Automation
Application Note AUT-AN2601
August, 2026

Automated Preparation and Rapid Analysis of Coolant Samples by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES)

Jude Sakowski; Teledyne LABS

Keywords: SimPrep+, ICP-OES, Automated Dilution, Trace Element Analysis, Coolant Analysis

Introduction

The analysis of in-service coolant samples from heavy machinery is an important component of predictive maintenance programs. Like lubricating oil analysis, elemental analysis of coolant samples provides valuable information regarding equipment condition and performance. Monitoring elemental concentrations can help identify contamination from external sources, coolant dilution, additive package depletion, and wear or corrosion of engine components. When combined with proactive maintenance practices, coolant analysis can reduce unplanned downtime and help prevent costly equipment failures.

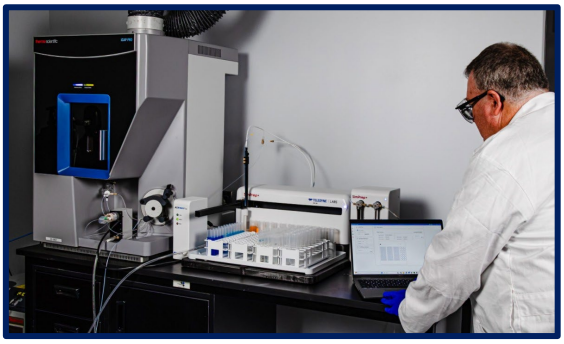


Figure 1. CETAC SimPrep+ Automated Liquid Handling Station with iCAP PRO.

Accurate elemental analysis of coolant samples by ICP-OES typically requires sample dilution to minimize matrix effects and adjust analyte concentrations to the instrument's calibration range. Required calibration standards, internal standards, matrix spikes, and quality control samples must be prepared before analysis begins. These preparation steps can be labor-intensive and are susceptible to operator error when performed manually.

The Teledyne LABS CETAC SimPrep+ Automated Liquid Handling Station streamlines laboratory workflows by automatically performing sample dilutions, calibration standard preparation, internal standard additions, matrix spike preparation, and quality control sample preparation. (Figure 1). Sample introduction was performed using a Teledyne LABS CETAC ASX-560 Autosampler with an ASXpress® PLUS rapid sample introduction system to reduce, analytical cycle times and increase sample throughput. A sample introduction kit optimized for improving stability, washout, and preventing cross-contamination while reducing downtime due to particulate-containing coolant samples consisted of the Guardian™ Probe, SeaSpray™ DC nebulizer, Tracey™ BC spray chamber, and E-Torch™ with ceramic plasma tube set, all provided by Glass Expansion.

This application note evaluates the performance of the CETAC SimPrep+ for automated preparation of coolant samples, calibration standards, and quality control solutions prior to ICP-OES analysis. Coolant samples were analyzed for Al, B, Ca, Cu, Fe, Mg, Mo, Na, P, Pb, Si, and Zn, and the accuracy, precision, throughput, and washout performance of the automated workflow were assessed.

Equipment and Reagents

Following are lists of primary equipment and reagents used for manual and automated standard and sample preparation.

Equipment:

1. ICP-OES: iCAP PRO DUO, Thermo Fisher Scientific, Waltham, Massachusetts USA
2. Autosampler: Teledyne LABS CETAC brand ASX-560, Omaha, NE USA
3. Automated Liquid Station: SimPrep+, Teledyne LABS, Omaha, NE USA

4. Rapid Sample Introduction System: ASXpress® PLUS, Teledyne LABS, Omaha, NE USA
5. SimPrep+ Probe: Guardian™ Probe Assembly, 70-803-1787, Glass Expansion, Port Melbourne, Victoria, Australia
6. Spray Chamber: Tracey™ BC Spray Chamber, 20-809-5318, Glass Expansion, Port Melbourne, Victoria, Australia
7. Nebulizer: SeaSpray™ DC Nebulizer 2mL/min, A310O7-USS2, Glass Expansion, Port Melbourne, Victoria, Australia
8. Torch: E-Torch™ with Ceramic Tube Set, 30-808-4388 and 31-808-4502, Glass Expansion, Port Melbourne, Victoria, Australia

Note: The SimPrep+ is a combination of the CETAC brand ASX-560 4-rack autosampler with the SPM-201 dual syringe pump module. The combination is controlled by the Teledyne LABS AQ-Prep software.

Reagents/ Samples

1. Multi Element Calibration Standards: IV-78077 (100 mg/L: B, K, Mo, Na, P, Si 50 mg/L: Al, Ca, Cu, Fe, Mg, Pb, Sn, Zn in 5% Ethylene Glycol, 0.5% HCl, tr. HF), IV-78565 (10 mg/L, 5 mg/L), IV-78566 (1 mg/L, 0.5 mg/L), IV-78567 (0.1 mg/L, 0.05 mg/L), Inorganic Ventures, Christiansburg, VA, USA.
2. Calibration Blank: IV-78568 (5% Ethylene Glycol, 0.5% HCl), Inorganic Ventures, Christiansburg, VA, USA.
3. Internal Standard: IV-78254 (5000 mg/kg: Co, Sc, Y, 80 g/L H_4EDTA), Inorganic Ventures, Christiansburg, VA, USA
4. Ethylene glycol, >99.0%, Macron brand, Avantor Inc., Radnor, PA USA
5. Nitric Acid: TraceMetal™ Grade, Thermo Fisher Scientific, Fair Lawn, NJ USA.
6. In-Service (used) Passenger Vehicle Coolant Sample – Used Coolant A (green), Used Coolant B (Pink)
7. PEAK® Universal Coolant, Old World Industries, Northbrook, IL USA
8. O'Reilly® Conventional Green Coolant, Ozark Automotive Distributer, Springfield, MO USA

TraceMetal™ is a trademark of Thermo Fisher Scientific.

