) > 3 × Area (blank)
Robustness	LOQ RSD (%)	<40%
	LOQ bias (%)	<20%

Accuracy and reliability

Aligning with the SANTE guidelines, it is recommended to verify at least three criteria:

- Two mass transitions precursor ion to product ion, with ion ratio ±30% relative (sample vs. standard) of average calibration standards from same sequence.
- One retention time within ±0.1 minutes (sample vs. standard); the analyte peaks from both product ions in the extracted ion chromatogram must fully overlap.

Guidance Document on Analytical Parameters for the Determination of Per- and Polyfluoroalkyl Substances (PFAS) in Food and Feed Version 2.0 (incl. Annex Version 2.0) also states that for PFAS showing only one ion or one MRM (quantifier only, no qualifier), EURL recommends a second chromatographic separation for confirmation. However, our method provides 2 MRM per compound at LOQ.

Linearity facts

The results of the linearity study are consistent across several curves. Each compound was qualified using at least five different calibration curves, and each curve met the validation criteria (R^2 > 0.990 and a relative amount deviation of less than 40% for the LOQ and less than 20% for other levels).

As shown in Table 4, the limits of quantitation (LOQ) obtained range between 50 ng/L and 250 ng/L for a 10 µL injection. These results comply with current European regulations and require at least a 100-fold concentration factor, which is compatible with standard SPE method extraction protocols.

Examples of compound calibration curves are presented in Figure 3. Figure 4 shows the relative amount deviation for each calibration level (green points) across repeated curves. The white area represents the acceptable deviation limit (%), while the blue area indicates deviations beyond the tolerance limit. The criteria of less than 40% deviation at LOQ and less than 20% for other levels were consistently met in the calibration curves.

Table 4 (Part 1). Results of the linearity qualification study

Compound	CAS	Calibration type	Solvent LOQ (ng/L)	Range (ng/L or ppt)	R^2	Rel amount dev. (%)
10:2FTS	120226-60-0	Quad, WithOffset, 1/A	50	50–5,000	0.99992	<40% at the LOQ <20% for all other levels
11Cl-PF2OUdS	763051-92-9	Lin, WithOffset, 1/A	50	25–5,000	0.99984	
3,6-OPFHpA	151772-58-6	Quad, WithOffset, 1/A	50	25–5,000	0.99937	
3:3 FTCA	356-02-5	Quad, WithOffset, 1/A	50	25–5,000	0.99936	
4:2FTS	757124-72-4	Quad, WithOffset, 1/A	50	25–5,000	0.99908	
5:3 FTCA	914637-49-3	Lin, WithOffset, 1/A	50	50–5,000	0.99617	
6:2 FTAB	34455-29-3	Quad, WithOffset, 1/A	100	50–5,000	0.9976	
6:2/8:2diPAP	943913-15-3	Lin, WithOffset, 1/A	50	50–5,000	0.9989	
6:2diPAP	57677-95-9	Lin, WithOffset, 1/A	50	25–5,000	0.99979	
6:2FTOH	647-42-7	Quad, WithOffset, 1/A	500	500–5,000	0.99955	
6:2FTS	27619-97-2	Quad, WithOffset, 1/A	50	25–5,000	0.99881	
7:3 FTCA	812-70-4	Quad, WithOffset, 1/A	100	50–5,000	0.99939	
7HPFHpA	1546-95-8	Lin, WithOffset, 1/A	50	25–5,000	0.99866	
8:2 FTUCA	678-39-7	Quad, WithOffset, 1/A	50	25–5,000	0.99986	
8:2diPAP	70887-84-2	Quad, WithOffset, 1/A	50	25–5,000	0.99928	
8:2FTOH	678-41-1	Quad, WithOffset, 1/A	470	250–5,000	0.99175	
8:2FTS	39108-34-4	Lin, WithOffset, 1/A	50	25–5,000	0.99726	
8:3FTCA	34598-33-9	Quad, WithOffset, 1/A	100	100–5,000	0.99934	
9Cl-PF3ONS	756426-58-1	Lin, WithOffset, 1/A	50	25–5,000	0.99892	
ADONA	919005-14-4	Lin, WithOffset, 1/A	50	25–5,000	0.99936	
FBSA	30334-69-1	Lin, WithOffset, 1/A	50	25–5,000	0.9989	
FHxSA	41997-13-1	Quad, WithOffset, 1/A	50	25–5,000	0.99943	
FOEA	27854-31-5	Quad, WithOffset, 1/A	100	100–5,000	0.99788	
FOSA	754-91-6	Quad, WithOffset, 1/A	50	25–5,000	0.99832	
HFPO-DA	13252-13-6	Lin, WithOffset, 1/A	50	50–5,000	0.99736	
HFPO-TA	13252-14-7	Quad, WithOffset, 1/A	100	50–5,000	0.9999	
N-EtFOSA	4151-50-2	Quad, WithOffset, 1/A	50	25–5,000	0.99965	
N-EtFOSAA	2991-50-6	Quad, WithOffset, 1/A	100	50–5,000	0.99969	

