

ICP-Mass Spectrometry

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The Analysis of Drinking Waters by U.S. EPA Method 200.8 Using the NexION 300D ICP-MS in Standard, Collision and Reaction Modes

Introduction

Method 200.8 is a well-established method promulgated by the U.S. Environmental Protection Agency (EPA) for the analysis of ground waters, surface waters, drinking waters, and wastewaters by inductively coupled plasma mass spectrometry (ICP-MS). The method was first published in 1990 to support the National Primary Drinking Water Regulations (NPDWR), which specified

maximum contaminant levels (MCL) for 12 primary elemental contaminants in public water systems as part of the Safe Drinking Water Act (SDWA) of 1986. There have been many iterations of Method 200.8, including the addition of 9 secondary contaminants under the National Secondary Drinking Water Regulations (NSDWR). These 21 elements, along with suggested analytical masses, are shown in Table 1. The version in use today is Revision 5.4 of the Method, which was approved for drinking water in 1994 and became effective in January, 1995.³ In addition, Method 200.8 was also recommended in 1992 for the monitoring of wastewaters under the National Pollutant Discharge Elimination System (NPDES) permit program to control the discharge of pollutants into navigable water systems, as part of the amended Clean Water Act (CWA) of 1977.⁴ It was approved on a nation-wide basis for this matrix in 2007.

Application Note 3 of 3 – Why?

This is the third of a series of application notes describing the use of an innovative, next-generation ICP mass spectrometer – the NexION 300 – for the determination of 21 primary and secondary contaminants in drinking water samples using U.S. EPA Method 200.8. An overview of this technology will be given, and in particular, how the instrument’s Universal Cell Technology™ (UCT) can be used in either the Standard mode, Collision mode using Kinetic Energy Discrimination (KED), or Reaction mode (Dynamic Reaction Cell – DRC), depending on the severity of interferences presented by the sample matrices and the needs of the user.

The study is separated into three different application notes. Because collision/reaction cell technology is not currently permitted for the analysis of drinking water using Method 200.8, the first application note (The Analysis of Drinking Waters by U.S. EPA Method 200.8 using the NexION 300Q ICP-MS in Standard Mode) focuses on the use of the NexION 300Q in Standard mode using only the correction equations described in the method to minimize matrix-based polyatomic interference.¹ In anticipation of the method eventually allowing the use of collision/reaction cell technology for drinking water, the second application note (The Analysis of Drinking Waters by U.S. EPA Method 200.8 Using the NexION 300X ICP-MS in Standard and Collision Modes) describes a method using both the Standard and Collision (KED) modes (using helium gas) with a NexION 300X,² while this third application note in the series provides an overview of how the NexION 300D using all three modes – Standard, Collision (KED) and Reaction (DRC) (using ammonia gas) – can be utilized in one multielement method to achieve the optimum performance for this analysis.



Table 1. The complete list of elements defined in Method 200.8 with recommended analytical masses.

Analyte	Symbol	Recommended Mass (amu)
Beryllium	Be	9
Aluminum	Al	27
Vanadium	V	51
Chromium	Cr	52
Manganese	Mn	55
Cobalt	Co	59
Nickel	Ni	60
Copper	Cu	63
Zinc	Zn	66
Arsenic	As	75
Selenium	Se	78
Molybdenum	Mo	98
Silver	Ag	107
Cadmium	Cd	111
Antimony	Sb	121
Barium	Ba	137
Mercury	Hg	202
Thallium	Tl	205
Lead	Pb	206, 207, 208
Thorium	Th	232
Uranium	U	238
Sodium*	Na	23
Magnesium*	Mg	24
Potassium*	K	39
Calcium*	Ca	40
Iron*	Fe	56

Note: Elements marked with an asterisk () are included for information only.*

Several additional masses must be monitored, but not quantified, according to the U.S. EPA Method 200.8.³

Method 200.8 is a general analytical method that not only recommends procedures for selecting analyte masses, instrument tuning and calibration, and interference corrections, but also provides specific instructions concerning sample collection, preservation, and treatment. In addition, Method 200.8 also requires a specific set of quality assurance/control protocols to be run along with samples to ensure the quality of the data obtained. Method 200.8 is an exhaustive compendium of information which has been successfully used for the determination of trace elements in environmental samples for the past 17 years.