Figure 2. Guardian™ Probe

Manual Preparation of Blanks, Calibration Standards and Dilutions

A 2-liter reservoir of 5% (v/v) ethylene glycol was prepared in a fluorinated ethylene propylene (FEP) bottle with 18.2 Ω deionized water. 14-mL polypropylene (PP) vials and 50-mL polypropylene (PP) vials were precleaned by rinsing with 1% (v/v) trace metal grade nitric acid and 18.2 MΩ deionized water. A 50 mg/L internal standard (IS) solution in 5% (v/v) ethylene glycol was prepared gravimetrically from IV-78254 (5000 mg/kg: Co, Sc, Y, 80 g/L H_4EDTA).

CETAC SimPrep+ Configuration

The CETAC SimPrep+ SPM-201 syringe pump module was configured with one 10 mL syringe and one 1 mL syringe. Probe depth was set to 150, positioning the probe tip approximately 1 cm above the bottom of the destination vials.

To improve handling of coolant samples, the standard CETAC SimPrep+ probe was replaced with a Guardian™ Probe shown in Figure 3. The Guardian™ probe features a specially engineered cone shaped ceramic tip with an integrated particle filter to reduce sample carryover, minimize dripping during probe movement, and prevent

particulate from entering the sample introduction system. During bubble mixing, the filter also acts as a diffuser, improving mixing efficiency by generating a uniform column of bubbles within the sample.

Figure 3: Coolant Samples. From right to left: Used Coolant A, Used Coolant B, PEAK® Universal, O'Reilly® Conventional Green.

The CETAC ASX-560 autosampler was equipped with two 60-position vial racks in positions 1 and 2 and one 21-position vial rack in position 3. Rack 1 was used for coolant dilutions, continuing calibration verification (CCV) and continuing calibration blank (CCB) samples. Rack 2 contained the spiked samples and prepared calibration standards. Rack 3 contained undiluted samples, stock standards and blanks. The 60-position racks were loaded with pre-cleaned 14 mL round-bottom PP dilution vials, while the 21-position rack contained six pre-cleaned 50 mL PP source vials. The source vials contained, in order, Used Coolant A, Used Coolant sample B, PEAK® Universal Coolant, O'Reilly® Conventional Green Coolant, 50% (v/v) ethylene glycol, and an IV-78077 multielement standard containing 100 mg/L B, K, Mo, Na, P, and Si and 50 mg/L Al, Ca, Cu, Fe, Mg, Pb, Sn, and Zn (Figure 3). Additionally, a 50 mL PP vial containing 50 mg/L internal standard was placed in standard position 1, and a second 50 mL PP vial containing 50 mg/L internal standard and a 10-fold diluted IV-78077 standard was placed in standard position 2. These solutions were used for automated IS addition and matrix spike preparation. The vial layout is shown in Figure 4.

CETAC ASXPress™ *PLUS* Configuration

The CETAC ASX-560 autosampler was utilized for both automated sample preparation and ICP-OES analysis, eliminating the need for a dedicated sample introduction autosampler. During sample preparation, the CETAC ASX-560 was connected to the CETAC SimPrep+ SPM-201. Upon completion of sample preparation, the Guardian™ Probe assembly was removed and replaced with the CETAC ASXpress® PLUS probe connected to the 6-port injection. The 6-port valve was configured with a 2.5 mL sample loop. This approach minimizes laboratory footprint, reduces hardware requirements, and provides a seamless transition from automated sample preparation to rapid sample introduction and analysis. Using four 60-position racks, a laboratory could prepare up to 120 diluted coolant samples in a single batch and begin analysis immediately following a simple probe change. Thus, sample analysis can begin without the need to move prepared samples to another autosampler.

Automated Preparation of Calibration Standards, Coolant Samples and Matrix Spikes

First, calibration standards were prepared by diluting IV-78077 to concentrations of 0.1 mg/L, 0.25 mg/L, 1 mg/L, 2.5 mg/L, 10 mg/L and 25 mg/L. Standards with concentrations between 0.1 mg/L – 2.5 mg/L were prepared by serial dilution. For the preparation of calibration standards 5% ethylene glycol (v/v) was used as the diluent to maintain a consistent matrix and IS was added to each standard. Next, each of the four coolant samples were prepared for analysis. For each coolant sample 12 coolant aliquots were prepared at a 10x dilution with IS addition. During sample preparation CCV and CCB samples were prepared for every 10 samples. Finally, a matrix spike was prepared for each of the coolant samples. Coolant samples were diluted 10x and spiked with 1 mL of solution containing IS + 10 mg/L multielement standard. Samples and sample spikes were diluted with deionized water. Internal standard was added to all samples and calibration standards at a final concentration of 5 mg/L.

