Phosphate in Water and Seawater (MT518)

1 SCOPE

This method covers the determination of *ortho*-phosphate in drinking water and seawater. Additional sample pre-treatment might be required.

2 CALIBRATION RANGE

Low Range:
Water: 0.02 - 1 µmol/L (0.62 - 31 µg/L as P)
Seawater: 0.02 - 1 µmol/L (0.62 - 31 µgl/L as P)

High Range:
Water: 0.72 - 36 µmol/L (22 - 1120 µg/L as P)
Seawater: 0.08 - 4 µmol/L (2.5- 125 µg/L as P)

3 TYPICAL PERFORMANCE DATA

	Water		***Seawater***	
	Low Range	High Range	Low Range	High Range
Sampling	60 samples/h, 4:1		60 samples/h, 4:1	
Highest Calibrant	1 µmol/L	36 µmol/L	1 µmol/L	4 µmol/L
Blank variation (SD of 10 sequential blanks)	0.002 µmol/L	0.004 µmol/L	0.002 µmol/L	0.002 µmol/L
Detection limit (EPA procedure 40 CFR Part 136, App. B)	0.005 µmol/L	0.010 µmol/L	0.004 µmol/L	0.005 µmol/L

These performance statistics were generated using genuine SEAL Analytical parts and consumables. Performance may vary depending on system components and the number of channels selected.
Performance values are pooled from independent runs. Refer to section 16 for details.

4 METHOD PRINCIPLE

Following the method of Murphy and Riley (1), this automated procedure for the determination of ortho-phosphate is based on the colorimetric method in which a blue color is formed by the reaction of ortho-phosphate, molybdate and antimony followed by reduction with ascorbic acid at a pH < 1. The reduced blue phospho-molybdenum complex is read at 880 nm. The [H+] : [Mo] ratio in the reaction mixture corresponds to the optimum determined by Drummond and Maher (2).

5 REFERENCES

1. J. Murphy and J.P. Riley, 1962. A modified single solution method for the determination of phosphate in natural waters. Analytica Chimica Acta 27:31-36.
2. L. Drummond and W. Maher, 1995. Re-examination of the optimum conditions for the analysis of phosphate. Analytical Chimica Acta 302: 69-74.

6 HARDWARE REQUIREMENTS

Chemistry Hardware:	2.0 mm glass, 5 mL heating bath
Detector:	LED photometer at 880 nm, 10 mm flowcell
Pump tubes:	5 + 2 air + sampler wash

7 LIST OF REQUIRED CHEMICALS

All chemicals must be of analytical grade quality (ACS grade, pro analysi, etc.). DI water refers to high grade quality distilled or deionized water, free from organic contamination (e.g. ISO 3696 Grade 1 or ASTM standard D 1193 Type I/II)
Persons using this method should be familiar with normal laboratory practice. This method does not purport to address all safety risks, if any, associated with its use. It is the responsibility of the user to establish safety and health practices and to ensure compliance with local regulatory conditions.

Compound	CAS No.	Safety classification
Acetone	67-64-1	*GHS02, GHS07*
Ammonium heptamolybdate	12054-85-2	*GHS07*
Antimony potassium tartrate	331753-56-1	*GHS07, GHS09*
Ascorbic acid	50-81-7	--
Potassium dihydrogen phosphate	7778-77-0	--
Sodium chloride	7647-14-5	--
Sodium hypochlorite, 10% solution	7681-52-9	*GHS05, GHS09*
Sodium dodecyl sulfate (SDS) purest available grade	151-21-3	*GHS02, GHS05, GHS07*
Sodium hydroxide	1310-73-2	*GHS05*
Sulfuric acid, conc.	7664-93-9	*GHS05*

GHS01: Danger - Explosive; GHS02: Danger - Flammable; GHS03: Danger - Oxidizing; GHS04: Warning - Compressed gas; GHS05: Warning/Danger - Corrosive; GHS06: Danger - Toxic; GHS07: Irritant; GHS08: Danger - Health hazard; GHS09: Warning/Danger - Environmentally Damaging

8 REAGENT PREPARATION

To reach the stated performance values, standards, reagents and sampler wash must be free of solids and dissolved air.
For best performance vacuum filter all reagents through a 0.45 µm filter or glass filter paper. If necessary, vacuum filter all DI water used in the preparation of standards and for the sampler wash or degas the water in another way.
The total volume of each reagent can be varied, if the concentrations of its ingredients remain the same. It is recommended to only prepare the required amount of reagent, which can be calculated from the flowrate of its corresponding reagent pump tube.

8.1 SYNTHETIC SEAWATER

Raw Material	Amount	Reagent Label
Sodium chloride	35 g	N/A
DI water	to 1000 mL	
Storage: plastic container at room temperature Stability: one week		

Dissolve 35 g of sodium chloride in about 800 mL of DI water. Dilute to 1000 mL with DI water and mix thoroughly.

8.2 SYSTEM WASH SOLUTION

Raw Material	Amount	Reagent Label
Sodium dodecyl sulfate	2 g	N/A
DI water	to 1000 mL	
Storage: plastic bottle at room temperature Stability: infinite, replace if turbid or cloudy		

Dissolve 2 g of sodium dodecyl sulfate (SDS) in about 800 mL of DI water. Dilute to 1000 mL with DI water and mix thoroughly.

8.3 SPECIAL WASH SOLUTION

Raw Material	Amount	Reagent Label
Sodium hypochlorite solution, 10% free chlorine	20 mL	 **Warning**
DI water	to 100 mL	
Storage: plastic bottle at room temperature Stability: one day		

Add 20 mL of sodium hypochlorite solution to about 70 mL of DI water and mix. Dilute to 100 mL with DI water and mix thoroughly.

8.4 SODIUM HYDROXIDE, 1 mol/L

Raw Material	Amount	Reagent Label
Sodium hydroxide	40 g	 **Danger**
DI water	to 1000 mL	
Storage: plastic bottle at room temperature Stability: infinite, replace if turbid or cloudy		

Add 40 g of sodium hydroxide to about 800 mL of DI water and dissolve completely. Dilute to 1000 mL with DI water and mix thoroughly.

8.5 STOCK ANTIMONY POTASSIUM TARTRATE

Raw Material	Amount	Reagent Label
Antimony potassium tartrate	2.3 g	N/A
DI water	to 100 mL	
Storage: plastic bottle at room temperature Stability: one month		

Dissolve 2.3 g of antimony potassium tartrate in about 80 mL of DI water. Dilute to 100 mL with DI water and mix thoroughly.

8.6 AMMONIUM MOLYBDATE

Raw Material	Amount	Reagent Label
Sulfuric acid, conc.	200 mL	 Danger
Ammonium heptamolybdate	16 g	
Stock antimony potassium tartrate	15 mL	
DI water	to 1000 mL	
Storage: amber plastic bottle at 4°C Stability: one week.		

Add carefully 200 mL of conc. sulfuric acid to about 700 mL of DI water and cool. Dissolve 16 g of ammonium heptamolybdate and add 15 mL of stock antimony potassium tartrate. Dilute to 1000 mL with DI water and mix thoroughly. The ammonium heptamolybdate must be perfectly white, with no green tint and the solution must be colorless and free of turbidity.

8.7 ASCORBIC ACID

Raw Material	Amount	Reagent Label
Ascorbic acid	8 g	 Danger
Acetone	45 mL	
Sodium dodecyl sulfate (SDS)	10 g	
DI water	to 1000 mL	
Storage: amber plastic bottle at 4°C Stability: one week		

Dissolve 8 g of ascorbic acid in about 600 mL of DI water. Add 45 mL of acetone and 10 g of sodium dodecyl sulfate. Dilute to 1000 mL with DI water and mix thoroughly.

9 STANDARDS

These formulas assume that samples are preserved with the described preserving solution (see section 10). If other preservation methods are used, the sample and standard matrix and the sampler wash solution should be similar.

9.1 STOCK STANDARD A – 1000 mg/L PO_4-P

Raw material	Amount	Reagent Label
Potassium dihydrogen phosphate	0.439 g	N/A
DI water	to 100 mL	
Storage: plastic bottle at 4°C Stability: one year		

Dissolve 0.439 g of potassium dihydrogen phosphate in about 60 mL of DI water. Dilute to 100 mL with DI water and mix thoroughly.

9.2 STOCK STANDARD B – 3600 µmol/L

Raw Material	Amount	Reagent Label
Stock Standard A – 1000 mg/L PO_4-P	11.16 mL	N/A
DI water	to 100 mL	
Storage: plastic bottle at 4°C Stability: three month		

Pipette 11.16 mL of stock standard A into a 100 mL volumetric flask. Dilute to 100 mL with DI water and mix thoroughly.

9.3 STOCK STANDARD C – 100 µmol/L

Raw Material	Amount	Reagent Label
Stock Standard A – 1000 mg/L PO_4-P	0.31 mL	N/A
DI water	to 100 mL	
Storage: plastic bottle at 4°C Stability: three month		

Pipette 0.31 mL of stock standard A into a 100 mL volumetric flask. Dilute to 100 mL with DI water and mix thoroughly.

