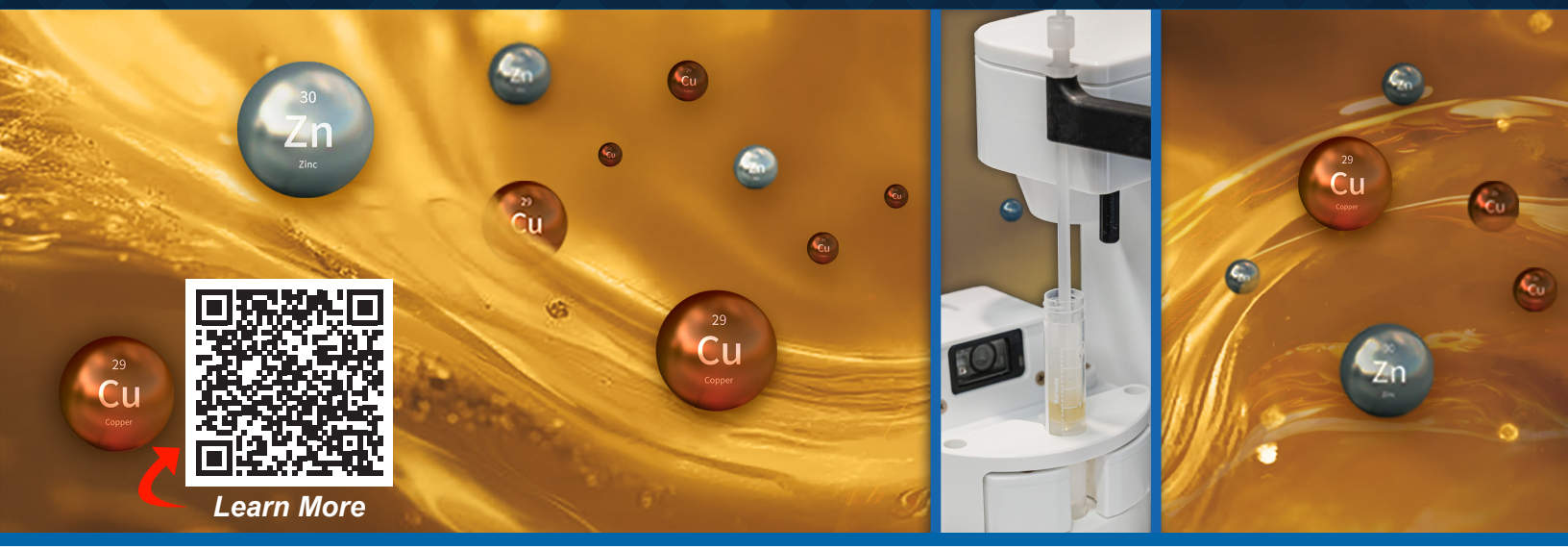


Authors: Patrick Messina, Owen Madigan, Libbie Smith

***TRAX*Station Clinical – Fully Automated Preparation of Serum Samples for the Analysis of Copper and Zinc**

Introduction

Trace element analysis plays a critical role in modern clinical diagnostics, providing essential information for evaluating nutritional status, toxic exposures, and metabolic disorders. Traditionally, the workflow for preparing and analyzing clinical samples by inductively coupled plasma mass spectrometry (ICPMS) has relied heavily on manual liquid handling steps. These steps – such as uncapping, rocking, pipetting, and dilution are time-consuming, prone to operator variability, and present ongoing risks of contamination, especially at trace and ultra-trace concentrations. As clinical demand grows, laboratories processing hundreds to thousands of patient samples per day face the mounting pressure to increase throughput while maintaining uncompromising analytical quality.

***TRAX*Station Clinical directly addresses these challenges by automating routine sample preparation tasks in a controlled, contamination-free environment. Built with chemically inert materials, the platform is designed to handle clinical matrices reliably while eliminating common sources of error. Advanced features such as automated vial uncapping, liquid-level detection, barcode tracking, sample mixing and precise dilution routines ensure consistent preparation across large sample sets. For high-volume laboratories, this level of automation translates to improved reproducibility, reduced operator workload, and a streamlined path from original patient specimen to analysis-ready sample.

Figure 1. ***TRAX*Station Clinical 422.**

Introduction *(Continued)*

Figure 2. **TRAX**Station Clinical takes up a serum aliquot for automated preparation.

TRAXStation Clinical automates the full preparation workflow for serum samples collected in plastic metal free serum tubes. The compact platform integrates all key steps into a single system, improving laboratory efficiency, traceability, and operator safety while ensuring high-quality, reproducible results. By replacing labor-intensive manual steps, **TRAX**Station Clinical reduces errors, shortens turnaround times, and increases throughput while maintaining strict regulatory compliance and sample integrity.

TRAXStation Clinical Workflow

Barcode Reading & Sample Tracking
Integrated barcode scanning provides complete traceability and seamless connection to instruments and LIMS.

Automated Uncapping
Hands-free uncapping reduces manual handling, contamination risk, and biohazard exposure.

Sample Level Detecting
Sound waves are used to detect sample liquid levels. The probe will aspirate from just below the liquid surface.

Precision Sampling & Dilution
High-accuracy pipetting enables aliquoting into tubes or 96-well plates, with programmable dilutions for flexible assay workflows.

Mixing & Plate Preparation
Automated mixing ensures consistent sample readiness.

(Optional) Sample Tube Rocker
Gentle rocking of tubes prior to processing guarantees homogeneous samples for accurate downstream analysis.