It is therefore important that new instrumentation demonstrate the ability to meet the requirements of existing and potential new methodology, through the initial demonstration of performance and ongoing quality control procedure requirements. With this in mind, the NexION 300, a next-generation ICP-MS, was evaluated for the analysis of drinking water samples, and in particular to get a better understanding of how it performs under the extreme demands of a high sample workload, which is typical of many laboratories carrying out environmental monitoring, both in the U.S. and around the world.

Instrumentation

For this study, the NexION® 300D (PerkinElmer Inc., Shelton, CT) was used for the determination of all the elements defined in Method 200.8. The instrument has been described in the literature,⁵ but it's worth explaining that besides the Standard mode, this version does have collision and reaction cell capabilities. For this study, the instrument was used in all three modes – Standard mode, Collision mode and Reaction mode (Dynamic Reaction Cell – DRC) configurations. The choice of what mode to use was dictated by the severity of the polyatomic interferences on each of the analytes. No elemental corrections for polyatomic interferences were used. For those not familiar with the Universal Cell Technology, a brief description of the three modes of analysis is given in the call-out box on this page.

The objective of this particular application note was therefore to evaluate the capability of the instrument in the Standard mode, the Collision mode using helium gas and the Reaction mode using ammonia gas, for the analysis of drinking water, using the operating parameters shown in Table 2.

Table 2. ICP-MS instrumental operating conditions.

Component/Parameter	Type/Value/Mode
Nebulizer	Meinhard® glass microconcentric
Spray Chamber	Glass cyclonic
Triple Cone Interface Material	Nickel/Aluminum
Plasma Gas Flow	16.0 L/min
Auxiliary Gas Flow	1.2 L/min
Nebulizer Gas Flow	1.00 – 1.05 L/min
Sample Uptake Rate	250 µL/min
RF Power	1600 W
Integration Time	500 – 1500 ms
Replicates per Sample	3
Mode of Operation	Standard, Collision (using He gas), and Reaction (using NH ₃)

NexION 300 ICP-MS Configurations and Capabilities

The NexION 300 ICP-MS is available in four different instrumental configurations. The 300Q version does not contain a collision/reaction cell and can only be used in the Standard mode, while the NexION 300X, 300D and 300S instruments all come with the Universal Cell installed. The 300X version has the ability to use one reaction/collision gas, while the 300D and 300S versions have the flexibility to use two reaction/collision gases. The 300S version is also intended for applications that require the highest performance and sensitivity, such as those found in the semiconductor industry. The NexION's three modes of operation include:

Standard Mode: The cell is actively vented to remove residual gases. This enables the instrument to be run in true Standard mode, with the cell conditions turned off. This means the instrument doesn't suffer from decreased sensitivity encountered with passively vented systems, which are forced to use KED even in standard mode because of potential interferences, and as a result, are limited to using only a single collision gas. In this mode, the instrument is effectively a standard ICP-MS system with the collision cell turned off.

Collision Mode using KED: In this mode, the instrument offers conventional collision cell capability using Kinetic Energy Discrimination (KED). By using a non-reactive gas, such as helium, Collision mode removes many of the simple solvent- and argon-based polyatomic spectral interferences, which makes it ideal for semi-quantitative analyses, environmental sample monitoring, and the testing of unknown samples. It offers the ideal combination of performance and simplicity for straight-forward sample matrices.