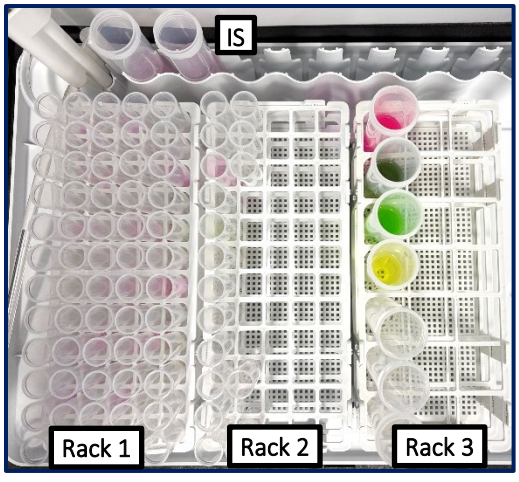


Figure 4: Top View Rack and Vial Layout

AQ Prep Dilution Method and Sample List

AQ-Prep software is used to control the CETAC SimPrep+ sample preparation protocol. The AQ-Prep software provides user configurable control of syringe aspiration and dispense speeds, air segment gap volume, mixing technique, probe wash volume, and probe depth. The method used for preparation of 1:10 sample dilutions with 1 mL IS addition is shown in Figure 5. Samples were mixed using a 6 mL bubble-mixing step to ensure homogeneity. A final 6 mL wash step flushed the sample loop and probe tubing to minimize carryover between samples while simultaneously rinsing the exterior of the probe in the rinse station. The same method was also used for preparation of matrix spike samples and calibration standards, with dilution ratios, spike volumes, and standard source locations modified directly within the sample list. The calibration sample list is shown in Figure 6a.

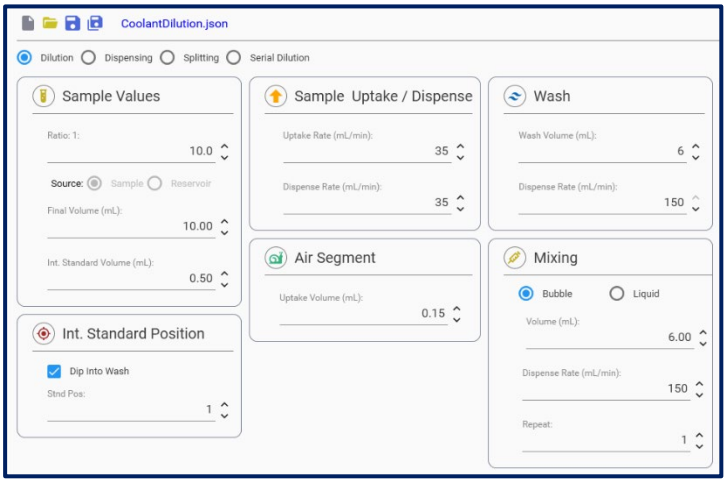
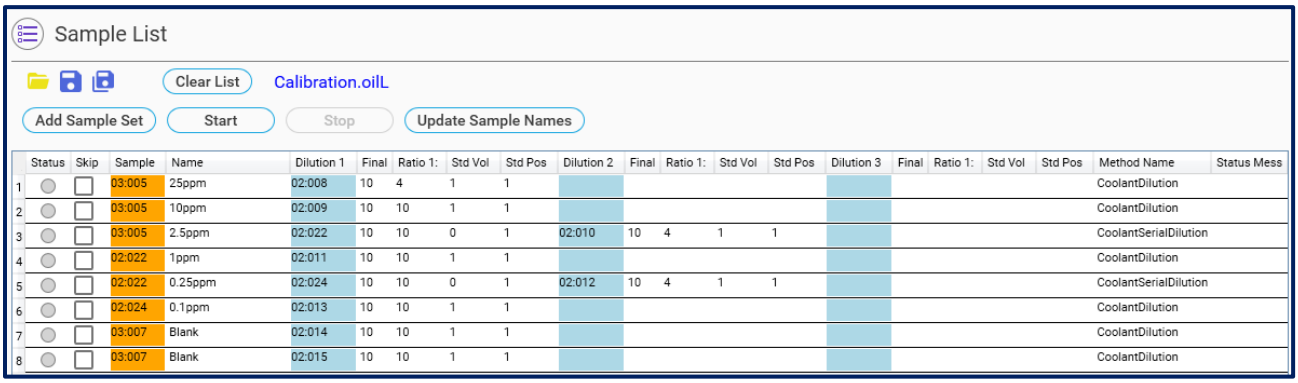