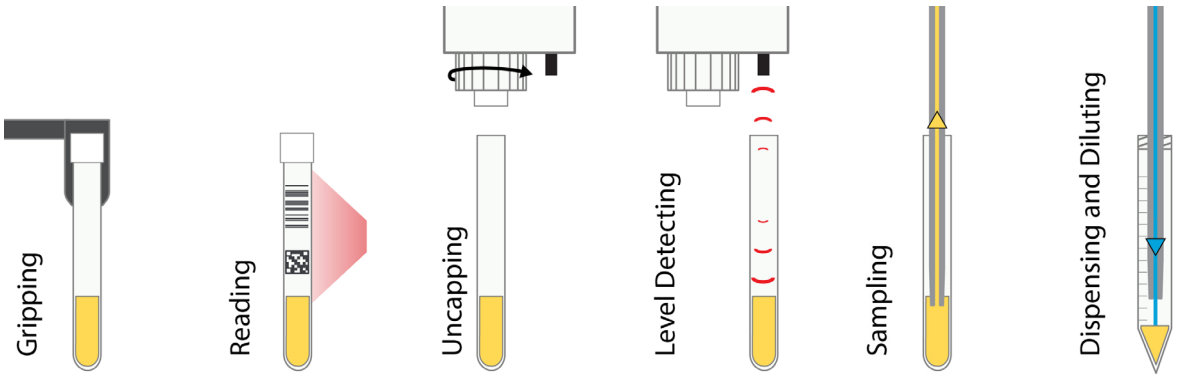


Figure 3. **TRAX**Station Clinical automated workflow for serum sample preparation.

Background

Laboratories routinely test for Copper and Zinc levels in serum because both are essential trace elements that play critical roles in human health, and imbalances can signal significant clinical conditions. By measuring serum levels of these elements, laboratories provide clinicians with crucial information for diagnosing deficiencies, monitoring disease progression, and guiding nutritional or therapeutic interventions. Millions of samples are tested by Clinical Laboratories every year. See below for details on each element.

Copper in Serum

Copper is required for enzymes that regulate energy production, connective tissue, brain development, and iron metabolism. Imbalances or disorders related to copper can lead to serious symptoms. Some of the common reasons for testing are:

- Nutritional status – copper deficiency or excess from diet, supplements, or parenteral nutrition
- Wilson's disease – inherited disorder causing toxic copper buildup in liver, brain, eyes
- Menkes disease – rare genetic disorder causing copper deficiency
- Chronic liver disease – since copper is processed and excreted via bile
- Anemia or Neutropenia – copper deficiency can mimic iron deficiency anemia
- Neurologic symptoms – weakness, numbness, movement disorders can be linked to copper imbalance

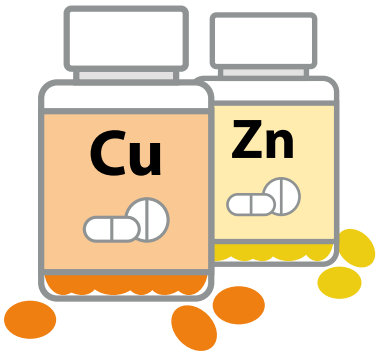
Zinc in Serum

Zinc is essential for immune function, wound healing, growth, and reproduction, serving as a cofactor in hundreds of enzymes affecting metabolism and DNA repair. Some of the common reasons for testing are:

- Nutritional status – zinc deficiency or excess from diet, supplements, or parenteral nutrition
- Malnutrition or malabsorption – e.g. celiac disease, Crohn's, chronic diarrhea
- Chronic illness or inflammation – zinc deficiency can worsen healing and immunity
- Delayed wound healing or frequent infections
- Growth and development issues in children
- Suspected Toxicity – though rare, very high zinc can cause copper deficiency, anemia, and neurologic symptoms

Example for Normal Laboratory Reference Ranges

- Serum Copper: 700 µg/L (men), 800-1550 µg/L (women)
- Serum Zinc: 600-1200 µg/L (both sexes)



Experimental – TRAXStation Automated Sample Prep

Evaluation that the combinaton of **TRAX**Station preparation & ICPMS measurement produces acceptable precision (repeatability and reproducibility) and accuracy (bias vs assigned concentrations) for copper and zinc across the clinical range using three pooled sample levels: Low (below normal levels), Normal (clinically relevant mid-range), and High (above normal range that may represent toxicity).

Table 1. Homogenized, bovine serum pools.

Pool Level	Target Concentration (µg/L)	Number of Aliquots into Identical Sample Tubes
Low	~250	25
Normal	~1000	25
High	~2500	25

Table 2. Additional reagents.

Reagent	Preparation
Calibration Standards	Prepare according to method SOP
Blanks	Prepare required blanks
Carryover Check (Negative)	Prepare negative sample
Diluent	1% HNO_3 (v/v), 20 ppb Ge

Table 3. Run structure.

Component	Description
Samples per Run	25 prepared aliquots of each level: Low, Normal, High
Additional Samples	Blank, Calibrators, Negative (carryover check)
Total Runs	25 total runs
Data Output	Generate accuracy and precision plots
ICPMS Analysis	Transfer **TRAX**Station-prepared samples to 4DXCi SampleSense *FAST* UHT-C autosampler and analyze each batch
Data Processing	Export results to spreadsheet for statistical analysis

Table 4. **TRAX**Station Clinical preparation.