Reaction Mode using DRC: Universally recognized as the technique that offers the ultimate detection capability, the instrument's true Reaction mode, using Dynamic Reaction Cell (DRC) technology, removes any and all interferences with little or no loss of analyte sensitivity. Unlike collision cells, DRC technology features a scanning quadrupole that removes all interferences created by reactions in the Universal Cell, which enables any reactive gas to be used. And by optimizing the cell's quadrupole conditions, only the element of interest is allowed to pass through to the analyzing quadrupole. It is well recognized that ion-molecule reaction chemistry offers the very best performance for the reduction of complex polyatomic spectral interference.⁶

200.8 Methodology

It is not the intent of this investigation to go into great detail about Method 200.8 and what is involved in carrying out the full analytical procedure, because an application note describing this method using previous ICP-MS technology has been available since 2008.⁷ However, before a suite of samples can be analyzed, a set of protocols must be followed to ensure the instrument is working at its optimum performance. A summary of Method 200.8's analytical protocol is shown below.

- Ignite plasma, allow 30 minutes to warm up
- Optimize instrument, as per instrument manufacturer's instructions
- Perform mass calibration check – adjust if change is > 0.1 amu
- Perform resolution check – adjust if > 0.75 amu at 5% peak height
- Calibrate using blank and standards
- Monitor all masses necessary for interference correction
- Screen new samples for relative levels and presence of internal standards
- Run instrument performance evaluation tests:
 - Instrument detection limits (IDLs)
 - Method detection limits (MDLs)
 - Linear dynamic range (LDR)
 - Spike recoveries
 - Long-term stability
- Run quality control samples (QCSs) or standard reference materials (SRMs) such as:
 - High-Purity Standards Trace Metals in Drinking Water (TMDW), both neat and diluted
 - NIST® 1643e
- Run unknown samples (e.g. local tap water)
- Review results of quality control samples for pass/fail criteria

It can be seen that once the instrument has been tuned and optimized for use, results from the performance evaluation tests and the successful analysis of the known reference samples are critical to achieve good accuracy and precision of unknown samples using Method 200.8. For this reason, it is important to compare the performance of the different modes of analysis, especially its polyatomic spectral interference reduction capabilities. This study will therefore emphasize the flexibility of NexION's Universal Cell to use a combination of Standard mode, Collision mode and Reaction mode and in particular the benefits of using the Dynamic Reaction Cell (Reaction mode) for the elements which are recognized as being the most spectrally challenging to determine. For data on the NexION 300's other modes of analysis, please refer to the first application note (The Analysis of Drinking Waters by U.S. EPA Method 200.8 using the NexION 300Q ICP-MS in Standard Mode) on the use of Standard mode¹ and the second application note (The Analysis of Drinking Waters by U.S. EPA Method 200.8 Using the NexION 300X ICP-MS in Standard and Collision Modes) on using both the Standard and Collision modes² for the analysis of drinking water using Method 200.8.

Calibration Standards

The multielement calibration standards made up in 1% nitric acid (HNO₃) used for the evaluation are shown in Table 3.

All tuning and monitoring of internal standards, together with the measurement of additional isotopes for interference correction purposes, were carried out exactly as defined in Method 200.8. Once completed, all the performance tests mentioned in the Method protocol shown earlier were carried out.

Table 3. Calibration standards.

Analytes	Standard 1 (µg/L)	Standard 2 (µg/L)	Standard 3 (µg/L)	Standard 4 (µg/L)
Be, Al, V, Cr, Mn, Co, Ni, Cu, Zn, As, Se, Mo, Ag, Cd, Sb, Ba, Tl, Pb, Th, U, Fe*	1	10	50	100
Hg	0.1	1	5	10
Na*, Mg*, K*, Ca*	100	1000	5000	10000
Internal Standards – ⁴⁵ Sc, ⁷² Ge, ¹⁰³ Rh, ¹¹⁵ In, ¹⁵⁹ Tb	20 – 200 µg/L			

Note: Elements marked with an asterisk () are not included in Method 200.8 – they are for information only.*

Performance Tests

A list of the most important performance tests described in Method 200.8, are listed below:

- Instrument detection limits (IDLs)
- Method detection limits (MDLs)
- Linear dynamic range (LDR)
- Analysis of standard reference materials (SRMs) or quality control samples (QCSs)
- Spike recoveries in typical samples
- Long-term stability of quality control samples

Each of these tests is described in greater detail below.