Table 4 (Part 2). Results of the linearity qualification study

Compound	CAS	Calibration type	Solvent LOQ (ng/L)	Range (ng/L or ppt)	R^2	Rel amount dev. (%)
N-EtFOSE	1691-99-2	Quad, WithOffset, 1/A	50	25–5,000	0.99988	<40% at the LOQ <20% for all other levels
N-MeFBSA	68298-12-4	Lin, WithOffset	500	1,000–5,000	0.99053	
N-MeFBSAA	159381-10-9	Quad, WithOffset, 1/A	50	25–5,000	0.99947	
N-MeFOSA	31506-32-8	Quad, WithOffset, 1/A	100	25–5,000	0.99929	
N-MeFOSAA	2355-31-9	Quad, WithOffset, 1/A	100	50–5,000	0.99933	
N-MeFOSE	24448-09-7	Lin, WithOffset, 1/A	50	25–5,000	0.99922	
PF4OPeA	377-73-1	Lin, WithOffset, 1/A	50	25–5,000	0.99921	
PF5HxA	863090-89-5	Quad, WithOffset, 1/A	50	25–5,000	0.9994	
PFBA	375-22-4	Lin, WithOffset, 1/A	50	50–5,000	0.9995	
PFBS	375-73-5	Quad, WithOffset, 1/A	50	25–5,000	0.99953	
PFDA	335-76-2	Lin, WithOffset, 1/A	50	25–5,000	0.99802	
PFDoA	307-55-1	Lin, WithOffset, 1/A	50	25–5,000	0.99945	
PFDoS	79780-39-5	Quad, WithOffset, 1/A	50	25–5,000	0.99928	
PFDS	335-77-3	Quad, WithOffset, 1/A	50	50–5,000	0.9988	
PFECHS	646-83-3	Quad, WithOffset, 1/A	50	25–5,000	0.99889	
PFEESA	113507-82-7	Quad, WithOffset, 1/A	50	25–5,000	0.99943	
PFHpA	375-85-9	Lin, WithOffset, 1/A	50	25–5,000	0.99906	
PFHpS	375-92-8	Quad, WithOffset, 1/A	50	25–5,000	0.99963	
PFHxA	307-24-4	Quad, WithOffset, 1/A	50	25–5,000	0.99926	
PFHxDA	67905-19-5	Quad, WithOffset, 1/A	50	25–5,000	0.99988	
PFHxS	355-46-4	Quad, WithOffset, 1/A	50	25–5,000	0.99943	
PFNA	375-95-1	Lin, WithOffset, 1/A	50	25–5,000	0.99945	
PFNS	68259-12-1	Quad, WithOffset, 1/A	50	25–5,000	0.99986	
PFOA	335-67-1	Quad, WithOffset, 1/A	50	25–5,000	0.99973	
PFOcDA	16517-11-6	Lin, WithOffset, 1/A	50	25–5,000	0.9985	
PFOS	1763-23-1	Quad, WithOffset, 1/A	50	50–5,000	0.99854	
PFPeA	2706-90-3	Quad, WithOffset, 1/A	500	100–5,000	0.99988	
PFPeS	2706-91-4	Lin, WithOffset, 1/A	50	25–5,000	0.99939	
PFTeDA	376-06-7	Quad, WithOffset, 1/A	50	25–5,000	0.99967	
PFTrDA	72629-94-8	Quad, WithOffset, 1/A	50	25–5,000	0.99937	
PFTrDS	791563-89-8	Quad, WithOffset, 1/A	50	50–5,000	0.99921	
PFUdA	2058-94-8	Quad, WithOffset, 1/A	50	25–5,000	0.9993	
PFUnDS	749786-16-1	Quad, WithOffset, 1/A	50	25–5,000	0.99912	