Component	Setting Preparation
Rinse 1	DI H_2O
Rinse 2	DI H_2O
Diluent	Connect prepared diluent (1% HNO_3, 20 ppb Ge)
Sample Loading	Load capped aliquots, blanks, calibrators
Dilution Method	100x dilution (40 µL sample + 3960 µL diluent)

Data Analysis Criteria

For clinical serum copper and zinc testing, good precision and accuracy are demonstrated through rigorous statistical validation consistent with CLIA, CAP, and CLSI guidelines. Precision is evaluated by repeated analysis of serum pools at low, normal, and high concentrations, with 25 replicates per level over 25 runs/batches and expressed as coefficient of variation (%CV). For trace metals such as copper and zinc, intra-assay and inter-assay %CVs should generally be ≤5% at normal and high levels and ≤10% at low levels. Accuracy is verified by comparison with mean recovery required to fall within ±10% of target values. According to CLIA proficiency testing criteria, the allowable total error (TEa) is ±15% or 150 µg/L for serum copper and ±15% or 100 µg/L for serum zinc, whichever is greater. Both short-term and long-term reproducibility must be assessed across runs, days, and operators to ensure robustness. Adherence to Good Laboratory Practice (GLP) principles and use of trace-element–free collection and processing materials are essential to minimize contamination. Together, these statistical and procedural controls ensure that serum copper and zinc results are analytically valid, reproducible, and compliant with regulatory standards for clinical testing.

ICPMS Instrument Parameters

All samples were prepared using **TRAX**Station Clinical, and analyzed using 4DXCi SampleSense *FAST* UHT-C autosampler in combination with a single quad ICPMS.

Table 5. Instrument information.

Parameter	Value
Sample Introduction System	ESI 4DCXi Autosampler SampleSense *FAST* UHT-C **TRAX**Station Clinical
Instrument	Single Quad ICPMS
Valve	Magnetically-Coupled Inert 6-port Valve
Probe	Blue Carbon Fiber Probe
Nebulizer	High Solids PFA Microflow Nebulizer
Rinse 1	1% Nitric Acid (v/v)
Rinse 2	1% Nitric Acid (v/v)
Carrier	1% Nitric Acid (v/v)
Method Time	**24 sec/sample analysis**

Table 6. Instrument parameters.

Parameter	Value
Analytes	Cu (m/z 65) Zn (m/z 66)
ISTD	Ge (m/z 72)
ICPMS Mode	Standard Mode
Sweeps per Replicate	10
Replicates per Sample	3
Dwell	100 ms

Figure 4. AutoBench4 with SampleSense *FAST* UHT-C system was used to hold the single quad ICPMS.