Instrument Detection Limits

Instrument detection limits (IDLs) were determined using the procedure referenced in Section 3.5 of Method 200.8, which defines the IDL as the concentration of analyte signal which is equal to three times the standard deviation of a series of ten replicate measurements of the calibration blank (1% HNO₃) signal at the selected analytical masses. Results should be in close approximation or better than estimated IDLs stated in Method 200.8.

Method Detection Limits

MDLs were determined using the protocol outlined in Section 9.2.4 of Method 200.8, which states that seven replicate aliquots of the spiked calibration blank (2% HNO₃) should be analyzed, and the MDLs calculated with the following equation:

$$\text{MDL} = (t) X (S)$$

Where:

t = Student's t value for a 99% confidence level and a standard deviation estimate with n-1 degrees of freedom

(t = 3.14 for seven replicates)

S = standard deviation (n-1 degrees of freedom) of the replicate measurements

Different spike concentrations were used to obtain the MDLs, since Method 200.8 specifies that MDL determinations should be made on spikes at levels 2 – 5 times the estimated MDL. Results should be equal to or better than estimated MDLs stated in Method 200.8.

Linear Dynamic Range

Linear calibration ranges were established for each isotope measured according to Section 9.2.2 of Method 200.8. After calibrating the instrument with a blank and the standards listed in Table 3, a series of standards of increasing concentration were analyzed. The LDR was defined as the concentration for which the results (in concentration units) were within ±10% of the true value of the standard. According to Method 200.8, the upper LDR limit should be an observed signal no more than 10% below the level extrapolated from the lower calibration standards.

Analysis of Standard Reference/Quality Control Samples

Accuracy and precision of the method was tested by analyzing two standard reference/quality control samples. For this test, the reference samples analyzed were High-Purity Standards Trace Metals in Drinking Water (TMDW), where spiked additions were analyzed in both the neat and a 10-fold dilution of the sample. In addition, NIST® 1643e "Trace Elements in Water" SRM was analyzed and compared to the certificate values.

Spike Recoveries

Spike recoveries were assessed by making spiked additions of 20 µg/L to a tap water sample from our laboratory. Spike recoveries should be within the Method 200.8 acceptance limits of ±30%.

Long-Term Stability of Quality Control Samples

The QC sample can also be used as the calibration check standard throughout the course of the run, which will allow the long-term stability of the instrument to be assessed over a "typical" working day of over nine hours.

Quality control procedures specified in Section 9.2.3 of Method 200.8 state that a quality control sample (QCS) must be run immediately after calibration and after every ten samples throughout the entire analytical batch of samples. The measured results for the QCS are compared to the true values to determine the percent recoveries. If QCS results are not within ±10% of the true value, the analysis should be terminated, the problem corrected, and the analysis repeated.

Results

The analysis was performed using the analyte isotopes shown in Table 4. Instead of using correction equations specified in Method 200.8, either the Standard mode, Collision mode (with He) or Reaction mode (with NH₃) was used, which was based on our experience of analyzing these types of matrices and dealing with the polyatomic interferences encountered in drinking water samples.

Table 4. Isotopes measured together with selected mode of analysis for Method 200.8 using the NexION 300D ICP-MS.