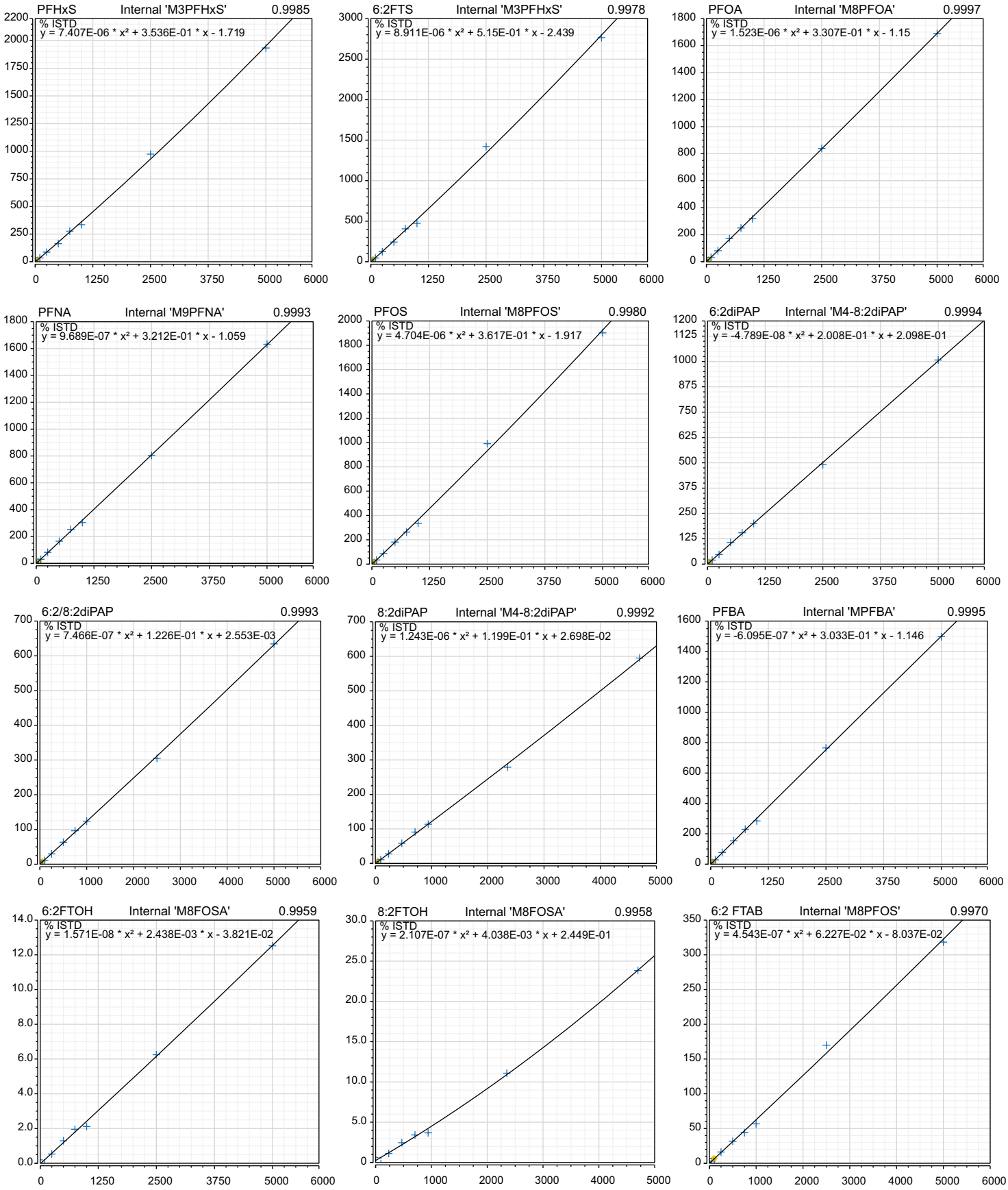
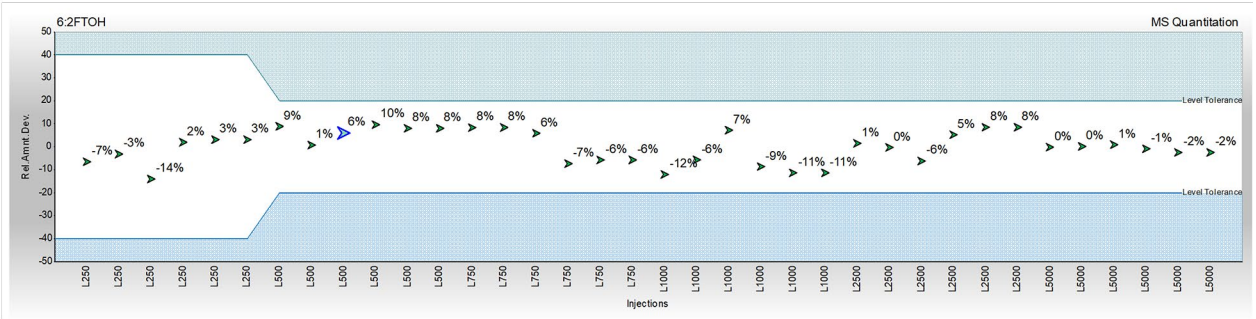