Copper and Zinc Calibration – Analytical Measurement Range (AMR) 50-5000 µg/L

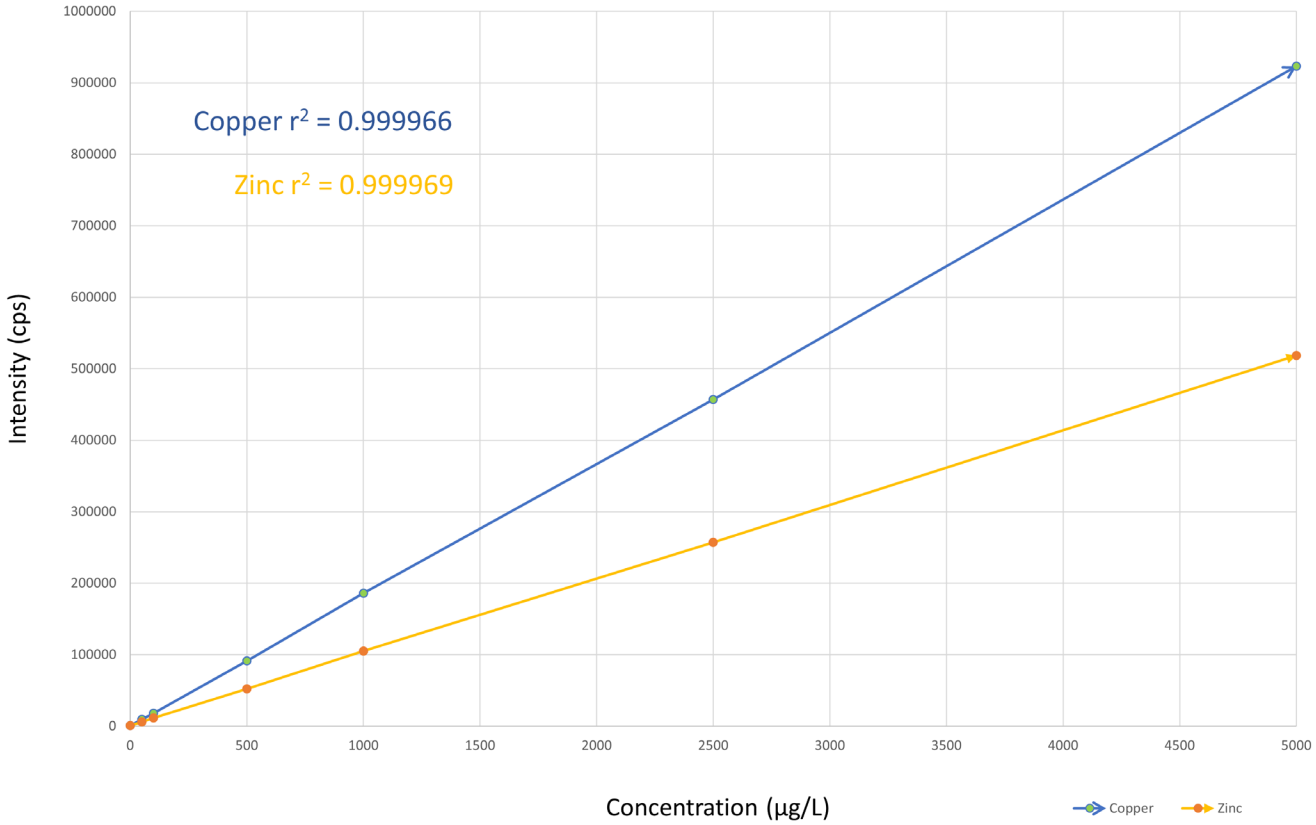


Figure 5. Calibration results demonstrated excellent precision and accuracy for both copper and zinc when aqueous calibrators were pipetted and prepared using the **TRAX**Station Clinical automated platform. Measured concentrations closely matched target values, and all Correlation Coefficients were 0.999 or better, indicating minimal bias and strong agreement with expected results. Together, these findings validate that **TRAX**Station Clinical delivers consistent, contamination-free preparation, ensuring reliable quantitation of copper and zinc in clinical testing workflows.

Summary Results

Serum copper (Cu) and zinc (Zn) were quantified using validated ICPMS methodology following automated preparation on the **TRAX**Station Clinical platform. Results demonstrated exceptional analytical performance, with both elements showing excellent precision and accuracy across the reportable range.

Table 7. Copper serum results.

	Low Concentration	Normal Concentration	High Concentration
Average	268.9 µg/L	1003.9 µg/L	2562.2 µg/L
Standard Deviation	2.86 µg/L	7.70 µg/L	22.49 µg/L
Intra-Assay Precision	1.26% CV	1.34% CV	1.38% CV
Inter-Assay Precision	1.06% CV	0.77% CV	0.88% CV

Table 8. Zinc serum results.

	Low Concentration	Normal Concentration	High Concentration
Average	267.5 µg/L	1002.1 µg/L	2581.0 µg/L
Standard Deviation	3.32 µg/L	9.69 µg/L	38.40 µg/L
Intra-Assay Precision	1.46% CV	1.31% CV	1.39% CV
Inter-Assay Precision	1.24% CV	0.97% CV	1.49% CV

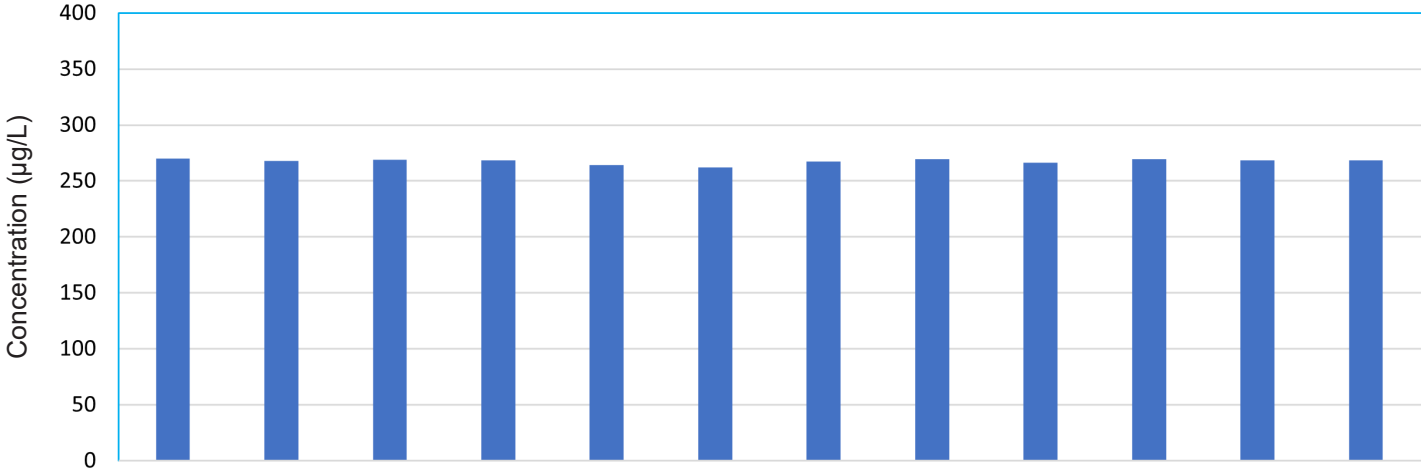
The **TRAX**Station Clinical 221 platform was used in this experiment. This compact version delivers the full power of automated sample preparation in a smaller footprint – ideal for laboratories with limited bench space. It automates uncapping, mixing, pipetting, and dilution steps to eliminate manual variability, improve reproducibility, and protect sample integrity through contamination-free, metal-inert processing. With intuitive LabSymphony software, barcode tracking, and flexible rack configurations, the **TRAX**Station Clinical 221 integrates seamlessly into existing ICPMS workflows while reducing labor, consumable costs, and operator exposure. Despite its smaller size, it provides high-throughput performance, superior consistency, and enhanced laboratory safety – all in a compact, efficient design.

Figure 6. **TRAX**Station Clinical 221.

See raw data on the following pages.