9.4 WORKING STANDARDS

Prepare working standards fresh every day before use. For example:

9.4.1 WATER

Low range	
mL of Stock C	**µmol/L**
0.1	0.1
0.25	0.25
0.5	0.5
0.75	0.75
1	1

High range	
mL of Stock B	**µmol/L**
0.1	3.6
0.25	9
0.5	18
0.75	27
1	36

Pipette each aliquot of Stock standard B or C into a 100 mL volumetric flask. Dilute to volume with DI water and mix thoroughly.

9.4.2 SEAWATER

Low range	
mL of Stock C	**µmol/L**
0.1	0.1
0.25	0.25
0.5	0.5
0.75	0.75
1	1

High range	
mL of Stock C	**µmol/L**
0.5	0.5
1	1
2	2
3	3
4	4

Pipette each aliquot of Stock standard C into a 100 mL volumetric flask. Dilute to volume with synthetic seawater and mix thoroughly.

10 SAMPLE PRESERVATION AND STORAGE

If filtering is required (in case of particles of diameter > 0.1 mm), samples for the determination of orthophosphate should be filtered through a membrane filter (0.45 µm) immediately after sampling and stored at 4°C ± 2°C. The filtration reduces biological reactions, and avoids interferences by sulphide and clogging of the analyser tubing. Seawater samples should be analysed as quickly as possible after collection and sample cups need to be rinsed with sample first.
Samples may also be frozen to analyse them later.
Strongly acidic or alkaline samples must be neutralized before analysis.

11 INTERFERENCES

Silicate does not interfere below 2 mg/L. Arsenate inference can be eliminated as described in

(1) Hansen, H. P., and F. Koroleff. 1999. Determination of nutrients, p. 159-223.
(2) K. Grasshoff, K. Kremling, and M. Ehrhardt (ed.), Methods of seawater analysis. Wiley-VCH, Weinheim, Germany.

12 MANUAL START-UP PROCEDURE

1. Switch on all modules
2. Start pumping:
   - DI water through the sampler wash
   - System wash solution through the reagent lines
3. Wait for a stable bubble pattern
4. Switch the reagent lines from wash solution to their corresponding reagent
5. Wait for the baseline to stabilize again.

13 MANUAL SHUTDOWN PROCEDURE

1. Switch the reagent lines:
   - DI water through the sampler wash
   - 1N NaOH solution through the reagent lines
2. Pump for at least 10 minutes
3. Switch reagent lines to system wash solution
4. Pump for at least 10 minutes
5. Release the pump platen
6. Switch of all modules.

14 SYSTEM CLEANING PROCEDURE

DAILY:
Pump sodium hydroxide 1 mol/L solution followed by system wash solution through all reagent lines for at least 10 minutes each.

WEEKLY:
Pump sodium hydroxide 1 mol/L solution followed by system wash solution through all reagent lines for at least 10 minutes each. Pump special wash solution through the reagent lines for 20 minutes followed by system wash solution for at least 30 minutes.

15 OPERATING NOTES

1. Recommended procedures for best performance when analysing low concentrations
   - For accurate low-level work, all glassware used for making reagents should be rinsed with 10% hydrochloric acid followed by rinsing with DI water two or more times. Store flasks “shaken dry” and capped. Regular cleaning of storage containers reduces variances in analytical results. Do not wash the glassware in a washer or with any kind of detergent.
   - Sample cups must be perfectly clean. For low-level work, fill sample cups with 10% hydrochloric acid and leave standing for at least 15 min. Then rinse the sample cups twice with DI water followed by two rinses with sample or standard solution. Sample containers must be rinsed at least twice with sample before filling.
   - Skin contact must be avoided with anything, which will touch the reagents and samples.
   - The laboratory temperature should be reasonably stable, with no strong air currents around the analyser. Run the system with the manifold cover in place.
   - All chemicals should be of high purity. In particular, impure, old or contaminated SDS and molybdate will cause carryover, drift and noise.
   - The prepared reagents should be degassed by vacuum membrane filtration for best performance. Filters with a pore size of 0.45 µm or less should be used. The reagents, pure water and standards should be protected from atmospheric contamination.
   - Samples should be measured as soon as possible after sampling.
   - The volume between the air valve and the injection fitting should be minimal, using 0.015" polyethylene tubing cut as short as possible. The joints between glass parts must be without gaps.
   - After replacing the pump tubes or parts of the manifold, pump 1N NaOH through all reagent tubes and the sample line for 15 minutes.

2. Even flow and regular air/liquid distribution in the transmission tube from the debubbler after the first mixing coil to the pump is critical to correct method performance. Check for correct flow and that the tubing is wetted (trailing edge of the bubbles must be rounded, not straight). If necessary, especially for new tubing, increase the concentration of surfactant.

16 PERFORMANCE VALIDATION

16.1 TEST CONDITIONS

Sampler type	XY-3
Sample probe	High-Tech 1.0 mm
Sample tubing and length	PE15, 100 cm
Total sample flow rate (incl. by-pass and other channels)	3.2 mL/min
Wash pot type	Fixed
Wavelength	880 nm
Reference energy	
Sample:ref ratio	
Light power	98%
Room temperature	22 – 25°C

16.2 PERFORMANCE DATA – OVERVIEW

	Water		***Seawater***	
	Low range	High range	Low range	High range
Highest Calibrant	**1 µmol/L**	**36 µmol/L**	**1 µmol/L**	**4 µmol/L**
Sensitivity *(in specified flowcell)*	0.015-0.019 AU	0.54-0.66 AU	0.014-0.018 AU	0.07-0.09 AU
Correlation Coefficient *(linear, six points)*	0.999	0.999	0.999	0.999
Reagent absorbance	0.01 AU		0.01 AU	
Coefficient of Variation	0.002 µmol/L 0.31%	0.022 µmol/L 0.12%	0.002 µmol/L 0.32%	0.004 µmol/L 0.17%
Pooled SD	0.003 µmol/L	0.027 µmol/L	0.001 µmol/L	0.004 µmol/L
Blank variation (SD of 10 sequential blanks)	**0.002 µmol/L**	**0.004 µmol/L**	**0.002 µmol/L**	**0.002 µmol/L**
Detection limit (EPA, spikes)	**0.005 µmol/L**	0.009 µmol/L	0.002 µmol/L	0.003 µmol/L
Detection limit (EPA, blanks)	0.003 µmol/L	**0.010 µmol/L**	**0.004 µmol/L**	**0.005 µmol/L**

These performance statistics were generated using genuine SEAL Analytical parts and consumables.
Performance may vary depending on system components and the number of channels selected.
Performance values are pooled from independent runs. The **bold** values are reported on the first page of this method document.

16.3 CALIBRATION DATA

16.3.1 WATER

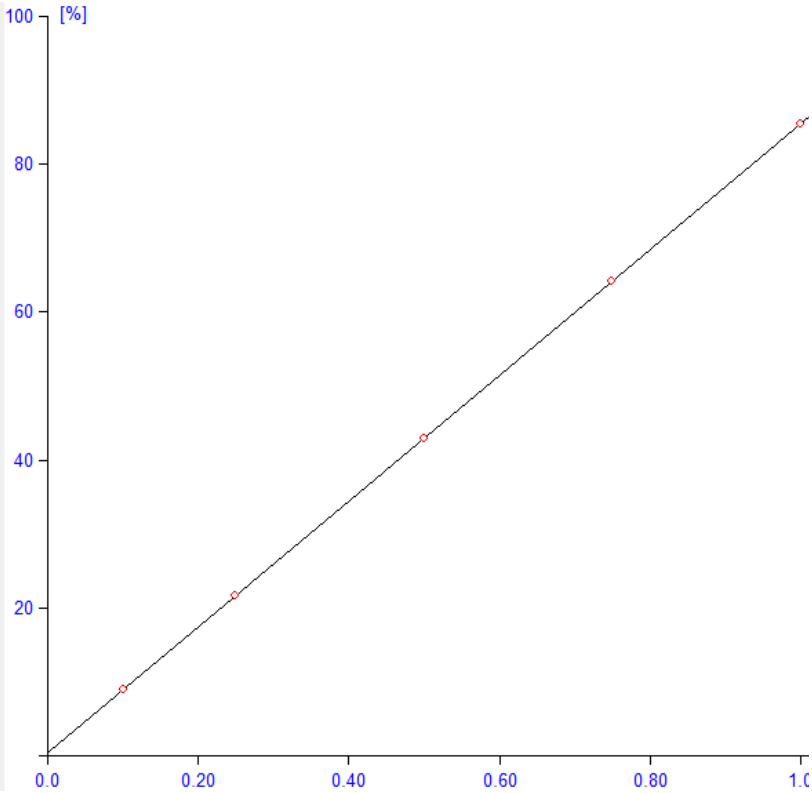
PO4

Calibr. Fit: Linear
Baseline not in cal.
Corr.Coeff.(r): 1.0000
Gain/AUFS: 503 / 0.0199
Equation: y = bx + a
y = peak height
x = conc. in <µmol/L>
a = 3.9170E+003
b = 5.5730E+004

Corrections:
Baseline: done
Drift: done
Carryover: no

Calib. values:

Type	Calculated	Target	Diff. (conc.)	Diff. (%)
1C	0.100	0.100	0.000	-0.18
2C	0.250	0.250	0.000	-0.10
3C	0.500	0.500	0.000	0.07
4C	0.751	0.750	0.001	0.10
5C	0.999	1.000	-0.001	-0.06



Low calibration range: 0.1 µmol/L to 1.0 µmol/L. Absorbance of top standard: 0.017 AU

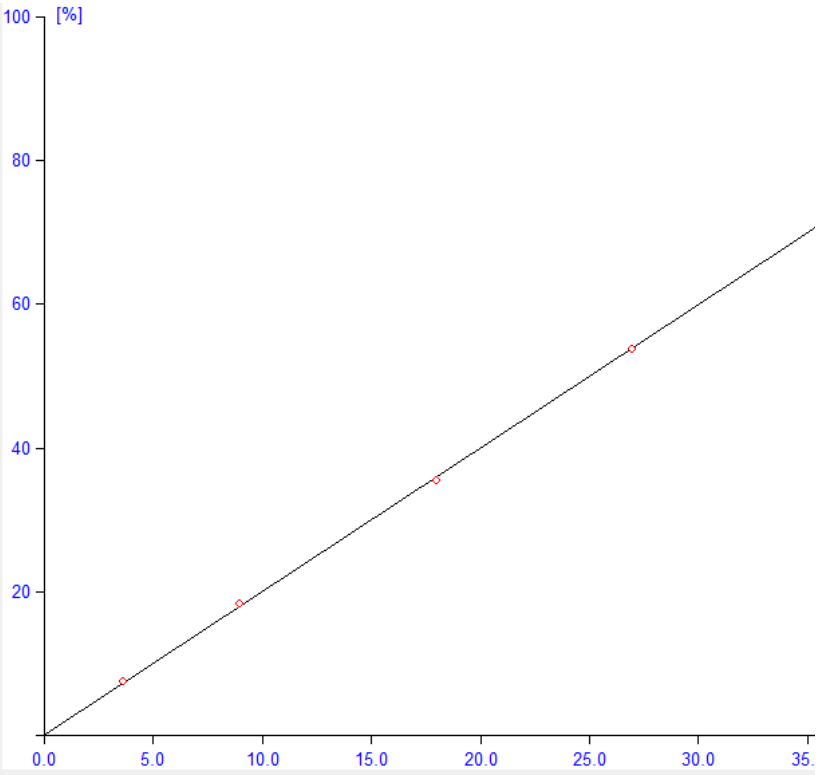
PO4

Calibr. Fit: Linear
Baseline not in cal.
Corr.Coeff.(r): 0.9999
Gain/AUFS: 12 / 0.8333
Equation: y = bx + a
y = peak height
x = conc. in <µmol/L>
a = 3.1704E+003
b = 1.3085E+003

Corrections:
Baseline: done
Drift: done
Carryover: done 0.13 %

Calib. values:

Type	Calculated	Target	Diff. (conc.)	Diff. (%)
1C	3.670	3.600	0.070	1.93
2C	9.138	9.000	0.138	1.53
3C	17.727	18.000	-0.273	-1.52
4C	26.881	27.000	-0.119	-0.44
5C	36.184	36.000	0.184	0.51



High calibration range: 3.6 µmol/L to 36.0 µmol/L. Absorbance of top standard: 0.60 AU

16.3.2 SEAWATER

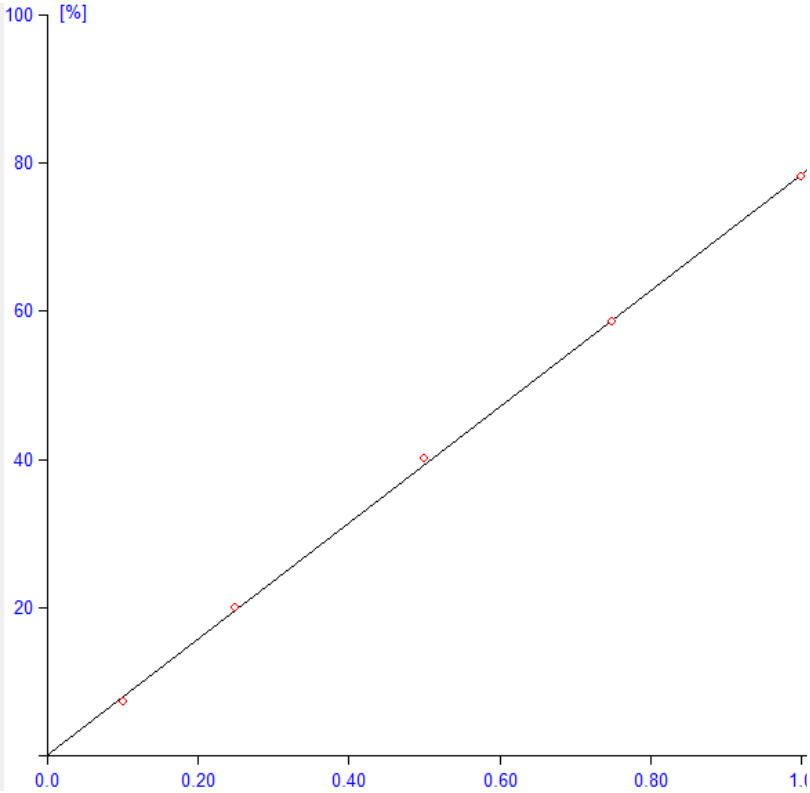
PO4

Calibr. Fit: Linear
Baseline not in cal.
Corr.Coeff.(r): 0.9997
Gain/AUFS: 493 / 0.0203
Equation: y = bx + a
y = peak height
x = conc. in <µmol/L>
a = 3.2991E+003
b = 5.1322E+004

Corrections:
Baseline: done
Drift: done
Carryover: done 0.24 %

Calib. values:

Type	Calculated	Target	Diff. (conc.)	Diff. (%)
1C	0.091	0.100	-0.009	-9.01
2C	0.254	0.250	0.004	1.49
3C	0.512	0.500	0.012	2.43
4C	0.747	0.750	-0.003	-0.41
5C	0.996	1.000	-0.004	-0.38



Low calibration range: 0.1 µmol/L to 1.0 µmol/L. Absorbance of top standard: 0.0158 AU

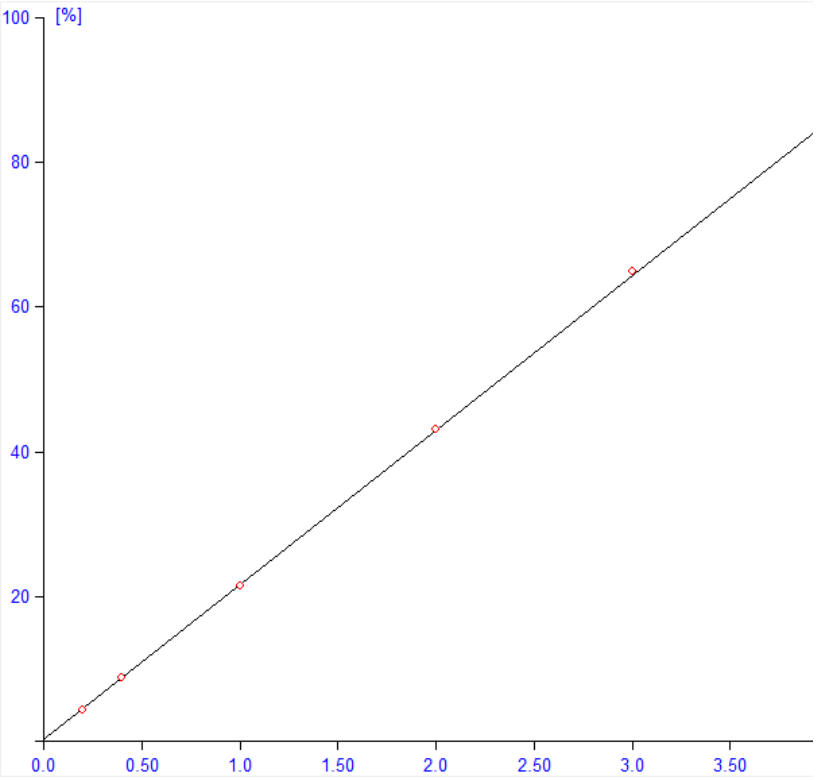
PO4

Calibr. Fit: Linear
Baseline not in cal.
Corr.Coeff.(r): 0.9999
Gain/AUFS: 108 / 0.0926
Equation: y = bx + a
y = peak height
x = conc. in <µmol/L>
a = 3.5071E+003
b = 1.4001E+004

Corrections:
Baseline: done
Drift: done
Carryover: done 0.13 %

Calib. values:

Type	Calculated	Target	Diff. (conc.)	Diff. (%)
1C	0.188	0.200	-0.012	-5.76
2C	0.402	0.400	0.002	0.40
3C	0.997	1.000	-0.003	-0.30
4C	2.010	2.000	0.010	0.48
5C	3.028	3.000	0.028	0.93
6C	3.975	4.000	-0.025	-0.61



High calibration range: 0.2 µmol/L to 4.0 µmol/L. Absorbance of top standard: 0.079 AU

16.4 REPRODUCIBILITY – SAME CONCENTRATION

The reproducibility is checked by measuring 20 replicates of a 50% calibration range standard. Three runs are performed on three different days. Baseline and sensitivity drift correction are applied. The coefficient of variation is calculated by dividing the standard deviation of the replicates by the mean and then multiplying with 100.