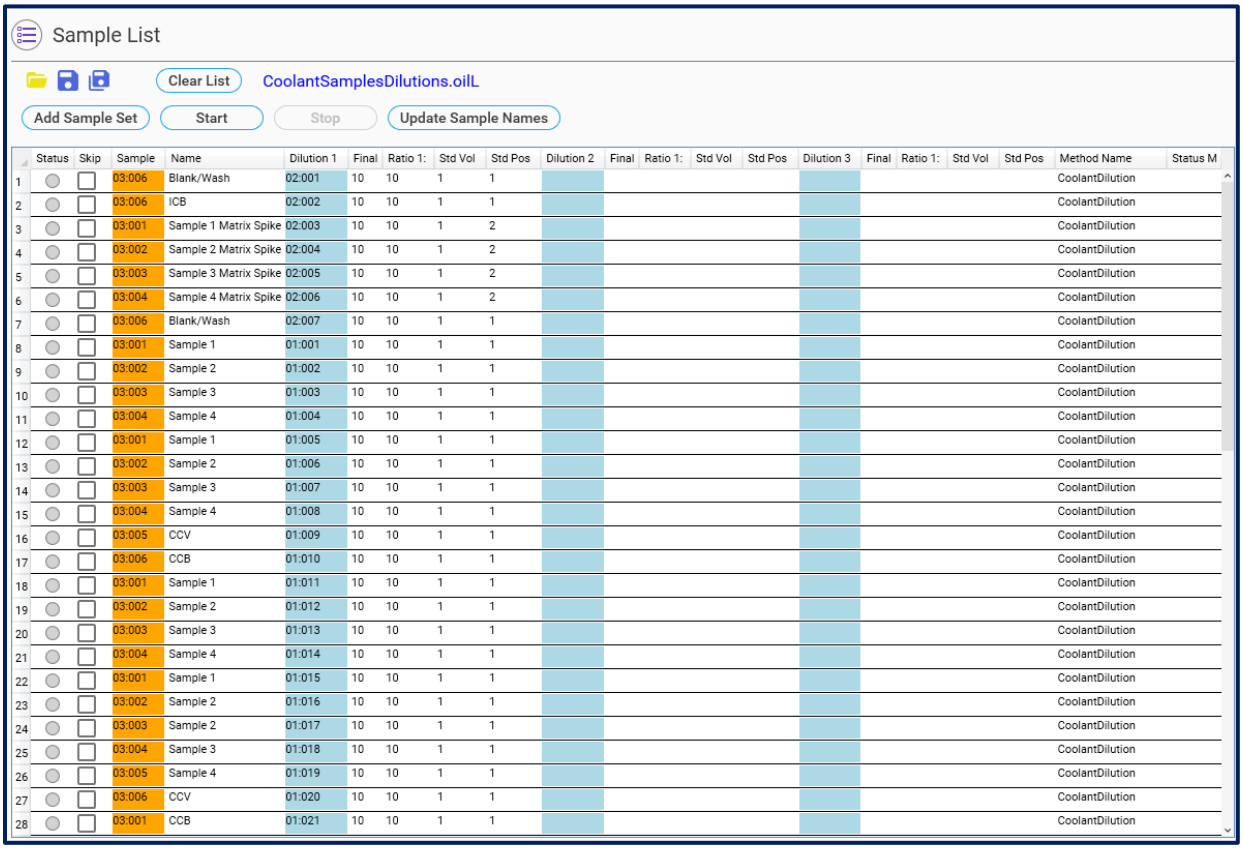
Figure 5: AQ Prep Coolant Dilution Method

Using this method, the CETAC SimPrep+ automatically prepared the sample list shown (abbreviated) in Figure 6b, consisting of 48 coolant dilutions, four matrix spikes, six CCV samples, six CCB samples, and two reagent blanks in approximately 68 minutes.



	Status	Skip	Sample	Name	Dilution 1	Final	Ratio 1:	Std Vol	Std Pos	Dilution 2	Final	Ratio 1:	Std Vol	Std Pos	Dilution 3	Final	Ratio 1:	Std Vol	Std Pos	Method Name	Status Mess
1			03:005	25ppm	02:008	10	4	1	1											CoolantDilution	
2			03:005	10ppm	02:009	10	10	1	1											CoolantDilution	
3			03:005	2.5ppm	02:022	10	10	0	1	02:010	10	4	1	1						CoolantSerialDilution	
4			02:022	1ppm	02:011	10	10	1	1											CoolantDilution	
5			02:022	0.25ppm	02:024	10	10	0	1	02:012	10	4	1	1						CoolantSerialDilution	
6			02:024	0.1ppm	02:013	10	10	1	1											CoolantDilution	
7			03:007	Blank	02:014	10	10	1	1											CoolantDilution	
8			03:007	Blank	02:015	10	10	1	1											CoolantDilution	

Figure 6a: AQ Prep Coolant Sample List



	Status	Skip	Sample	Name	Dilution 1	Final	Ratio 1:	Std Vol	Std Pos	Dilution 2	Final	Ratio 1:	Std Vol	Std Pos	Dilution 3	Final	Ratio 1:	Std Vol	Std Pos	Method Name	Status M
1			03:006	Blank/Wash	02:001	10	10	1	1											CoolantDilution	
2			03:006	ICB	02:002	10	10	1	1											CoolantDilution	
3			03:001	Sample 1 Matrix Spike	02:003	10	10	1	2											CoolantDilution	
4			03:002	Sample 2 Matrix Spike	02:004	10	10	1	2											CoolantDilution	
5			03:003	Sample 3 Matrix Spike	02:005	10	10	1	2											CoolantDilution	
6			03:004	Sample 4 Matrix Spike	02:006	10	10	1	2											CoolantDilution	
7			03:006	Blank/Wash	02:007	10	10	1	1											CoolantDilution	
8			03:001	Sample 1	01:001	10	10	1	1											CoolantDilution	
9			03:002	Sample 2	01:002	10	10	1	1											CoolantDilution	
10			03:003	Sample 3	01:003	10	10	1	1											CoolantDilution	
11			03:004	Sample 4	01:004	10	10	1	1											CoolantDilution	
12			03:001	Sample 1	01:005	10	10	1	1											CoolantDilution	
13			03:002	Sample 2	01:006	10	10	1	1											CoolantDilution	
14			03:003	Sample 3	01:007	10	10	1	1											CoolantDilution	
15			03:004	Sample 4	01:008	10	10	1	1											CoolantDilution	
16			03:005	CCV	01:009	10	10	1	1											CoolantDilution	
17			03:006	CCB	01:010	10	10	1	1											CoolantDilution	
18			03:001	Sample 1	01:011	10	10	1	1											CoolantDilution	
19			03:002	Sample 2	01:012	10	10	1	1											CoolantDilution	
20			03:003	Sample 3	01:013	10	10	1	1											CoolantDilution	
21			03:004	Sample 4	01:014	10	10	1	1											CoolantDilution	
22			03:001	Sample 1	01:015	10	10	1	1											CoolantDilution	
23			03:002	Sample 2	01:016	10	10	1	1											CoolantDilution	
24			03:003	Sample 2	01:017	10	10	1	1											CoolantDilution	
25			03:004	Sample 3	01:018	10	10	1	1											CoolantDilution	
26			03:005	Sample 4	01:019	10	10	1	1											CoolantDilution	
27			03:006	CCV	01:020	10	10	1	1											CoolantDilution	
28			03:001	CCB	01:021	10	10	1	1											CoolantDilution	