Copper Inter and Intra-Assay Data – Low Concentration (625 data points)

(Each bar represents the average of 25 data points)



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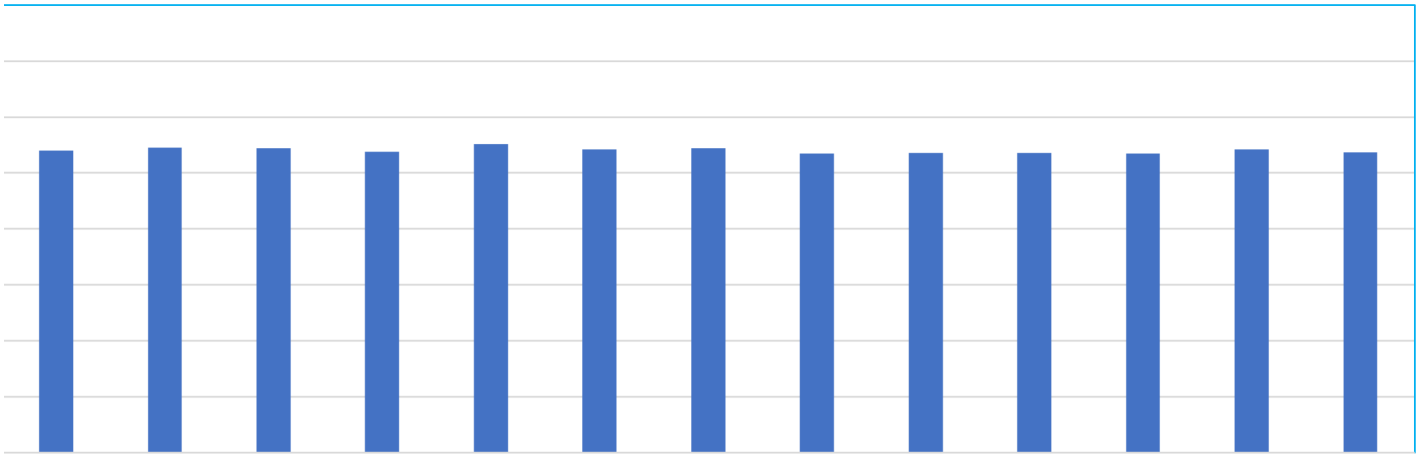
	266	267	270	267	258	257	267	266	260	264	263	256
	273	267	269	265	264	261	268	268	257	267	266	267
	271	269	270	264	270	263	263	273	261	268	270	269
Ave.	**269.8**	**267.9**	**269.1**	**268.2**	**264.4**	**262.0**	**267.5**	**269.5**	**266.5**	**269.2**	**268.5**	**268.4**
SD	**3.22**	**2.27**	**3.18**	**2.72**	**5.16**	**3.11**	**2.62**	**4.35**	**4.33**	**3.79**	**2.43**	**3.51**
CV	**1.19%**	**0.85%**	**1.18%**	**1.01%**	**1.95%**	**1.19%**	**0.98%**	**1.62%**	**1.63%**	**1.41%**	**0.90%**	**1.31%**

Copper Inter and Intra-Assay Data – Low Concentration (625 data points) *(Continued)*



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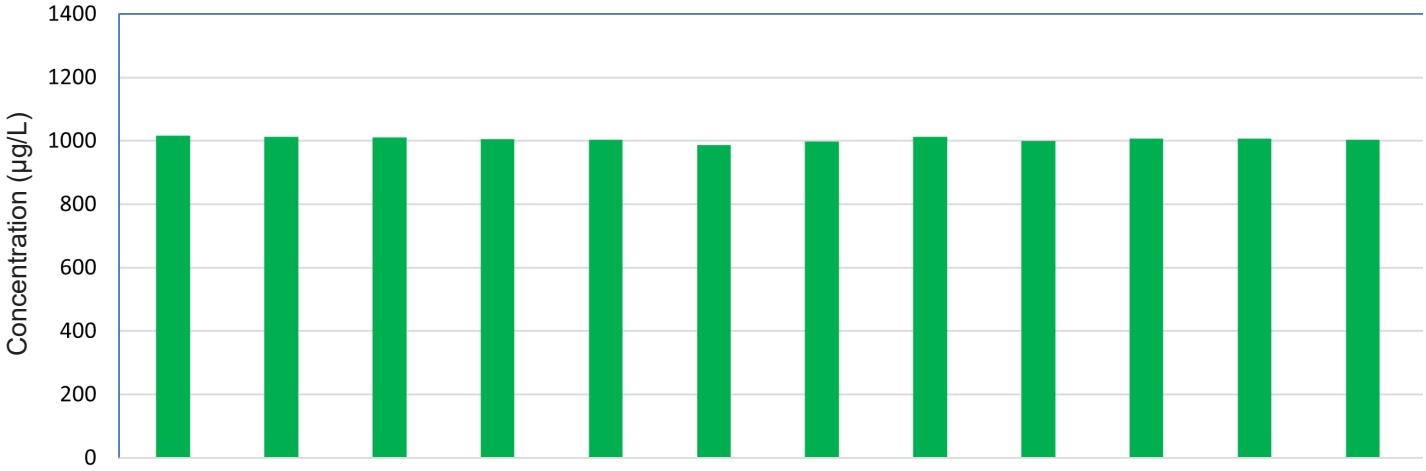
273	268	281	272	276	269	270	263	271	270	265	266	267
269.7	**272.4**	**272.2**	**268.9**	**275.6**	**270.8**	**271.9**	**267.1**	**267.9**	**267.7**	**267.6**	**270.9**	**268.6**
3.42	**2.44**	**3.34**	**3.13**	**5.31**	**2.96**	**4.25**	**2.89**	**2.95**	**3.09**	**3.45**	**2.52**	**2.81**
1.27%	**0.90%**	**1.23%**	**1.16%**	**1.93%**	**1.09%**	**1.56%**	**1.08%**	**1.10%**	**1.16%**	**1.29%**	**0.93%**	**1.04%**

Figure 7. Results of low concentration copper measured by ICPMS (m/z 65). Each number 1-25 corresponds to a batch. The graph above each number shows the average, and the numbers below it show the individual sample data from the batch.