Analyte	Symbol	Recommended	
		Mass (amu)	Mode
Beryllium	Be	9	Standard
Aluminum	Al	27	Standard
Vanadium	V	51	Reaction
Chromium	Cr	52	Reaction
Manganese	Mn	55	Reaction
Cobalt	Co	59	Collision
Nickel	Ni	60	Collision
Copper	Cu	63	Collision
Zinc	Zn	66	Collision
Arsenic	As	75	Collision
Selenium	Se	78	Reaction
Molybdenum	Mo	98	Standard
Silver	Ag	107	Standard
Cadmium	Cd	111	Collision
Antimony	Sb	121	Standard
Barium	Ba	137	Standard
Mercury	Hg	202	Standard
Thallium	Tl	205	Standard
Lead	Pb	206, 207, 208	Standard
Thorium	Th	232	Standard
Uranium	U	238	Standard
Sodium*	Na	23	Collision
Magnesium*	Mg	24	Reaction
Potassium*	K	39	Reaction
Calcium*	Ca	40	Reaction
Iron*	Fe	56	Collision

Note: Elements marked with an asterisk () are included for information only.*

The IDLs, MDLs, and LDR were measured and the results are shown in Table 5. All analytes in this table are well within the Method guidelines using integration times of 0.5 – 1.5 seconds per mass. It’s also worth emphasizing that the IDLs and MDLs for the elements that benefited from the Dynamic Reaction Cell, such as V, Cr, Mn and Se, were an average of 5 – 7x lower than when the Collision mode was used for these elements in the second application note (Benefits of the NexION 300X ICP-MS System in Standard and Collision Modes for the Analysis of Drinking Waters Using U.S. EPA Method 200.8).² The total measurement time was 2 min 22 sec per sample for all 21 analytes and for the 5 internal standards mandated by the Method.

Table 5. Method 200.8 instrument detection limits (IDLs) and method detection limits (MDLs), together with the linear dynamic range (LDR) using the Standard, Collision (using He) and Reaction (using NH₃) modes of the NexION 300D ICP-MS.

Analyte	IDL (µg/L)	MDL Spike (µg/L)	MDL (µg/L)	Linear Range (mg/L)	Mode
Be	0.0005	0.002	0.0008	50	Standard
Al	0.01	0.05	0.03	100	Standard
V	0.0003	0.002	0.0009	100	Reaction
Cr	0.0009	0.002	0.001	50	Reaction
Mn	0.0009	0.002	0.009	100	Reaction
Co	0.001	0.002	0.002	100	Collision
Ni	0.006	0.01	0.02	50	Collision
Cu	0.004	0.01	0.009	50	Collision
Zn	0.04	0.5	0.1	100	Collision
As	0.015	0.05	0.03	100	Collision
Se	0.03	0.05	0.04	100	Reaction
Mo	0.0006	0.002	0.001	100	Standard
Ag	0.0006	0.002	0.001	100	Standard
Cd	0.005	0.01	0.01	100	Collision
Sb	0.0009	0.002	0.001	100	Standard
Ba	0.0009	0.002	0.002	50	Standard
Hg	0.0003	0.002	0.002	0.05	Standard
Tl	0.0002	0.002	0.0008	50	Standard
Pb	0.0003	0.002	0.0004	50	Standard
Th	0.0002	0.002	0.0006	20	Standard
U	0.0001	0.002	0.0004	20	Standard
Na*	0.03	0.05	0.03	50	Collision
Mg*	0.05	0.5	0.07	50	Reaction
K*	0.2	0.5	0.4	50	Reaction
Ca*	0.03	0.1	0.03	50	Reaction
Fe*	0.06	0.5	0.1	100	Collision

Note: Elements marked with an asterisk () are included for information only.*

The results from a spike recovery study of an undiluted and diluted drinking water standard reference material (High-Purity Standards TMDW) sample are shown in Table 6, while the analysis of the NIST® 1643e standard reference material is shown in Table 7. Finally, spike recovery data for a typical drinking water from our laboratory are shown in Table 8. It can be seen that almost all CRM values are within 10% of the certified values, and all spike recoveries are well within the Method 200.8 criteria of ±30%.