Figure 6b: AQ Prep Calibration Sample List (abbreviated)

Sample Preparation Precision Comparison

Coolant samples are particularly difficult to handle due to their viscosity; manual preparation of coolant samples can introduce analysis error. To compare the CETAC SimPrep+ precision to manual sample preparation, a gravimetric dispense test was conducted. Individual 1 mL sample aliquots of coolant were transported from a sample vial into 10 separate 14-mL sample vials. The accuracy and precision of these dispenses were measured gravimetrically. As shown in Table 1, SimPrep+ produced a relative standard deviation of 0.43%, compared to 1.15% for manual dispensing, representing approximately a 2.7-fold improvement in dispensing precision.

Table I. **Dispensing Accuracy and Precision**

Technique	Mean (g)	RSD (%)
SimPrep+	0.99	0.43
Manual	1.01	1.15

ICP-OES Operating Conditions

The ICP-OES operating conditions are listed in Table II. A CETAC ASXpress® PLUS rapid sample introduction system was used for all analyses. Method parameters were configured using the Thermo Qtegra™ Configurator software. Sample loading was performed using a 3.5 s loop load time followed by a 2 s equilibration delay prior to injection. To minimize carryover, the extra loop rinse function was enabled with a 3 s loop rinse delay and a 2 s loop evacuation delay. Probe rinsing consisted of a 1 s probe evacuation step, a 5 s probe wash, and a 10 s rinse station refill between samples. Probe rinsing was performed concurrently with ICP-OES data acquisition. Including the ICP-OES sample uptake delay of 17 s, the total time between consecutive sample analyses was approximately 30 s. Analytical wavelengths are listed in Table III.

Table II. **ICP-OES Operating Conditions**

ICP-OES	iCAP PRO DUO
ICP Power	1300 W
Plasma Gas	12.5 L/min
Auxiliary Gas	1.5 L/min
Nebulizer Gas	0.60 L/min
Nebulizer / Spray Chamber	SeaSpray™ DC Nebulizer 2 mL/min
Sample Uptake Rate	1.5 mL/min
Instrument Uptake Time	17 s
Instrument Wash Time	0 s
Viewing	Axial: Al, B, Ca, Co, Cu, Fe, Mo, P, Pb, Sc, Si, Y: Radial – Mg, Na, Co
Integration Time	4 s Axial, 4 s Radial
Points / Peak	3
Replicates	3
Calibration Weighting	1/Concentration

Spray Chamber Washout

The Tracey™ BC Spray Chamber features a 30-mL low-volume cyclonic design for improved washout performance. A washout study was conducted to compare the Tracey™ BC Spray Chamber to a standard-volume cyclonic spray chamber. To isolate the effects of the spray chamber, solution was aspirated through a 150 mm capillary into a SeaSpray™ DC nebulizer at 1.5 mL/min using the iCAP PRO peristaltic pump.

First, a 5% (v/v) ethylene glycol blank was aspirated to establish baseline signal levels. Next, Used Coolant A + multielement spike (20 mg/L B, K, Mo, Na, P, and Si; 10 mg/L Al, Ca, Cu, Fe, Mg, Pb, Sn, and Zn) was aspirated for 30 s at 1.5 mL/min to simulate a typical in-service coolant sample analysis. The system was then returned to the 5% (v/v) ethylene glycol blank for the remainder of the experiment.

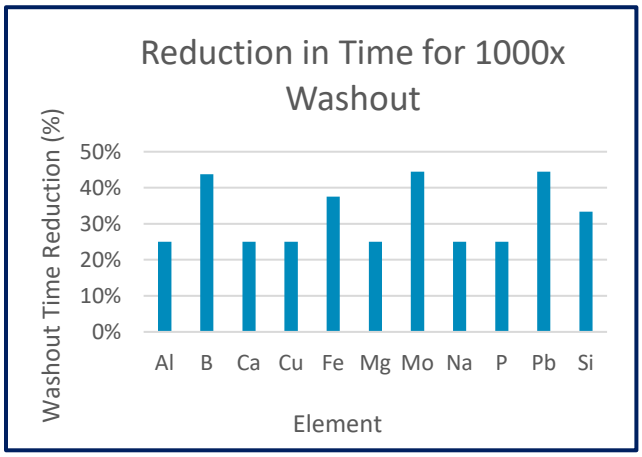


Figure 7: Tracey Spray Chamber Washout Improvement vs. Standard Spray Chamber

Washout was quantified as the time required for each element to reach a 1000-fold reduction in signal intensity, following the return to blank solution. Relative to the standard cyclonic spray chamber, the Tracey™ BC spray chamber reduced washout time by as much as 49%, with the largest improvements observed for Mo, Pb, B. The washout improvement observed across all evaluated elements is summarized in Figure 7. Employing the Tracey™ BC spray chamber significantly reduces the required rinse time and risk of elevated carryover in a high-throughput laboratory.

The entire signal profile was acquired using 70 consecutive measurements with a 1 s integration time in axial mode. Due to instrument and software overhead, the effective measurement cycle time was approximately 2 s.