16.4.1 WATER

Run no.	Low Range			High Range		
	1	2	3	1	2	3
	µmol/L			µmol/L		
Nominal	*0.500*			*18.000*		
1	0.480	0.495	0.497	18.363	17.975	17.955
2	0.481	0.496	0.497	18.367	17.984	17.953
3	0.483	0.496	0.498	18.355	17.964	17.941
4	0.481	0.495	0.498	18.369	17.987	17.946
5	0.479	0.496	0.499	18.345	17.957	17.937
6	0.479	0.496	0.501	18.343	17.969	17.941
7	0.481	0.495	0.500	18.360	17.940	17.922
8	0.479	0.495	0.499	18.354	17.967	17.940
9	0.479	0.495	0.500	18.350	17.944	17.917
10	0.478	0.495	0.500	18.367	17.945	17.924
11	0.477	0.495	0.501	18.335	17.931	17.905
12	0.479	0.495	0.499	18.334	17.934	17.892
13	0.478	0.494	0.499	18.341	17.929	17.901
14	0.478	0.495	0.499	18.360	17.919	17.889
15	0.476	0.495	0.500	18.340	17.954	17.930
16	0.475	0.495	0.500	18.337	17.922	17.906
17	0.477	0.496	0.499	18.337	17.934	17.893
18	0.477	0.497	0.500	18.310	17.928	17.895
19	0.484	0.498	0.498	18.309	17.962	17.928
20	0.480	0.498	0.499	18.301	17.919	17.906
Mean	0.479	0.496	0.499	18.344	17.948	17.921
Std. deviation	0.002	0.001	0.001	0.020	0.022	0.022
Coefficient of variation	0.45%	0.21%	0.21%	0.11%	0.12%	0.12%

16.4.2 SEAWATER

Run no.	Low Range			High Range		
	1	2	3	1	2	3
	µmol/L			µmol/L		
Nominal	*0.500*			*2.000*		
1	0.500	0.499	0.499	2.007	1.997	1.995
2	0.501	0.499	0.499	2.009	1.993	1.994
3	0.500	0.499	0.500	2.008	1.992	1.994
4	0.502	0.500	0.500	2.006	1.992	1.988
5	0.501	0.501	0.501	2.005	1.994	1.994
6	0.503	0.500	0.500	2.002	1.991	1.997
7	0.501	0.500	0.501	2.005	1.991	1.995
8	0.501	0.503	0.499	2.006	1.990	1.995
9	0.501	0.499	0.502	2.008	1.988	1.991
10	0.502	0.500	0.499	2.006	1.988	1.993
11	0.501	0.499	0.500	2.005	1.992	1.992
12	0.502	0.499	0.499	2.005	1.991	1.994
13	0.503	0.499	0.501	2.001	1.989	1.996
14	0.503	0.499	0.500	2.003	1.988	1.992
15	0.504	0.499	0.501	2.005	1.987	1.994
16	0.500	0.499	0.501	2.001	1.988	1.987
17	0.502	0.500	0.499	1.995	1.993	1.990
18	0.501	0.497	0.499	1.998	1.982	1.994
19	0.499	0.494	0.497	2.000	1.982	1.994
20	0.499	0.494	0.497	2.006	1.995	1.997
Mean	0.501	0.499	0.500	2.004	1.990	1.993
Std. deviation	0.001	0.002	0.001	0.004	0.004	0.003
Coefficient of variation	0.28%	0.40%	0.25%	0.18%	0.19%	0.13%

16.5 REPRODUCIBILITY – VARYING CONCENTRATION

Reproducibility is checked by running 10 replicates of five different standards in pseudo-random order. Three runs are performed on three different days. Baseline, sensitivity drift and carryover correction are applied.

16.5.1 WATER

	Low Range				**High Range**			
		1	**2**	**3**		**1**	**2**	**3**
Group	Nominal concentration µmol/L	Standard deviation in µmol/L			Nominal concentration µmol/L	Standard deviation in µmol/L		
1	1.000	0.002	0.001	0.003	36.000	0.024	0.057	0.037
2	0.750	0.003	0.002	0.004	27.000	0.023	0.039	0.025
3	0.500	0.003	0.002	0.002	18.000	0.024	0.011	0.012
4	0.250	0.003	0.002	0.002	9.000	0.015	0.025	0.021
5	0.000	0.002	0.002	0.002	0.000	0.010	0.017	0.007
Pooled SD		0.002	0.002	0.003	Pooled SD	0.020	0.034	0.023

16.5.2 SEAWATER

	Low Range				**High Range**			
		1	**2**	**3**		**1**	**2**	**3**
Group	Nominal concentration µmol/L	Standard deviation in µmol/L			Nominal concentration µmol/L	Standard deviation in µmol/L		
1	1.000	0.001	0.002	0.002	4.000	0.004	0.005	0.005
2	0.750	0.002	0.001	0.001	3.000	0.005	0.007	0.004
3	0.500	0.001	0.001	0.002	2.000	0.003	0.005	0.002
4	0.250	0.001	0.001	0.002	1.000	0.003	0.006	0.003
5	0.000	0.001	0.001	0.002	0.000	0.003	0.003	0.003
Pooled SD		0.001	0.001	0.001	Pooled SD	0.004	0.005	0.003

16.6 DETECTION LIMIT DATA (EPA SPIKE METHOD)

The detection limit MDL_S is determined from replicates of spikes. Three runs are performed on three different days. Baseline and sensitivity drift are applied. The detection limit is calculated by multiplying the standard deviation of the replicates by the student factor for 10 replicates (T = 2.821).

16.6.1 WATER

Run no.	Low Range			High Range		
	1	2	3	1	2	3
	µmol/L			µmol/L		
Nominal	*0.020*			*0.720*		
1	0.014	0.017	0.019	0.482	0.597	0.653
2	0.014	0.017	0.017	0.480	0.598	0.652
3	0.014	0.017	0.017	0.479	0.597	0.650
4	0.014	0.018	0.017	0.480	0.596	0.647
5	0.015	0.018	0.019	0.480	0.597	0.646
6	0.013	0.017	0.015	0.476	0.597	0.647
7	0.014	0.015	0.014	0.476	0.594	0.650
8	0.013	0.013	0.015	0.476	0.593	0.647
9	0.014	0.013	0.013	0.474	0.591	0.644
10	0.012	0.012	0.015	0.475	0.590	0.642
Mean	0.014	0.016	0.016	0.478	0.595	0.648
Std. deviation	0.001	0.002	0.002	0.003	0.003	0.003
Detection Limit	0.002	0.006	0.006	0.008	0.008	0.009

16.6.2 SEAWATER

Run no.	Low Range			High Range		
	1	2	3	1	2	3
	µmol/L			µmol/L		
Nominal	*0.020*			*0.080*		
1	0.024	0.022	0.023	0.073	0.117	0.063
2	0.025	0.021	0.023	0.075	0.116	0.063
3	0.026	0.020	0.023	0.073	0.115	0.064
4	0.024	0.022	0.022	0.072	0.113	0.065
5	0.024	0.020	0.023	0.072	0.115	0.064
6	0.024	0.020	0.023	0.071	0.115	0.062
7	0.026	0.020	0.023	0.073	0.116	0.063
8	0.025	0.019	0.022	0.073	0.116	0.063
9	0.025	0.019	0.022	0.071	0.114	0.064
10	0.024	0.020	0.023	0.071	0.112	0.064
Mean	0.025	0.020	0.023	0.072	0.115	0.064
Std. deviation	0.001	0.001	0.001	0.001	0.001	0.001
Detection Limit	0.002	0.003	0.001	0.003	0.004	0.002

16.7 DETECTION AND REPORTING LIMIT DATA (EPA BLANK METHOD)

The detection limit MDL_b is determined from replicates of blanks. Three runs are performed on three different days. Baseline and sensitivity drift are applied. The detection limit is calculated by multiplying the standard deviation of the blanks by the student factor for 10 replicates (T = 2.821) and adding the mean value, if it is positive.