Copper Inter and Intra-Assay Data – Normal Concentration (625 data points)

(Each bar represents the average of 25 data points)



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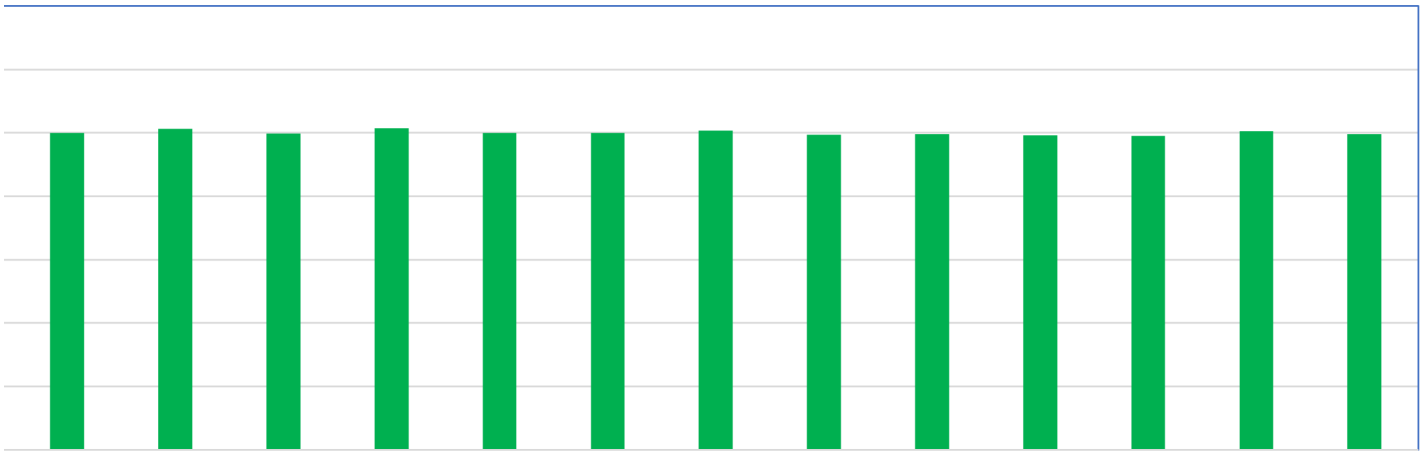
	977	970	974	979	968	961	955	979	968	977	988	974
Ave.	**1016.6**	**1012.6**	**1010.3**	**1005.0**	**1004.2**	**985.8**	**998.0**	**1011.7**	**999.2**	**1006.2**	**1007.6**	**1002.5**
SD	**13.35**	**13.20**	**12.88**	**9.46**	**13.22**	**14.41**	**16.63**	**13.92**	**12.33**	**11.43**	**11.90**	**15.80**
CV	**1.31%**	**1.30%**	**1.28%**	**0.94%**	**1.32%**	**1.46%**	**1.67%**	**1.38%**	**1.23%**	**1.14%**	**1.18%**	**1.58%**

Copper Inter and Intra-Assay Data – Normal Concentration (625 data points) *(Continued)*



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997	1030	1033	1018	1018	1012	1011	994	1009	1003	995	1008	989
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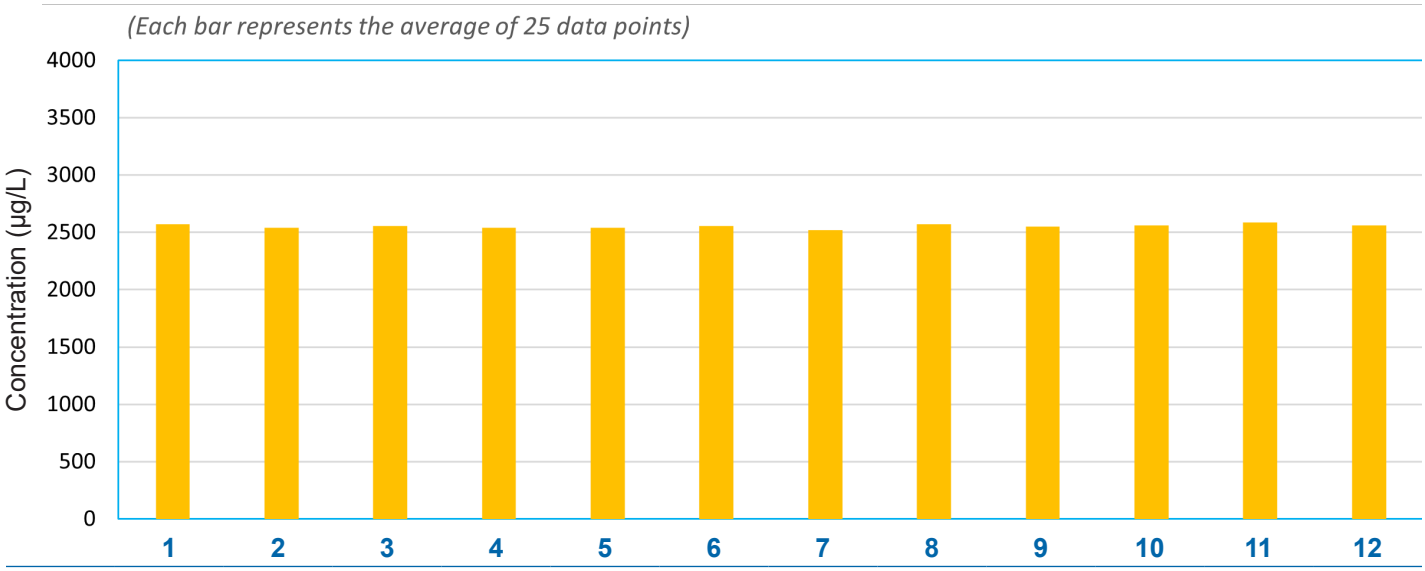
977	1004	961	978	993	983	992	986	980	983	974	979	957
971	982	962	971	986	975	979	972	972	964	936	975	960
1000.0	**1012.6**	**997.0**	**1015.0**	**1000.1**	**999.8**	**1006.2**	**994.4**	**996.8**	**992.0**	**989.6**	**1006.0**	**996.0**
11.58	**13.02**	**27.70**	**14.98**	**8.82**	**18.10**	**9.75**	**9.27**	**11.44**	**11.52**	**15.14**	**12.19**	**14.04**
1.16%	**1.29%**	**2.78%**	**1.48%**	**0.88%**	**1.81%**	**0.97%**	**0.93%**	**1.15%**	**1.16%**	**1.53%**	**1.21%**	**1.41%**