Table 6. Measured values and spike recoveries of trace elements in the High-Purity Standards Trace Metals in Drinking Water (TMDW) SRM using the NexION 300D ICP-MS (data for the neat sample are shown on the left and a 10x dilution of the sample is shown on the right).

Analyte	High-Purity Standards Trace Metals in Drinking Water (Neat)			High-Purity Standards Trace Metals in Drinking Water (10x dilution)			Mode
	Certified Value (µg/L)	Average Measured Value (µg/L)	Recovery (%)	Certified Value (µg/L)	Average Measured Value (µg/L)	Recovery (%)	
Be	20.0	17.55	87.8	20.0	18.71	93.6	Standard
Al	120	117.0	97.5	120	118.0	98.4	Standard
V	30.0	28.14	93.8	30.0	26.31	87.7	Reaction
Cr	20.0	18.60	93.0	20.0	18.69	93.4	Reaction
Mn	40.0	38.61	96.5	40.0	37.61	94.0	Reaction
Co	25.0	24.12	96.5	25.0	24.15	96.6	Collision
Ni	60.0	57.63	96.1	60.0	58.75	97.9	Collision
Cu	20.0	19.15	95.8	20.0	20.63	103.1	Collision
Zn	70.0	66.32	94.7	70.0	67.65	96.6	Collision
As	80.0	78.70	98.4	80.0	77.08	96.4	Collision
Se	10.0	9.28	92.8	10.0	9.48	94.8	Reaction
Mo	100	95.33	95.3	100	90.68	90.7	Standard
Ag	N/C	1.89	-	N/C	1.77	-	Standard
Cd	10.0	9.75	97.5	10.0	9.87	98.7	Collision
Sb	10.0	9.67	96.7	10.0	9.58	95.8	Standard
Ba	50.0	47.98	96.0	50.0	46.23	92.5	Standard
Hg	N/C	<0.002	-	N/C	<0.02	-	Standard
Tl	10.0	9.05	90.5	10.0	9.02	90.2	Standard
Pb	40.0	37.83	94.6	40.0	38.73	96.8	Standard
Th	N/C	<0.0006	-	N/C	<0.006	-	Standard
U	10.0	9.28	92.8	10.0	9.47	94.7	Standard
Na*	6000	5955	99.3	6000	5960	99.3	Collision
Mg*	9000	8999	100.0	9000	9322	103.6	Reaction
K*	2500	2474	99.0	2500	2619	104.8	Reaction
Ca*	35000	34522	98.6	35000	36020	102.9	Reaction
Fe*	100	97.57	97.6	100	99.60	99.6	Collision

Note: Elements marked with an asterisk (*) are included for information only.

N/C = Not Certified

Table 7. Analysis of NIST® 1643e Drinking Water SRM using the NexION 300D ICP-MS.

Analyte	NIST® SRM 1643e Trace Elements in Water			Mode
	Certified Value (µg/L)	Average Measured Value (µg/L)	Recovery (%)	
Be	13.98	12.88	92.1	Standard
Al	141.8	134.9	95.1	Standard
V	37.86	36.81	97.2	Reaction
Cr	20.40	19.54	95.8	Reaction
Mn	38.97	37.02	95.0	Reaction
Co	27.06	25.59	94.6	Collision
Ni	62.41	58.24	93.3	Collision
Cu	22.76	20.98	92.2	Collision
Zn	78.50	72.79	92.7	Collision
As	60.45	55.39	91.6	Collision
Se	11.97	11.44	95.6	Reaction
Mo	121.4	114.8	94.6	Standard
Ag	1.06	1.16	109.5	Standard
Cd	6.57	6.16	93.8	Collision
Sb	58.30	52.85	90.7	Standard
Ba	544.2	493.8	90.7	Standard
Hg	N/C	0.01	-	Standard
Tl	7.445	6.51	87.4	Standard
Pb	19.63	17.70	90.2	Standard
Th	N/C	<0.0006	-	Standard
U	N/C	<0.0004	-	Standard
Na*	20740	19379	93.4	Collision
Mg*	8037	7739	96.3	Reaction
K*	2034	1969	96.8	Reaction
Ca*	32300	30433	94.2	Reaction
Fe*	98.1	91.55	93.3	Collision

Note: Elements marked with an asterisk (*) are included for information only.