16.7.1 WATER

Run no.	Low Range			High Range		
	1	2	3	1	2	3
	µmol/L			µmol/L		
1	0.008	-0.002	0.002	-0.276	-0.135	-0.075
2	0.007	-0.002	0.000	-0.278	-0.138	-0.081
3	0.005	-0.002	0.000	-0.280	-0.138	-0.081
4	0.005	-0.003	0.000	-0.281	-0.141	-0.080
5	0.005	-0.003	0.000	-0.283	-0.141	-0.082
6	0.004	-0.003	0.001	-0.284	-0.143	-0.083
7	0.004	-0.002	-0.001	-0.285	-0.144	-0.084
8	0.003	-0.003	-0.001	-0.286	-0.146	-0.085
9	0.004	-0.003	-0.001	-0.287	-0.144	-0.083
10	0.003	-0.002	0.000	-0.287	-0.145	-0.082
Mean	0.005	-0.002	0.000	-0.283	-0.142	-0.082
Std. deviation	0.002	0.001	0.001	0.004	0.004	0.003
Detection Limit	0.004	0.001	0.003	0.011	0.010	0.008

16.7.2 SEAWATER

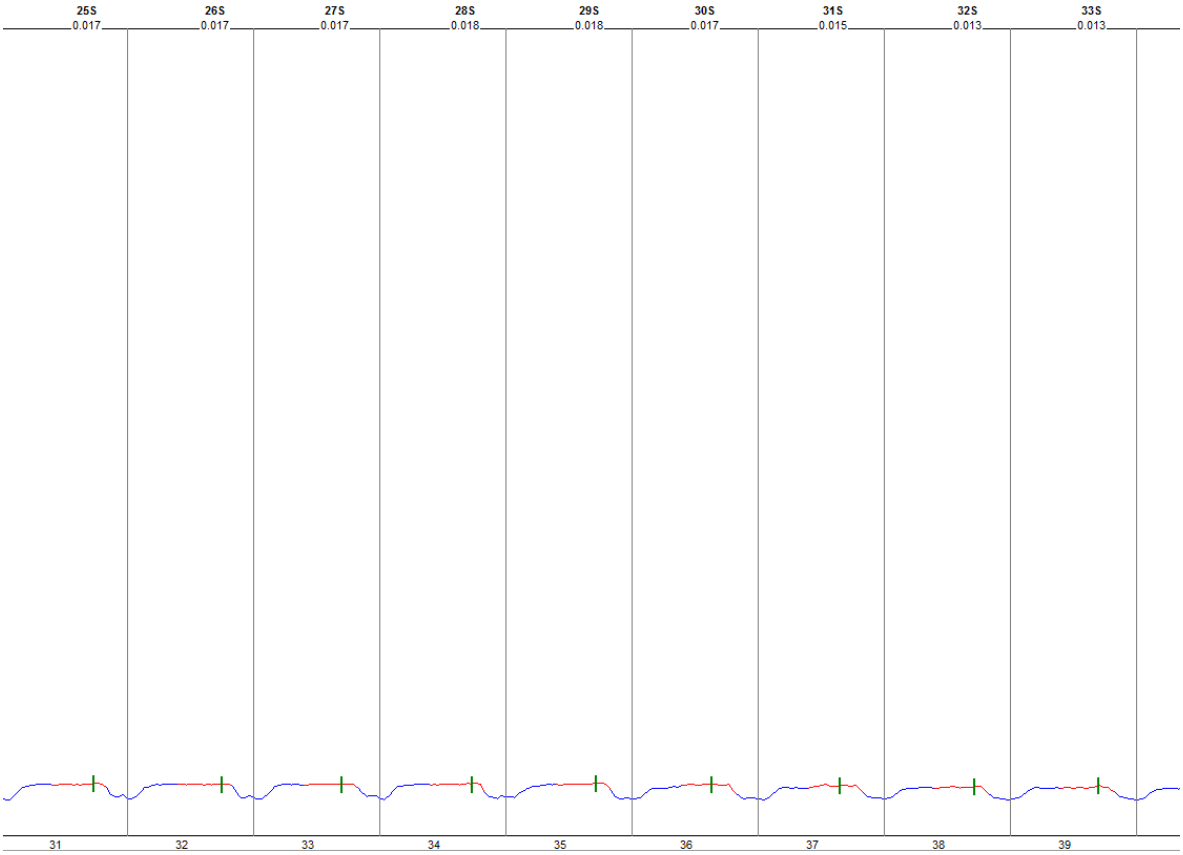
Run no.	Low Range			High Range		
	1	2	3	1	2	3
	µmol/L			µmol/L		
1	0.007	0.006	0.005	0.004	-0.001	-0.014
2	0.008	0.006	0.006	0.004	-0.002	-0.014
3	0.008	0.005	0.006	0.003	-0.004	-0.013
4	0.008	0.004	0.007	0.000	-0.003	-0.013
5	0.008	0.003	0.005	-0.001	-0.003	-0.016
6	0.007	0.002	0.004	0.000	0.000	-0.015
7	0.006	0.002	0.005	0.000	-0.002	-0.015
8	0.005	0.001	0.004	-0.002	-0.002	-0.016
9	0.006	0.002	0.005	-0.001	-0.002	-0.015
10	0.004	0.002	0.004	-0.002	-0.003	-0.014
Mean	0.007	0.003	0.005	0.001	-0.002	-0.015
Std. deviation	0.001	0.002	0.001	0.002	0.001	0.001
Detection Limit	0.004	0.005	0.003	0.006	0.003	0.003

16.8 OTHER METHOD DATA AND SETTINGS

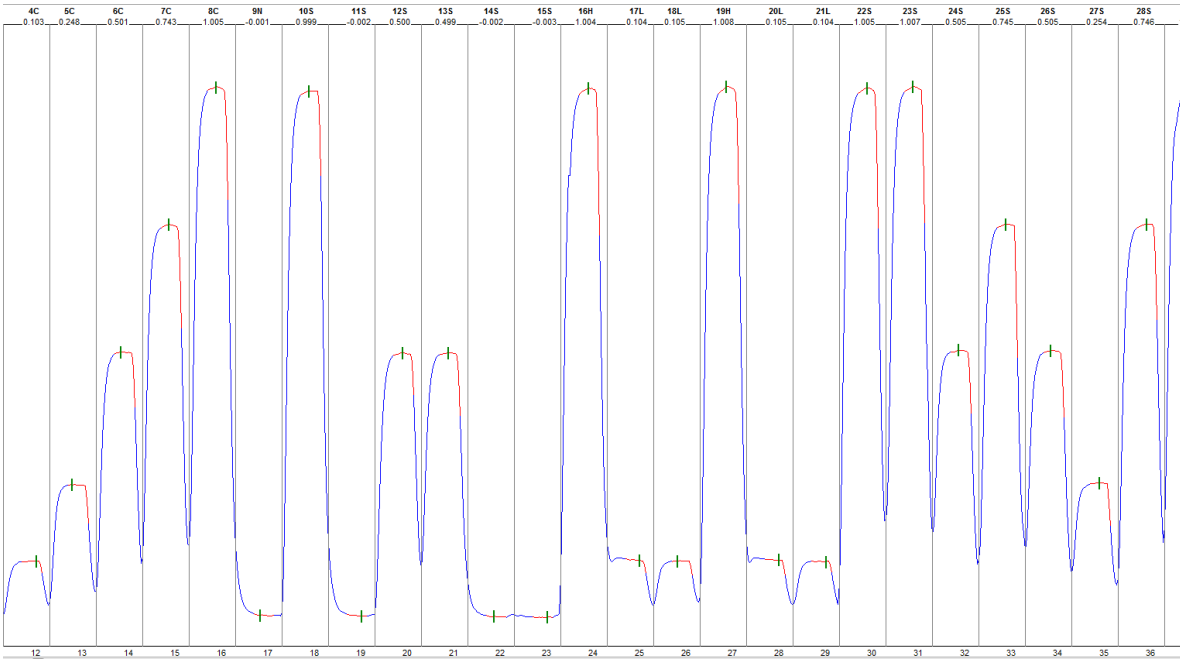
Parameter	Value	Notes
Lag time	8 min	Time between sample cup and detector. Depends on number of channels in use.
Carryover	0.1 – 0.3%	See AACE manual for calculation.
Reagent absorbance	0.01 AU	See AACE manual for how reagent absorbance is calculated.
Smoothing	none	See AACE manual for further information.