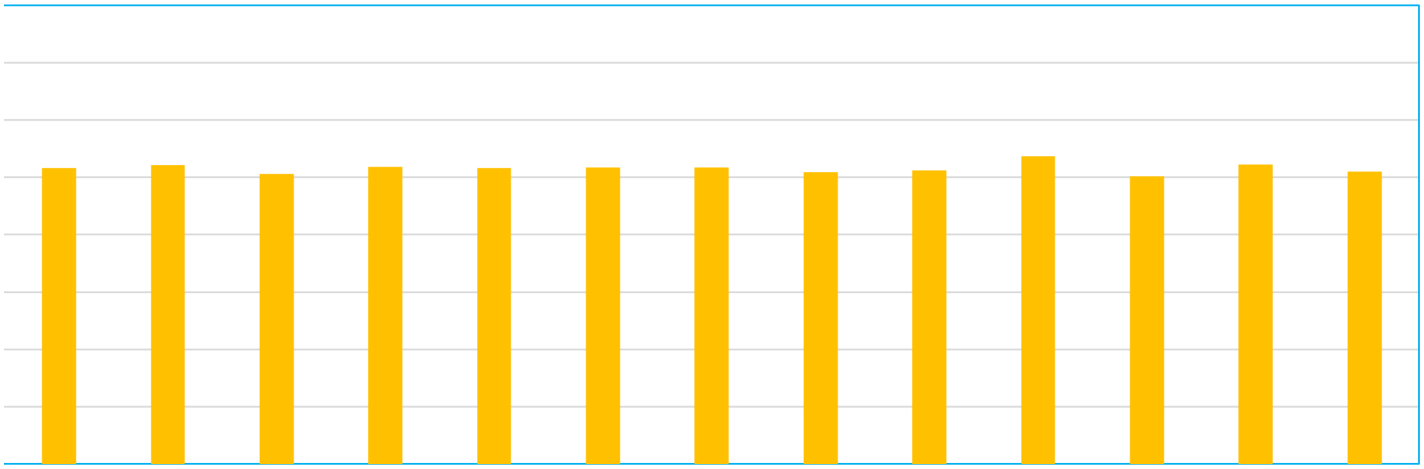
Figure 8. Results of normal concentration copper measured by ICPMS (m/z 65). Each number 1-25 corresponds to a batch. The graph above each number shows the average, and the numbers below it show the individual sample data from the batch.

Copper Inter and Intra-Assay Data – High Concentration (625 data points)



	1	2	3	4	5	6	7	8	9	10	11	12
	2557	2559	2568	2563	2486	2552	2546	2569	2539	2567	2589	2542
	2561	2550	2597	2539	2538	2499	2548	2627	2553	2562	2574	2545
	2554	2508	2557	2545	2556	2537	2522	2459	2487	2533	2589	2535
	2557	2489	2561	2554	2526	2541	2568	2586	2554	2559	2573	2573
	2582	2508	2541	2567	2578	2506	2578	2575	2377	2572	2581	2548
	2579	2536	2536	2539	2588	2565	2464	2570	2541	2601	2573	2564
	2596	2496	2583	2543	2538	2552	2490	2593	2534	2498	2560	2542
	2572	2531	2537	2550	2497	2563	2395	2575	2545	2587	2574	2559
	2597	2533	2598	2575	2549	2570	2503	2631	2502	2565	2579	2588
	2594	2568	2569	2546	2512	2543	2510	2569	2524	2614	2583	2569
	2590	2575	2453	2549	2501	2551	2494	2317	2503	2549	2601	2564
	2579	2541	2587	2542	2578	2575	2495	2566	2572	2527	2560	2588
	2497	2540	2553	2547	2513	2561	2557	2599	2578	2551	2618	2551
	2567	2541	2567	2445	2518	2525	2544	2585	2584	2541	2592	2555
	2590	2544	2532	2474	2426	2644	2494	2423	2552	2545	2583	2542
	2539	2565	2569	2389	2542	2551	2548	2578	2537	2599	2590	2548
	2580	2539	2535	2530	2552	2570	2558	2554	2613	2567	2557	2538
	2588	2529	2576	2541	2527	2591	2527	2594	2537	2557	2599	2597
	2599	2557	2577	2595	2570	2477	2528	2612	2552	2556	2604	2570
	2607	2561	2547	2559	2540	2550	2576	2629	2594	2585	2584	2558
	2575	2545	2569	2551	2593	2563	2533	2624	2589	2593	2617	2529
	2588	2579	2560	2538	2545	2587	2502	2625	2597	2545	2585	2568
	2594	2562	2473	2545	2564	2527	2433	2598	2587	2506	2616	2548
	2502	2497	2499	2547	2529	2584	2565	2628	2628	2580	2622	2579
	2470	2557	2588	2575	2600	2572	2501	2621	2576	2573	2606	2606
Ave.	**2568.5**	**2540.3**	**2553.3**	**2537.8**	**2538.7**	**2554.2**	**2519.1**	**2572.2**	**2550.2**	**2561.4**	**2588.3**	**2560.3**
SD	**33.62**	**24.40**	**34.84**	**41.89**	**37.58**	**32.49**	**43.48**	**70.79**	**49.07**	**27.65**	**17.96**	**19.64**
CV	**1.31%**	**0.96%**	**1.36%**	**1.65%**	**1.48%**	**1.27%**	**1.73%**	**2.75%**	**1.92%**	**1.08%**	**0.69%**	**0.77%**