Figure 3. Calibration curves from 25 ppt to 5 ppb for PFHxS, 6:2 FTS, PFOA, PFNA, PFOS, 6:2 di-PAP, 6:2/8:2 di-PAP, 8:2 di-PAP and PFBA, 6:2 FTOH, 8:2 FTOH, and 6:2 FTAB

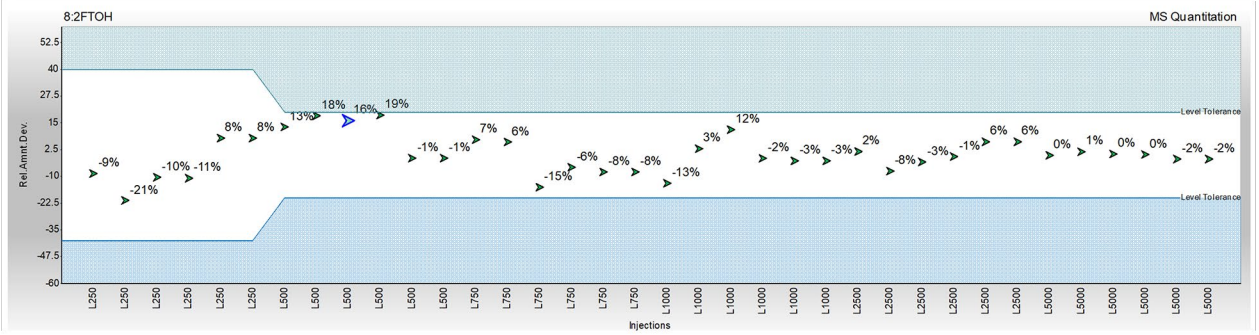
6:2 FTOH

from 250 ppt to 5 ppb



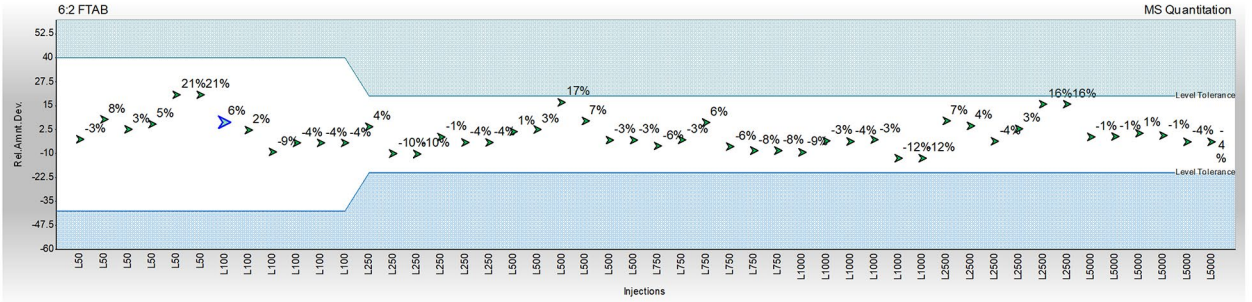
8:2 FTOH

from 235 ppt to 4.7 ppb



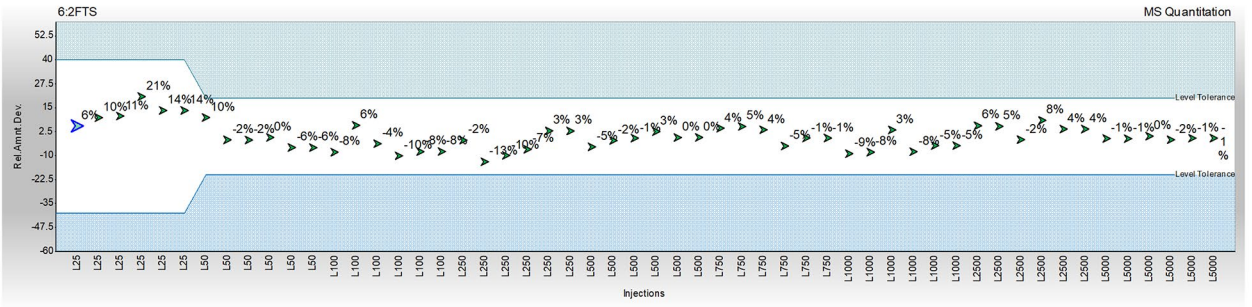