16.9 TYPICAL PEAK SHAPES

16.9.1 WATER – LOW RANGE

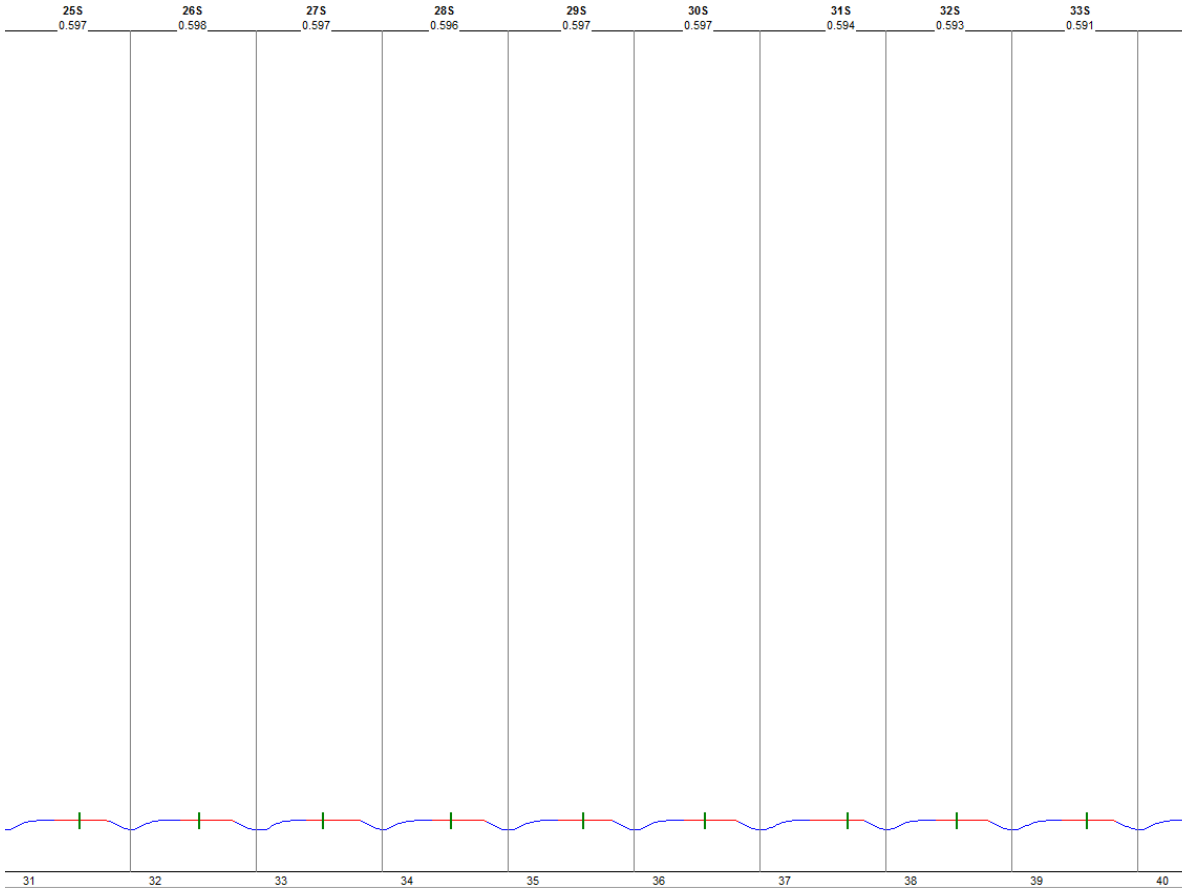


Low range: Spike replicates at 0.020 µmol/L (expanded view)

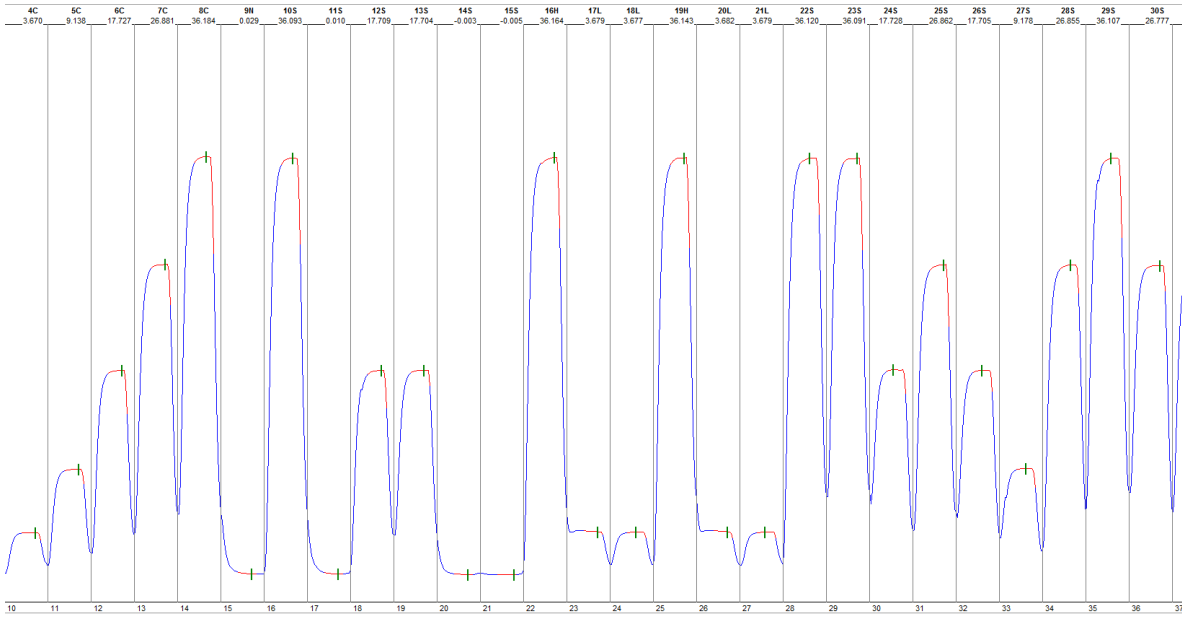


Low range: Excerpt from a test run at 5 concentrations

16.9.2 WATER – HIGH RANGE

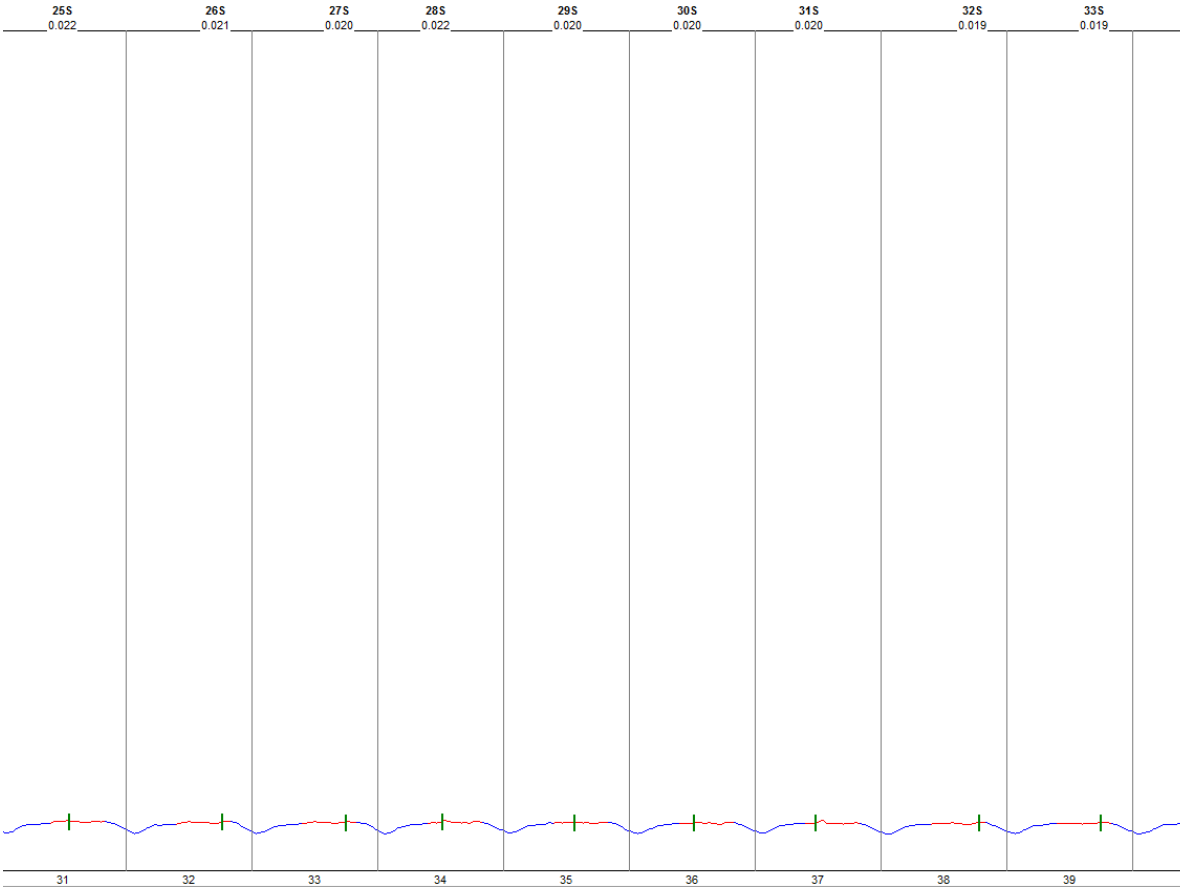


High range: Spike replicates at 0.720 µmol/L (expanded view)