A representative washout profile for molybdenum is shown in Figure 8.

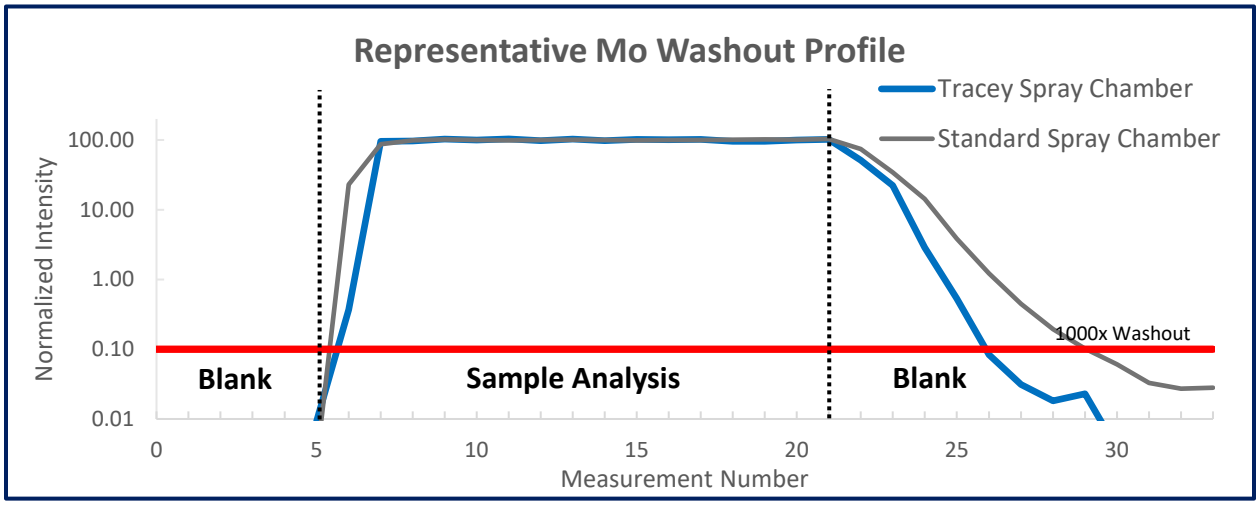


Figure 8: Comparison of Spray Chamber Washout for Mo.

Calibration

Calibration standards ranging from 0.1 to 25 mg/L were prepared automatically using the CETAC SimPrep+ from the IV-78077 multielement stock solution and a 5% (v/v) ethylene glycol diluent. Standards between 0.1 and 2.5 mg/L were prepared by serial dilution, while the 10 and 25 mg/L standards were prepared by single dilution from the stock solution. Internal standards were added to all standards by the SimPrep+ to produce a final concentration of 5 mg/L.

Calibration curves exhibited excellent linearity across the evaluated concentration range for all analytes with correlation coefficients of 0.9998 or higher. Representative calibration curves for B and Mo are shown in Figure 9a and Figure 9b, respectively. The strong linear response obtained for each element demonstrates the ability of SimPrep+ to accurately perform both single and serial dilutions during automated calibration standard preparation.

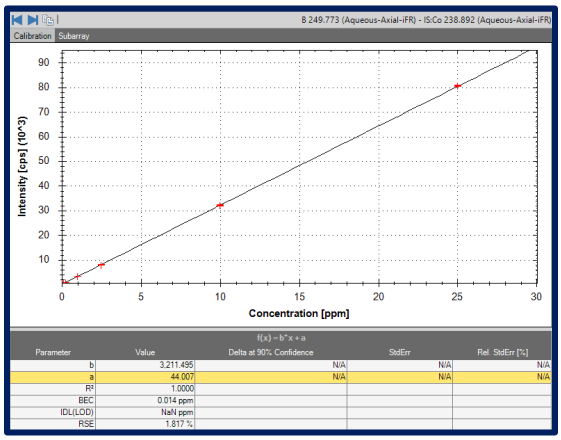


Figure 9a: B Calibration

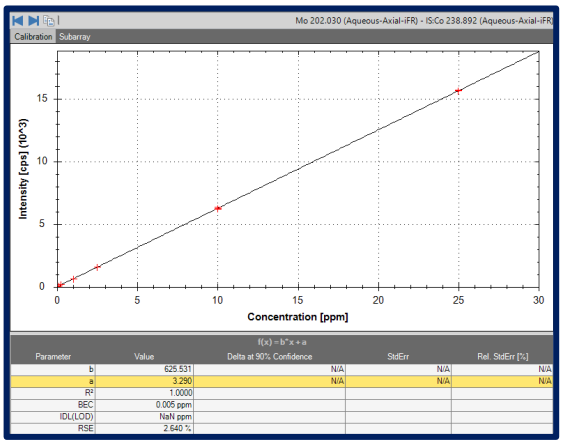


Figure 9b: Mo Calibration.

Spiked Coolant Samples Accuracy and Precision

To assess the precision and accuracy of coolant dilutions, sample aliquots were diluted 10x and spiked with 1-mL of IV-78077 multielement. After analysis the recovery of the spiked elements was calculated. Figure 10 shows measured elemental concentrations as a percent of expected concentrations.

All spike recoveries were within 93%-106%. Recoveries were omitted for elements outside of the calibration range.