6:2 FTAB

From 50 ppt to 5 ppb



6:2 FTS

from 25 ppt to 5 ppb



PFOS

From 50 ppt to 5 ppb

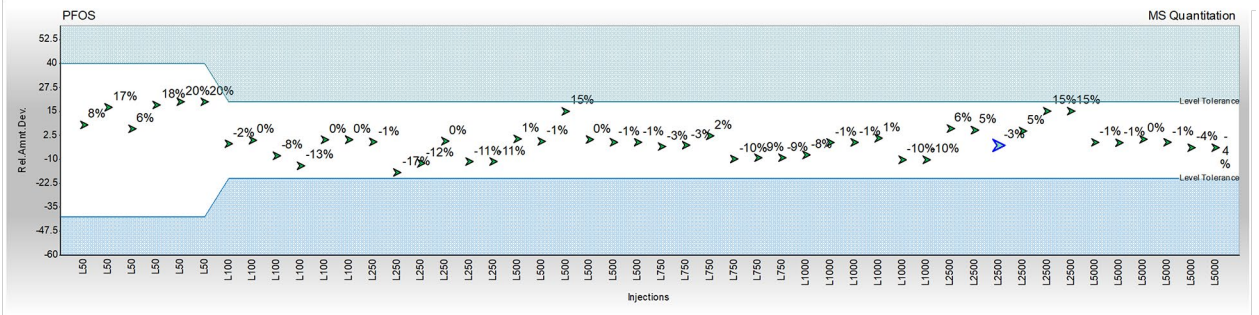
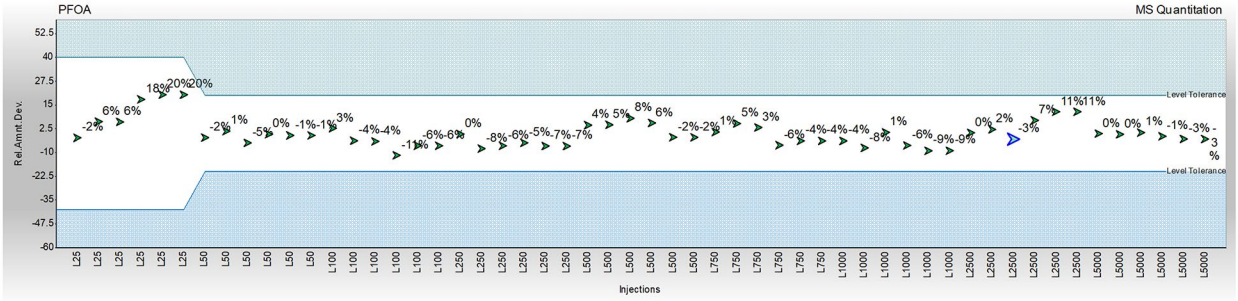


Figure 4 (part 1). Example of charts to assess the relative amount deviation according to criteria for 6:2 FTOH, 8:2 FTOH, 6:2 FTAB, 6:2 FTS, and PFOs

