

Sievers InnovOx Laboratory Total Organic Carbon (TOC) Analyzer — How Low Can You Go?

GE Analytical Instruments has developed an innovative laboratory TOC analysis technology based on Supercritical Water Oxidation (SCWO). Introduced in the new Sievers InnovOx Laboratory Total Organic Carbon (TOC) Analyzer, the SCWO technique is ultra efficient. It enables the InnovOx to run hundreds of difficult samples continuously with no recalibration, no system maintenance, and no replacement parts.

With any new technology, scientists want to know its detection and measurement capabilities. One of their most commonly asked questions is, “How low can you go?” The analytical instrument community interprets this very vague question in many different ways. This application note will help differentiate the terminology often used and apply it to the InnovOx’s performance ability. The three terms covered include Method Detection Limit (MDL), Limit of Detection (LOD), and Limit of Quantification (LOQ). All three specifications are based on the standard deviation achieved when analyzing ultrapure water. The standard deviation achieved from our tests was 0.0126 ppm. To exemplify the capabilities of the InnovOx, all laboratory conditions were optimized to achieve the best possible data for this demonstration.

Operating Conditions for InnovOx

Measure Mode	NPOC (non-purgable organic carbon)
Calibration Range	0-1000 ppm
Acid	1% of sample volume

Oxidizer	0% of sample volume
Repetitions	20 analyses
Spurge Time	0.83 minutes
Blank Correction	On
Manual Dilution	1:1
Carrier Gas	CO ₂ free cylinder gas
Water Source	Continuous stream from ultra-pure water system

Method Detection Limit (MDL)

The Method Detection Limit (MDL) is sometimes confused with minimal detection limit or limit of detection (LOD). The method detection limit is generally described as a detector response that can be differentiated from background noise. In other words, an MDL is the lowest amount of a compound of interest that can be detected but not necessarily quantitated with any degree of reliability. As a general rule, that value equals the standard deviation. The MDL depends on the equipment, chemicals, methodology, materials, sample composition and even the analysts involved. The MDL for the InnovOx follows:

Standard Deviation ppm	MDL ppm
0.0126	0.013

Limit of Detection (LOD)

Simply stated, the Limit of Detection (LOD) is the lowest concentration for which analysis is feasible. Feasible



can be defined as a result being statistically different from a blank. LOD is sometimes called sensitivity. This is a misnomer since an LOD value has some degree of confidence. As a general rule, this value is three times the standard deviation above the measured average blank signal. The LOD calculation can be taken from three times the noise achieved when analyzing a blank. The Reagent Water, or blank, that we used had a standard deviation of 0.0126 ppm. Three times this value equals an LOD of 0.038 ppm.

Standard Deviation ppm	LOD ppm
0.0126	0.04

Limit of Quantification (LOQ)

The LOQ is defined as the lowest concentration for which quantitative results may be obtained. The corresponding LOQ is recommended to be ten standard deviations above the blank, which corresponds to a 99% confidence level.

Ten times the standard deviation of the blank equals an LOQ of 0.13 ppm.

Standard Deviation ppm	LOQ ppm
0.0126	0.13

System Performance

The following data demonstrate the InnovOx's performance at low concentrations with associated

Concentration	Average ppm	Std. Dev. ppm	Relative Std. Dev. ppm
Reagent Water	0.06	0.01	18.20%
0.1 ppm	0.11	0.02	20.10%
0.25 ppm	0.26	0.03	12.40%
0.50 ppm	0.45	0.05	11.20%
0.75 ppm	0.78	0.04	5.00%
1.0 ppm	1	0.01	1.20%
10 ppm	11	0.06	0.50%

standard deviations and percent relative standard deviations. This performance has been optimized for exclusive low-level use. For example, if the sample concentration were around 0.75 ppm, the expected RSD achieved by the InnovOx would be around 5%.

InnovOx Methodology

The Sievers InnovOx's principle of operation is based on the wet chemical oxidation technique, which adds an acid and oxidizer to the sample of interest. The inorganic carbon is removed by purging, and the sample is then oxidized with persulfate at elevated temperatures. The resultant carbon dioxide is measured by a nondispersive infrared spectrometer.

The Sievers InnovOx elevates the temperature of the sample and reagent mixture to ensure efficient oxidation and to convert the liquid water sample into supercritical water. Once in this phase, a phenomenon called Supercritical Water Oxidation (SCWO) occurs. This innovation achieves greater than 99% efficient oxidation, resulting in superior accuracy and precision.

SCWO also can remove problematic sample matrix contamination at the end of every analysis. As a result, no salt or oxidation by-product build up in the reactor, tubing, or valves.

Conclusion

To answer the question, "How low can you go?," it is important to know the true scientific meaning of the acronyms MDL, LOD, and LOQ. Based on this information and testing, the InnovOx has been demonstrated to reach the low performance limits shown below.

MDL 0.01 ppm	LOD 0.04 ppm	LOQ 0.13 ppm
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The Americas
GE Analytical Instruments
6060 Spine Road
Boulder, CO 80301-3687 USA
T +1 800 255 6964
T +1 303 444 2009
F +1 303 527 1797
geai@ge.com

Europe/Middle East/Africa
GE Analytical Instruments
Unit 3, Mercury Way
Urmston, Manchester
UK M41 7LY
T +44 (0) 161 864 6800
F +44 (0) 161 864 6829
geai.europe@ge.com

Asia Pacific
GE Analytical Instruments
5 United Plaza
1468 Nanjing Rd (W)
Shanghai 200040
China
T +86 021 3222 4555
geai.asia@ge.com