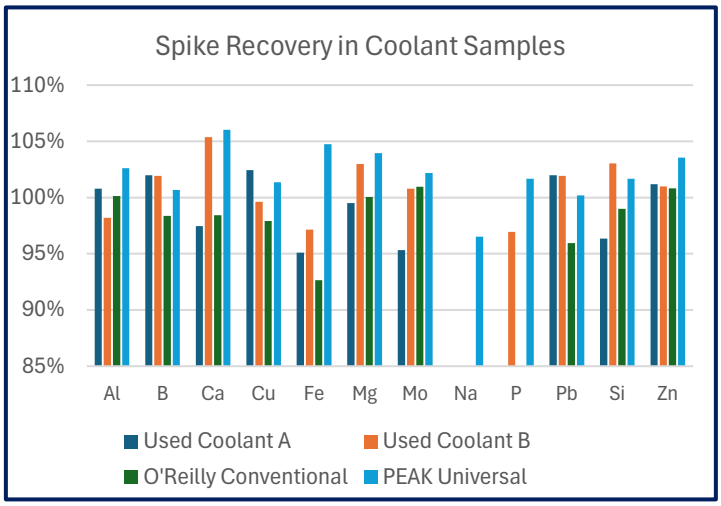


Figure 10: Coolant Matrix Spike % Recovery

Automated Calibration Verification

To verify the accuracy of automated standard preparation, an initial calibration verification (ICV) sample and CCV samples were analyzed throughout the study. The ICV was prepared manually and analyzed immediately following calibration. CCV samples were automatically prepared by the SimPrep+ after every eight sample preparation events and incorporated into the analytical sequence to monitor calibration stability and dilution accuracy throughout the run. All CCV samples contained a final internal standard concentration of 5 mg/L (added via SimPrep+).

Figure 11 summarizes the recovery of the ICV and six CCV samples for each analyte. Recoveries ranged from 92-106% of the expected concentration for all elements evaluated. This is well within the commonly accepted QC limits of 90%-110%. The close agreement between the ICV and CCV recoveries demonstrates the accuracy and reproducibility of the SimPrep+ automated dilution process. Consistent recoveries throughout the analytical sequence also indicate excellent calibration stability and confirm that no significant drift occurred during sample preparation or analysis

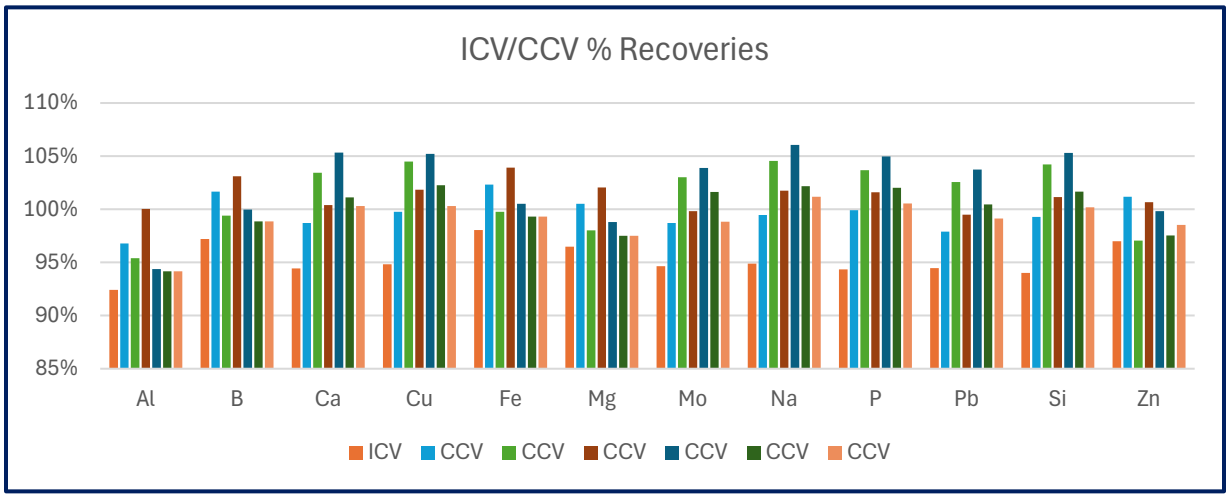


Figure 11: Percent ICV/CCV Recoveries

Internal Standard Stability

IV-78254 internal standard solution (5,000 mg/L Co, Sc, and Y) was diluted to 50 mg/L and placed in a dedicated standard position on the SimPrep+. The internal standard was automatically added to all calibration standards, coolant samples, matrix spikes, and quality control samples to produce a final concentration of 5 mg/L.

Figure 12 shows the normalized recoveries of the Co, Sc, and Y internal standards for 12 replicate preparations of Used Coolant A, Used Coolant B, O'Reilly Conventional Green Coolant, and PEAK Universal Coolant. Internal

standard recoveries ranged from 96.5% to 103.5% for all three elements. No visible precipitation or solution instability was observed following internal standard addition, despite the wide range of coolant compositions evaluated.