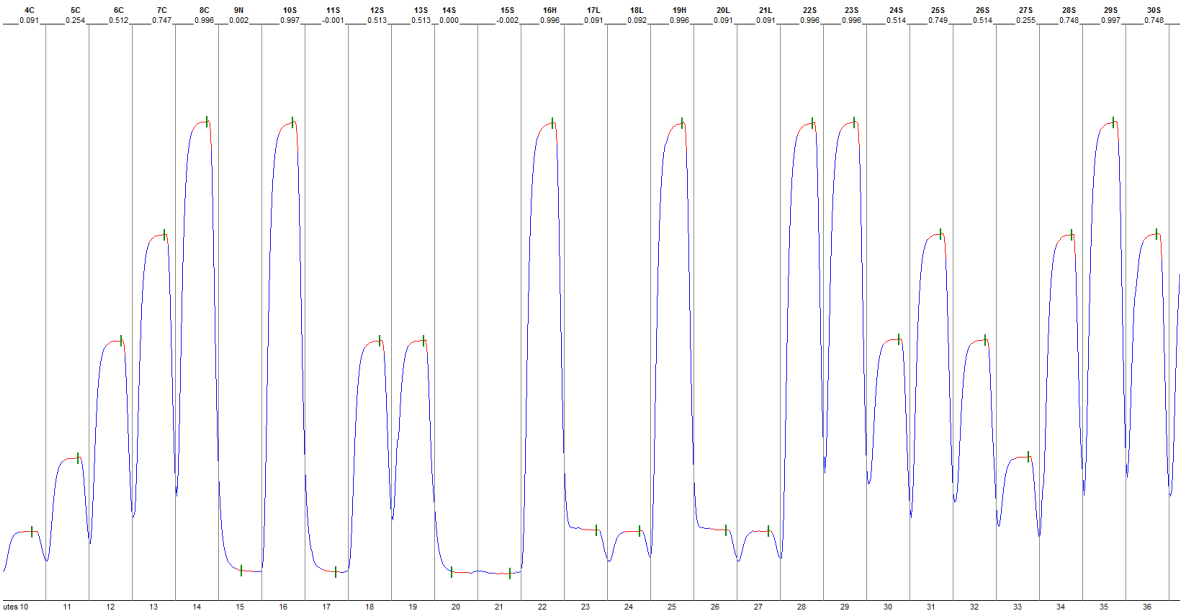


High range: Excerpt from a test run at 5 concentrations

16.9.3 SEAWATER – LOW RANGE

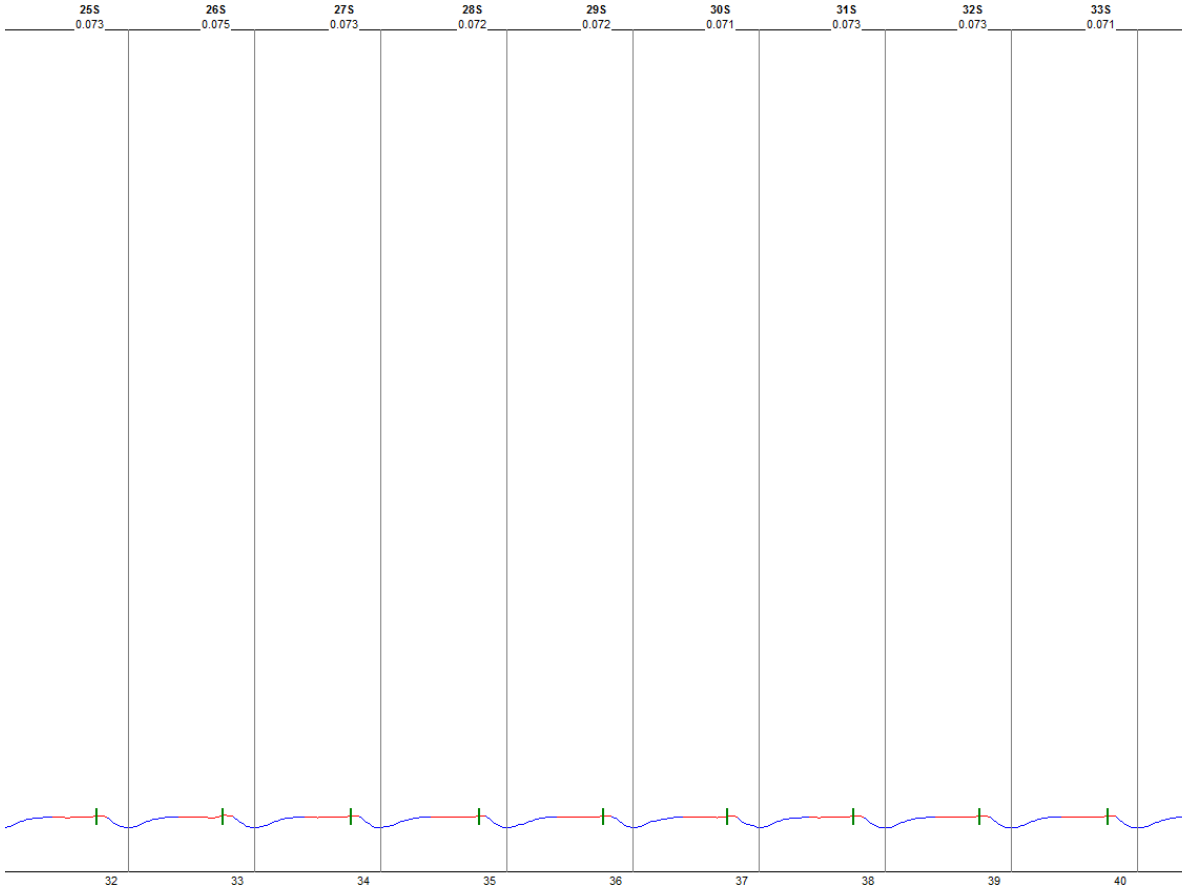


Low range: Spike replicates at 0.020 µmol/L (expanded view)

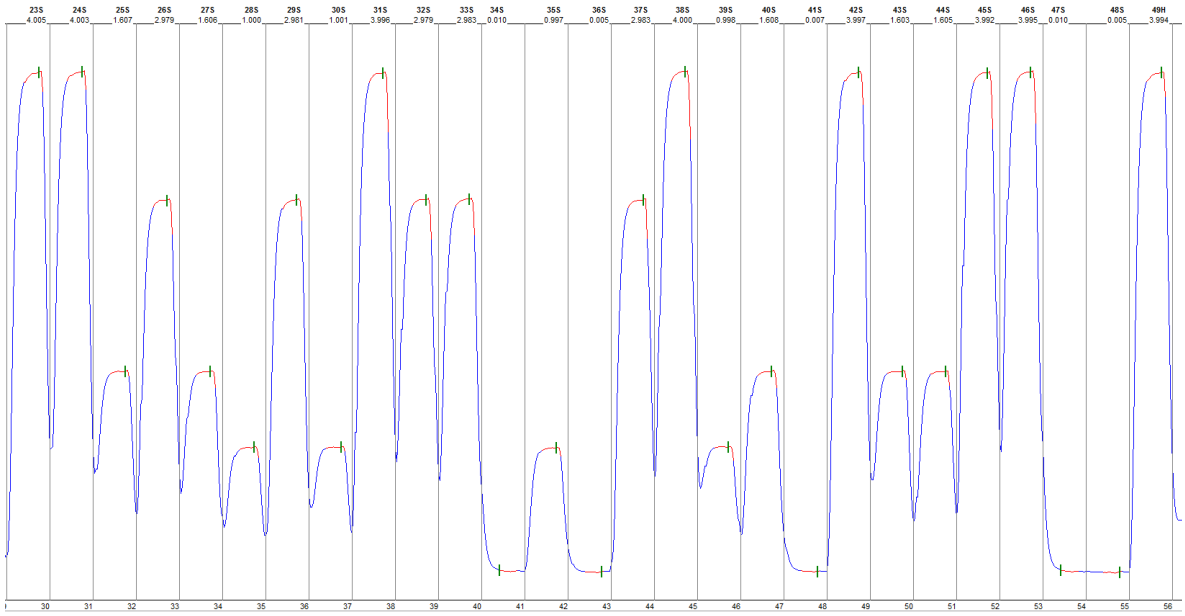


Low range: Excerpt from a test run at 5 concentrations

16.9.4 SEAWATER – HIGH RANGE



High range: Spike replicates at 0.080 µmol/L (expanded view)



High range: Excerpt from a test run at 5 concentrations

17 REVISIONS

Revision	Date	Changes
0	Nov. 2018	New method
1	May 2019	De/rebubbler changed from ad to cx. Parts list and flowcharts updated.
2	March 2020	Logo updated, Ranges updated, Reagent line tubings changed, Parts List and Flowchart updated
3	March 2021	Flowchart and Parts list updated.
4	August 2021	Air valves tube changed. Consumables list and flowchart updated.

18 PARTS LIST

Only use genuine SEAL parts and consumables with the SEAL logo or the “SEAL Tec” stamp on the package or the part itself. Performance cannot be guaranteed if parts from other sources are used and warranty might be lost If repairs are carried out with non-genuine spare parts or by unauthorized personnel.