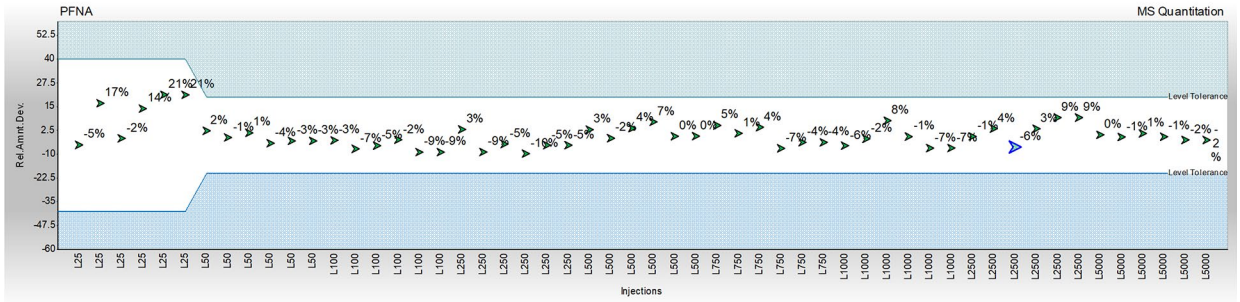
PFOA

from 25 ppt to 5 ppb



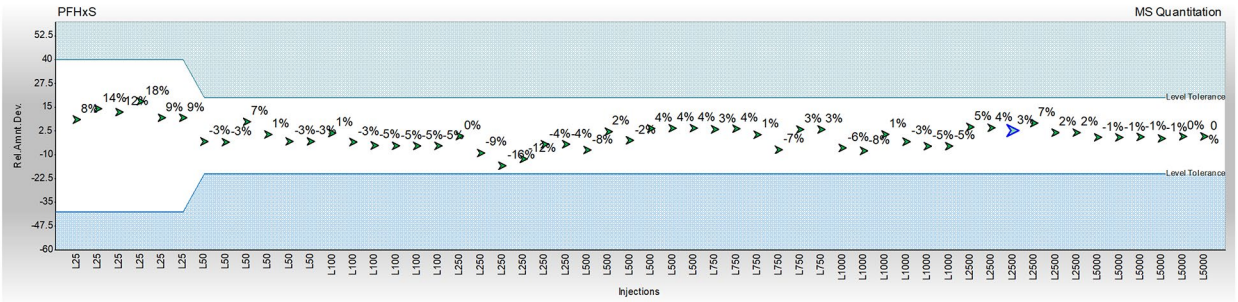
PFNA

from 25 ppt to 5 ppb



PFHxS

from 25 ppt to 5 ppb



8:2 di-PAP

from 25 ppt to 5 ppb

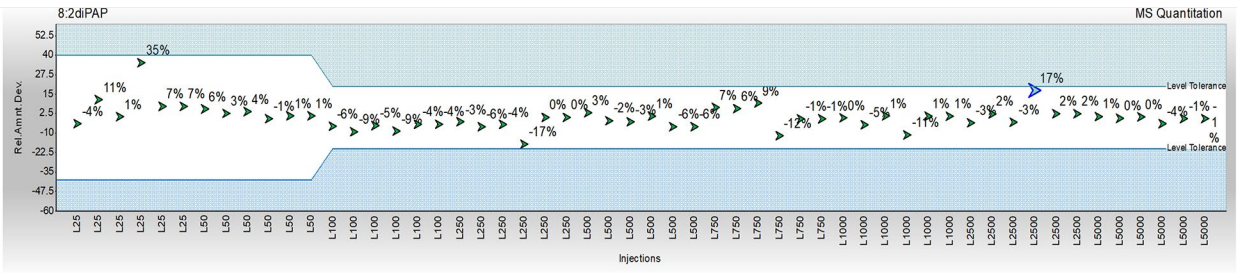


Figure 4 (part 2). Example of charts to assess the relative amount deviation according to criteria for PFOA, PFNA, PFHxS, and 8:2 di-PAP

Sensitivity check

The chromatograms below illustrate examples of eight PFAS at the LOQ in solvent, showcasing excellent resolution and peak shape (Figures 5 and 6). The overlays correspond to 2 MRM transitions selected—the most intense, plus confirmation with the second most intense—which can be an isotope depending on the specific structural and chemical characteristics of the PFAS. PFHxS and PFOS show the expected resolved peaks for linear and branched isomers. While the MS can detect lower LOQs, due to the ubiquitous nature of PFAS in the lab environment, LOQs were limited to the background level of the PFAS in our lab environment. LOQs should be set in accordance to PFAS level in the end-user laboratory atmosphere. It is acknowledged that some laboratories may experience high levels of air contamination with PFBA. Other background compounds—PFPeA (consumables, pipette tips, or reagent contamination), N-MeFBSA (when using acid in sample prep), 6:2FTS (when using SPE as the sample extraction protocol)—can also be observed occasionally.