N/C = Not Certified

With the accuracy of the instrument established, the long-term stability was assessed by measuring the TMDW QCS sample after every 10 samples throughout a 12-hour analysis. The results are shown in Figure 1. The recovery for all elements is $\pm 8\%$ of the true value over the 12 hours, demonstrating excellent instrumental stability, particularly as the Universal Cell gas is continually being vented to switch between Standard, Collision (using He) and Reaction (using NH₃) modes. The stability data are well within the Method 200.8 guidelines of $\pm 10\%$.

Table 8. Analysis of drinking water found in our laboratory using the NexION 300D ICP-MS.

Local Drinking Water Spike Recovery					
Analyte	Sample Value (µg/L)	Spike Level (µg/L)	Spiked Sample Value (µg/L)	Spike Recovery (%)	Mode
Be	0.04	20.00	20.31	101.4	Standard
Al	37.32	20.00	58.29	104.9	Standard
V	0.26	20.00	18.80	92.7	Reaction
Cr	0.11	20.00	19.59	97.4	Reaction
Mn	2.24	20.00	21.32	95.4	Reaction
Co	0.09	20.00	20.12	100.2	Collision
Ni	0.20	20.00	20.18	99.9	Collision
Cu	111.9	20.00	132.8	104.4	Collision
Zn	3.73	20.00	24.37	103.2	Collision
As	0.74	20.00	21.12	101.9	Collision
Se	0.05	20.00	19.92	99.4	Reaction
Mo	0.36	20.00	20.14	98.9	Standard
Ag	0.10	20.00	19.60	97.5	Standard
Cd	0.03	20.00	19.66	98.2	Collision
Sb	0.07	20.00	20.24	100.8	Standard
Ba	3.73	20.00	23.16	97.1	Standard
Hg	0.03	2.00	1.99	98.3	Standard
Tl	0.08	20.00	19.40	96.6	Standard
Pb	0.33	20.00	20.20	99.3	Standard
Th	0.05	20.00	19.37	96.6	Standard
U	0.16	20.00	19.30	95.7	Standard
Na*	3499	2000	5501	100.1	Collision
Mg*	283	2000	2351	103.4	Reaction
K*	215	2000	2280	103.3	Reaction
Ca*	3608	2000	5652	102.2	Reaction
Fe*	61.97	20.00	83.16	105.9	Collision

Note: Elements marked with an asterisk (*) are included for information only.

Conclusions

The evaluation has clearly demonstrated that the NexION 300D ICP-MS system is well-equipped to handle the real-world demands of U.S. EPA Method 200.8 for the analysis of drinking water samples. It has shown that by having the flexibility to use all three modes to minimize or remove interferences, the method IDLs and MDLs can be met with ease. In fact, of the analytes that benefited from Reaction mode conditions, the detection limits were approximately 5 – 7 lower than when the Collision mode was used for those

elements. It has also been shown that the analytical accuracy of reference materials is excellent, together with the spike recoveries in real-world drinking water samples. However, of all the Method 200.8 performance tests, the instrument's drift characteristics stand out. It shows that for a 12-hour stability test, analyte signals change by less than $\pm 8\%$ from their original concentrations, which is absolutely critical to meet the long-term stability requirements of environmental labs carrying out the high-throughput analysis of drinking water samples. This deserves particular mention, because the Universal Cell is continually being switched between Standard, Collision and Reaction modes for the suite of elements being determined. For an evaluation of the instrument's capability using the other modes for the analysis of drinking water using Method 200.8, please refer to the first two application notes in the series.^{1,2}