18.1 CONSUMABLES KIT – 12 MONTHS

Description	Legend	Part Number	Kit Contend
ORN/GRN, 0.10 ml/min		116-0549-04	2 pkg / 12
ORN/YEL, 0.16 ml/min		116-0549-05	1 pkg / 12
BLK/BLK, 0.32 ml/min		116-0549-07	2 pkg / 12
WHT/WHT, 0.60 ml/min		116-0549-09	1 pkg / 12
BLU/BLU, 1.60 ml/min		116-0549-13	1 pkg / 12
Tubing Norprene	PM07	117+0540-07	2.4 m

18.2 ADDITIONAL TUBINGS

Description	Legend	Part Number	Sales Unit
Tubing PE	PE02	562-2002-01	1 m
Tubing PE	PE15	562-2015-01	1 m
Tubing Tygon	T06	178-3993-06	1 m
Tubing Tygon	T11	116-0536-11	1 m
Tubing Tygon	T16	116-0536-16	1 m
Tubing reagent small, clear	R01S	116+1101-01	1 m
Tubing reagent small, red	R02S	116+1101-02	1 m

18.3 SPARES KIT

Description	Legend	Part Number	Kit Contend
Injection fitting 3 pt.	a	116-0489-01	1 pc
Coil 10 turns	10TM	163+G001-10	1 pc
Coil 10 turns+ Pt Nipple	10TM+PT	163+G003-10	1 pc
Glass tubing, l = 25 mm	c	116-G004-01	1 pc
Glass tubing l = 44 mm	d	116-G004-02	1 pc
Connector T	A10	116-B034-01	1 pc
Glass tubing, HB in/out	cl	163+G020-01	1 pc
De/rebubbler	cx	163+G035-03	1 pc
Nipple N5	N5	116-0002-01	6 pcs
Nipple N8	N8	116-0003-01	6 pcs
Nipple N7	N7	116-0005-01	6 pcs
Nipple R13	R13	116+B152-01	6 pcs

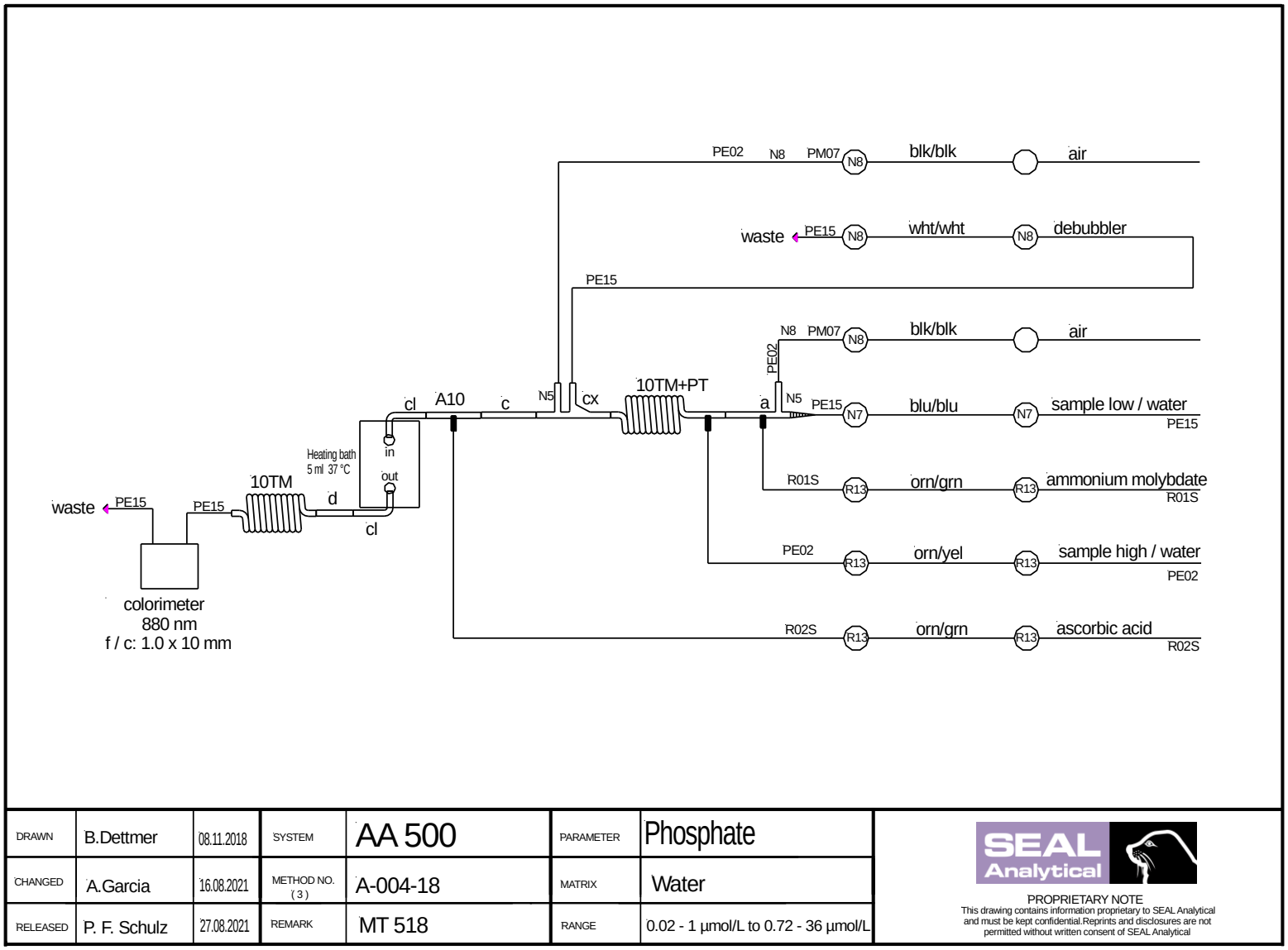
18.4 PHOTOMETER PARTS

Description	Legend	Part Number	Sales Unit
Flowcell 10 mm		169+B045-10	1 pc
Optic Assy 10 mm		161+B650-10	1 pc
Illumination LED, 880 nm		161+B661-88	1 pc
Glass coil 7 turns		161+G500-01	1 pc

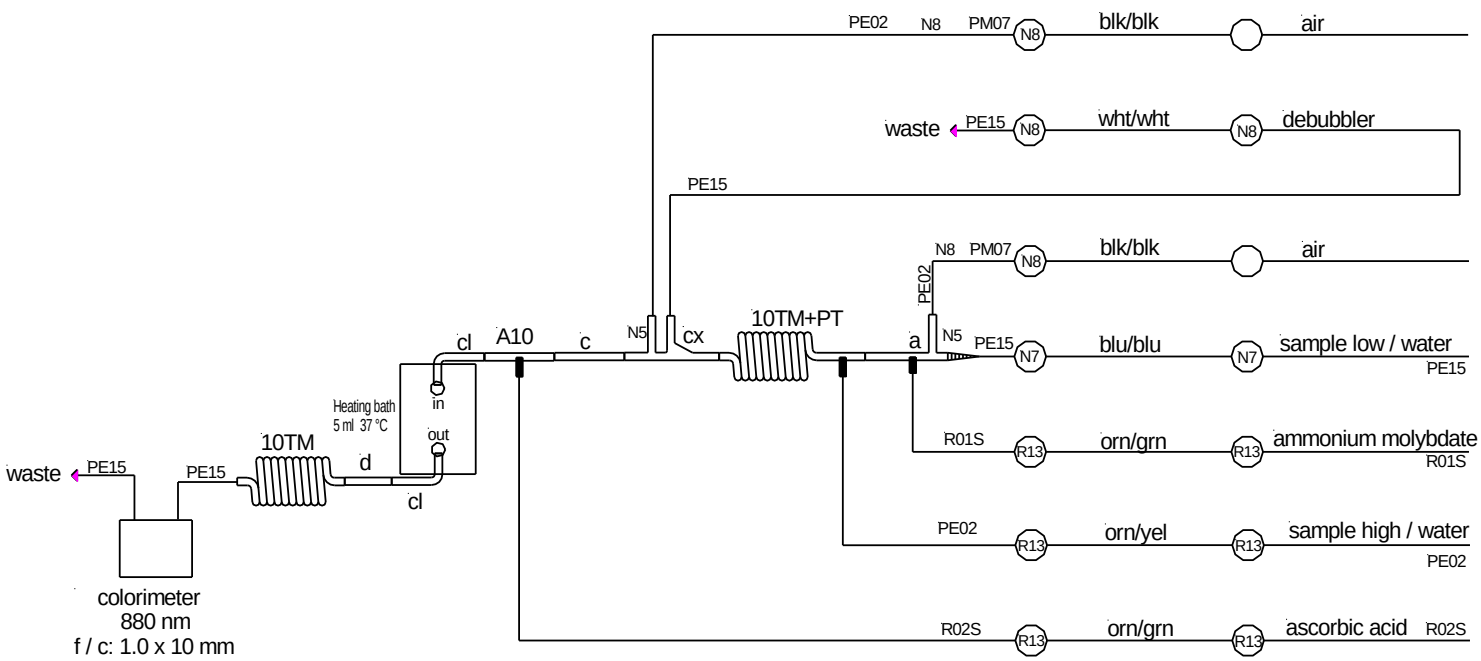
18.5 OTHER SPECIAL PARTS

Description	Legend	Part Number	Sales Unit
Coil Assy, 13 turns (5 ml), fix		163+B410-11	1 pc

19 FLOWCHART



DRAWN	B.Dettmer	08.11.2018	SYSTEM	AA 500	PARAMETER	Phosphate	SEAL Analytical
CHANGED	A.Garcia	16.08.2021	METHOD NO. (3)	A-004-18	MATRIX	Water	
RELEASED	P. F. Schulz	27.08.2021	REMARK	MT 518	RANGE	0.02 - 1 µmol/L to 0.72 - 36 µmol/L	



DRAWN	B.Dettmer	08.11.2018	SYSTEM	AA 500	PARAMETER	Phosphate
CHANGED	A.Garcia	16.08.2021	METHOD NO. (4)	A-004-18	MATRIX	Seawater
RELEASED	P. F. Schulz	27.08.2021	REMARK	MT 518	RANGE	0.02 - 1 µmo/L to 0.08 - 4 µmol/L

SEAL Analytical

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