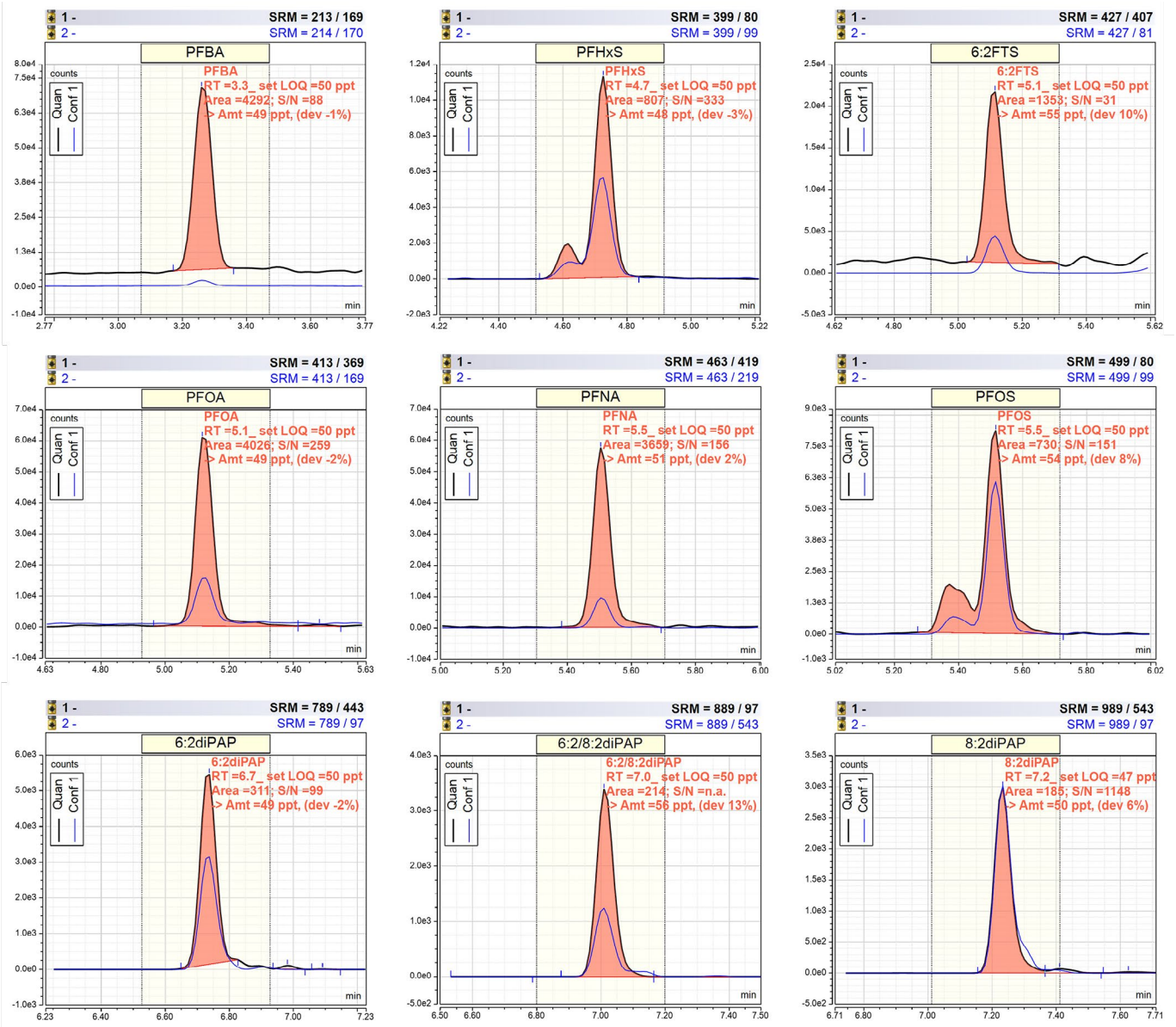


Figure 5. Overlaid MRM at the LOQ (50 ppt) for PFBA, PFHxS, 6:2 FTS, PFOA, PFNA, PFOS, 6:2 di-PAP, 6:2/8:2 di-PAP, and 8:2 di-PAP

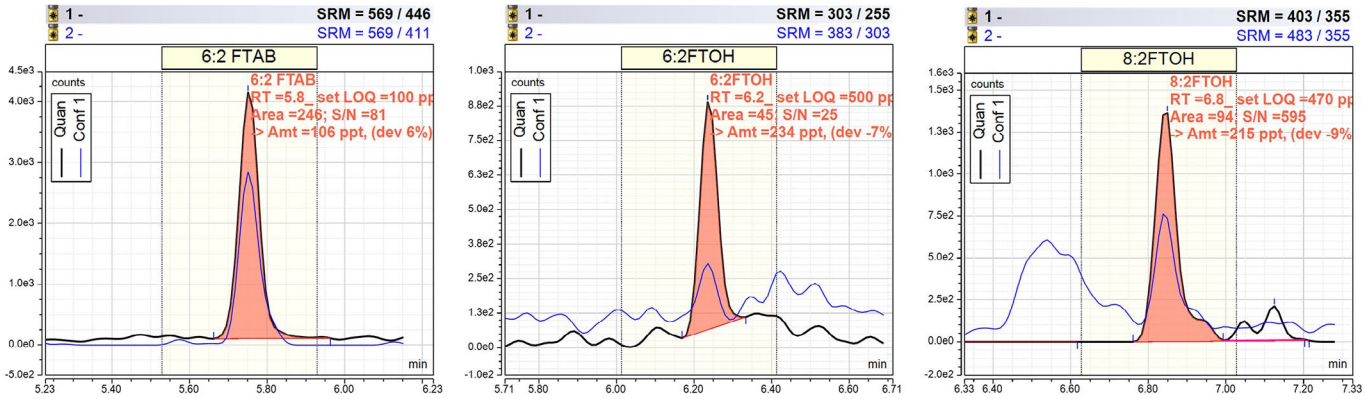


Figure 6. Overlaid MRM at the LOQ (100 ppt) for 6:2 FTAB, and below LOQ for 6:2 FTOH (250 ppt) and 8:2 FTOH (235 ppt)

Robustness check

The method robustness was assessed by injecting a QC in solvent at the LOQ every 10 matrix samples (extracts of sewage water, groundwater, and effluent). After 40 consecutive injections, the data presented in Table 5 demonstrated good robustness for injections. The amounts were always accurate, and all relative amount deviations (Rel. Amt. Dev.) were clearly below 40%. The stability was very good.