References

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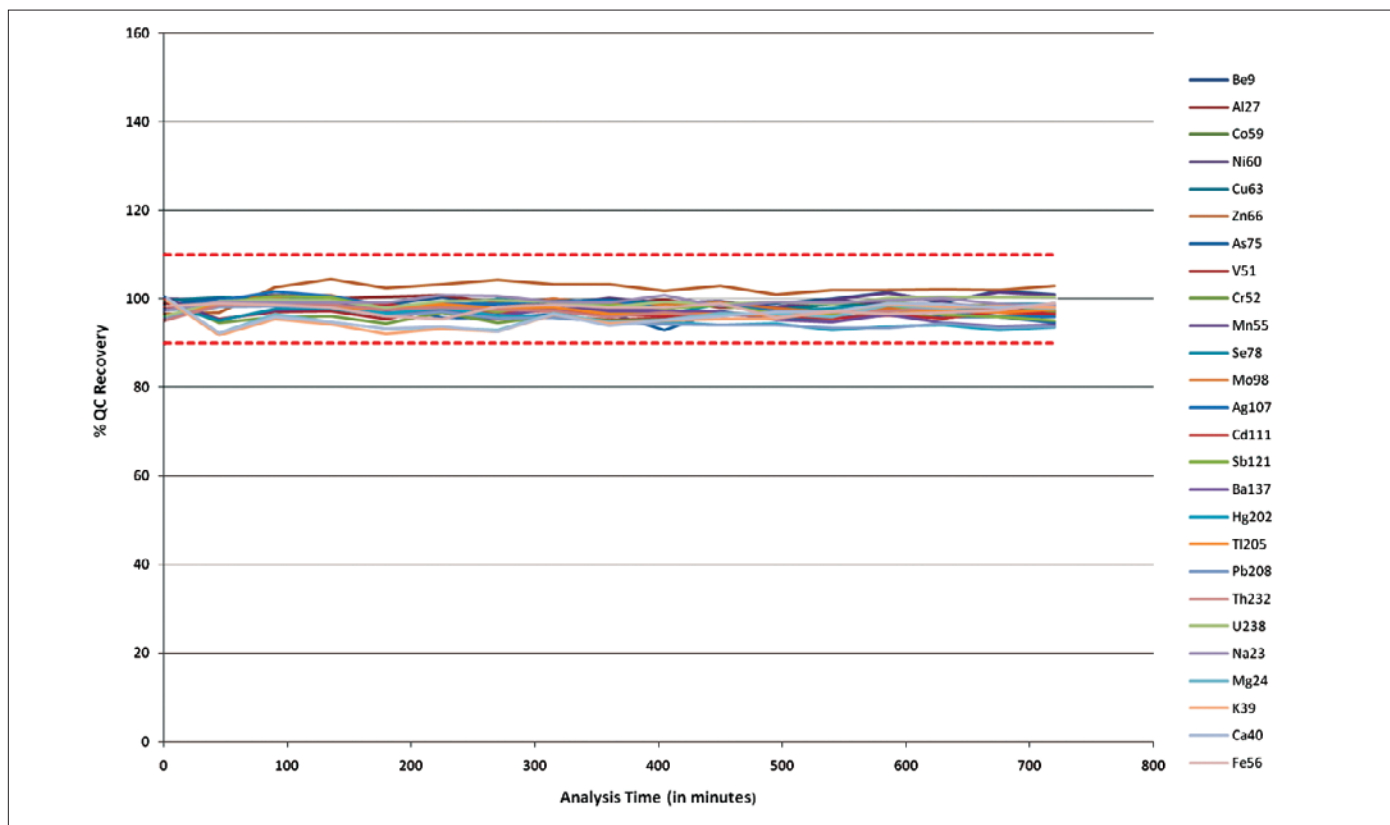


Figure 1. Long-term stability of the TMDW QCS sample measured every ten samples throughout a 12-hour analysis using the NexION 300D ICP-MS.

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