Across the four sets of 12 replicate samples, the internal standards demonstrated excellent reproducibility. The average %RSD values calculated for each 12-sample set were 1.30%, 1.21%, and 1.41% for Co, Y, and Sc, respectively. The close agreement between internal standard recoveries confirms the accuracy and precision of the SimPrep+ automated internal standard addition process while demonstrating that the internal standards remained stable in solution throughout the sample preparation workflow. The strong agreement between measured and expected matrix spike concentrations (Figure 10), together with excellent calibration linearity (Figure 9) and consistent CCV recoveries (Figure 11), demonstrates that the internal standards effectively corrected for matrix effects across the diverse coolant matrices evaluated. Coolant Replicate Analysis Results

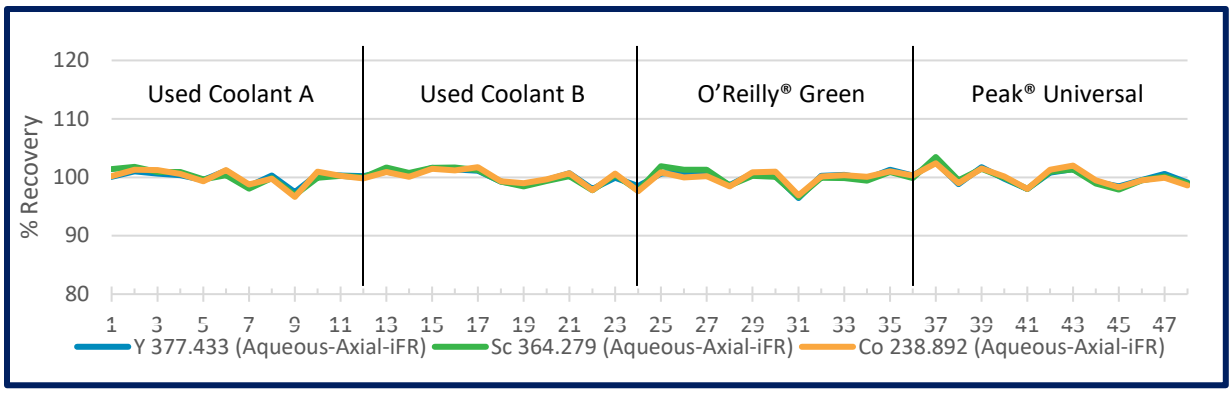


Figure 12: Normalized % Internal Standard Recoveries

Coolant Replicate Analysis Results

To show the precision of the CETAC Simprep+ dilution method 12 coolant sample aliquots were prepared for each coolant sample. The aliquots were diluted 10x, spiked with 5 mg/L internal standard, and analyzed for elemental concentrations. The results demonstrate the SimPrep+ provides precise and reproducible dilution of coolant samples. The strong reproducibility further confirms precise internal standard addition and solution stability throughout the analytical workflow. Results are reported as mean ± 2s uncertainty.

Table III. **Elemental Concentrations (mg/L) in Coolant Samples**

Element	Wavelength (nm)	Used Coolant A	Used Coolant B	O'Reilly® Green	PEAK® Universal
Al	309.271	2.13 ± 0.07	6.95 ± 0.10	ND	ND
B	249.773	1.08 ± 0.02	7.51 ± 0.12	221 ± 3	0.51 ± 0.02
Ca	422.673	9.60 ± 0.12	8.67 ± 0.13	10.1± 0.2	0.21 ± 0.05
Cu	324.754	0.58 ± 0.01	8.35 ± 0.13	ND	ND
Fe	259.94	ND	ND	ND	ND
Mg	285.213	1.71 ± 0.03	5.44 ± 0.07	2.14 ± 0.02	ND
Mo	202.03	238.0 ± 3.6	7.79 ± 0.11	0.22 ± 0.01	0.05 ± 0.01
Na	589.592	1337 ± 18	527 ± 7	900 ± 11	87.5 ± 2.2
P	177.495	533 ± 8	182.4 ± 2.7	1054.4 ± 11.6	0.35 ± 0.05
Pb	220.353	ND	0.18 ± 0.02	ND	ND
Si	251.611	27.43± 0.4	41.0 ± 0.7	123 ± 2	1.29 ± 0.02
Zn	213.856	0.29 ± 0.01	30.3 ± 0.5	ND	ND

ND= Not Detected (below the limit of quantitation). LOQ values were estimated as 10× the standard deviation of six CCB measurements

Conclusion

The CETAC SimPrep+ successfully automated the preparation of coolant samples, calibration standards, matrix spikes, and quality control samples for ICP-OES analysis. Automated preparation of 48 coolant samples, four matrix spikes, six CCV samples, six CCB samples, and two reagent blanks were completed in 68 minutes with minimal operator input. Gravimetric testing demonstrated improved dispensing precision relative to manual sample preparation, while matrix spike recoveries of 93-106% and CCV recoveries of 92-106% confirmed the accuracy and reproducibility of the automated workflow. Calibration curves prepared using SimPrep+ exhibited excellent linearity across the evaluated range, and replicate coolant analyses demonstrated highly reproducible sample dilution. The 5 mg/L Co, Sc, and Y internal standards remained stable across all sample types, including calibration standards, coolant dilutions, matrix spikes, and quality control samples, with no evidence of precipitation or analyte loss. Consistent and accurate recoveries further demonstrated effective correction of matrix effects.

Evaluation of the Tracey™ BC Spray Chamber proved to reduce washout time by up to of 49%, with the largest improvements observed for Mo, Pb and B. This is a significant advantage for a high-throughput coolant testing laboratory, reducing the required rinse time and minimizing the effects of carryover. The Guardian™ Probe improved handling of particulate-containing coolant samples and during mixing, acted as a diffuser, improving mixing efficiency by generating a uniform column of bubbles within the sample. The stable aerosol generation of the SeaSpray™ DC nebulizer, in addition to the E-Torch™ with ceramic plasma tube set, helped to improve the overall robustness of the plasma, leading to excellent stability in a challenging sample matrix of varying viscosity. Combined with the ASXpress® Plus rapid sample introduction system, SimPrep+ provides an efficient and reliable solution for high-throughput coolant analysis laboratories.