It is important to note that no maintenance or MS tuning was conducted during the evaluation of robustness. For reference, the table also shows the average value and stability of the LOQ when injected 10 times to qualify the limit of quantitation.

Table 5. Stability of LOQ for PFAS under stability, repeatability and robustness tests

	LoQ	Average R1 to R10	%RSD (n=10)	QC-50-1	QC-50-2	QC-50-3	QC-50-4	Average QC1 to QC4	%RSD (n=4, over 40 matrices extract, over 17 hr)
PFAS	ng/L	ng/L	%	Calc amount (% Rel. Amt. Dev.)				ng/L	%
6:2/8:2diPAP	50	49	15	56.4 (12.8%)	48 (-4%)	57.4 (14.7%)	47.9 (-4.2%)	50	14
6:2diPAP	50	46	12	59.5 (18.9%)	63 (26%)	50.5 (1.1%)	40.6 (-18.7%)	50	23
PFHxS	50	50	6	44.1 (-11.8%)	47.8 (-4.3%)	50 (-0.1%)	45.5 (-9%)	46	8
PFNA	50	49	5	42.8 (-14.5%)	52.2 (4.4%)	42.1 (-15.8%)	48.7 (-2.7%)	46	9
PFOA	50	49	4	49.9 (-0.2%)	46.8 (-6.4%)	47 (-6%)	45.9 (-8.1%)	47	3
PFOS	50	49	7	51.4 (2.7%)	49.1 (-1.9%)	56.6 (13.1%)	51.9 (3.7%)	51	9
6:2 FTAB	100	110	10	83.2 (-16.8%)	107.4 (7.4%)	113.9 (13.9%)	112.4 (12.4%)	107	13
8:2FTOH	470	572	12	488.2 (454.68%)	429 (-8.7%)	545.3 (16%)	448.6 (-4.6%)	455	15
6:2FTOH	500	553	9	491.6 (479.76%)	535.6 (7.1%)	466.8 (-6.6%)	443.2 (-11.4%)	480	7

Conclusions

Our method offers significant advantages for PFAS analysis, ensuring accurate, reliable, and compliant results. The major customer benefit is that we provide a ready-to-go solution, already optimized to meet regulatory limits in terms of performance, designed to comply with regulatory criteria, fully tested for robustness, applicable to any environmental sample type, and extremely easy to handle with a user-optimized interface.

- **Accurate PFAS quantitation:** The method enables the precise quantitation of a broad range of PFAS compounds using the targeted approach of the TSQ Altis Plus mass spectrometer, demonstrating high sensitivity, selectivity, and robustness.
- **Well-established configuration:** The TSQ Altis Plus configuration is well-established and widely used, ensuring reliability and familiarity.
- **Regulatory compliance:** Designed to comply with current European regulations for PFAS in drinking water (0.1 µg/L sum of 20 PFAS; 0.5 µg/L total PFAS); it can be extended to other regional PFAS lists.
- **Robust method:** Proven robustness with consistent performance across multiple injections and different matrices (drinking water, surface water, groundwater, wastewater), maintaining accuracy and stability without the need for maintenance or MS tuning.
- **Validated performance:** Meets stringent validation criteria, including linearity ($R^2 > 0.990$), accuracy, precision, and robustness, with relative amount deviations well within acceptable limits.
- **Practical application:** Applicable for the analysis of extracted water samples, including drinking water, surface water, groundwater, and wastewater, supporting environmental and public health monitoring.

For an alternative approach of this workflow, please refer to its twin application brief, run with the Thermo Scientific™ Orbitrap™ Exploris™ MX mass spectrometer.[10]

For further information, contact your local commercial representative.

Acknowledgment

We would like to thank John Quick from ALS Laboratories (UK) for providing us with SPE extracts and for sharing his insights, which significantly contributed to this study. Additionally, we extend our gratitude to all our colleagues from Thermo Fisher Scientific for sharing their previous work regarding PFAS analyses, particularly Chaima Aitmbark, Cédric Baudin, Debora D'Addona, and Kevin J. McHale.

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AB003941-EN 0725S