Copper Inter and Intra-Assay Data – High Concentration (625 data points) *(Continued)*

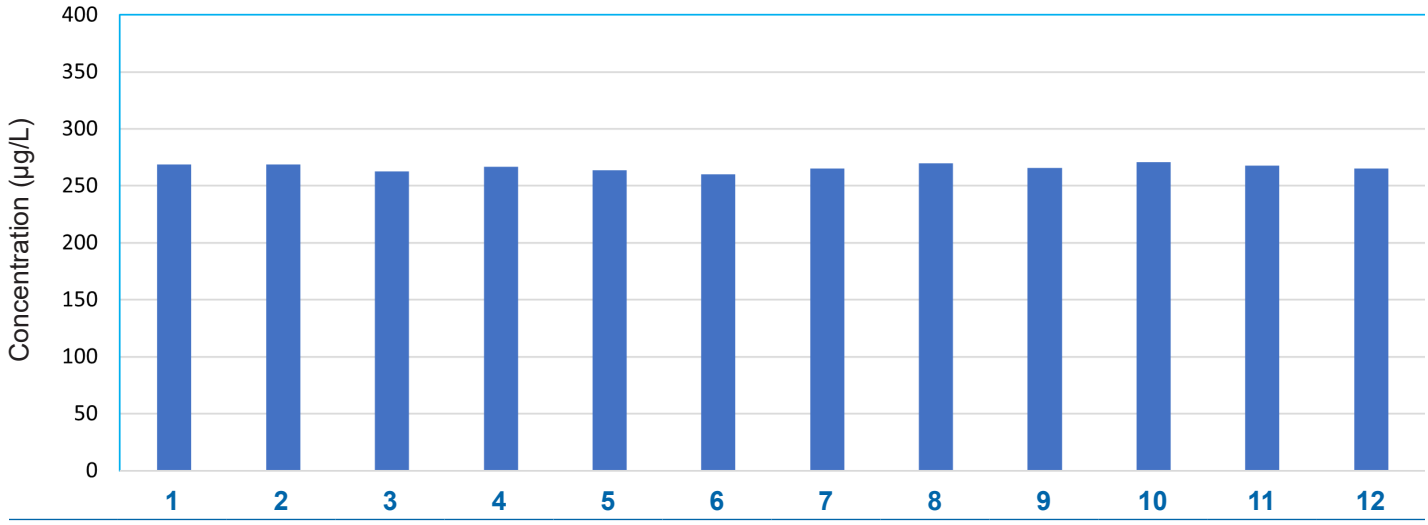


13	14	15	16	17	18	19	20	21	22	23	24	25
2598	2622	2458	2578	2545	2539	2561	2546	2560	2660	2535	2628	2518
2569	2601	2433	2587	2583	2573	2606	2536	2549	2691	2490	2644	2579
2582	2601	2512	2572	2558	2578	2608	2528	2573	2651	2520	2626	2532
2636	2635	2543	2586	2540	2586	2604	2557	2558	2757	2547	2597	2557
2587	2599	2510	2565	2546	2564	2568	2579	2597	2654	2531	2578	2576
2627	2599	2513	2496	2623	2608	2566	2539	2573	2697	2513	2672	2574
2571	2617	2552	2605	2524	2587	2563	2536	2582	2663	2545	2659	2579
2561	2586	2525	2617	2607	2578	2551	2528	2545	2669	2397	2637	2488
2628	2498	2547	2581	2598	2588	2601	2521	2554	2683	2524	2628	2590
2408	2572	2507	2616	2602	2608	2586	2571	2562	2635	2449	2519	2597
2607	2595	2530	2553	2545	2564	2578	2534	2588	2693	2488	2587	2561
2543	2635	2573	2593	2561	2577	2576	2546	2557	2686	2521	2624	2524
2644	2580	2582	2646	2610	2600	2541	2536	2560	2694	2512	2608	2536
2482	2638	2585	2608	2564	2595	2584	2588	2568	2702	2534	2490	2468
2591	2597	2516	2582	2547	2601	2551	2566	2401	2699	2507	2629	2581
2613	2635	2561	2588	2577	2544	2568	2512	2542	2693	2535	2530	2476
2606	2614	2457	2438	2502	2604	2587	2510	2553	2694	2500	2640	2561
2609	2626	2518	2601	2628	2578	2580	2541	2580	2667	2498	2683	2594
2638	2590	2497	2609	2606	2614	2591	2561	2558	2666	2548	2684	2599
2633	2629	2567	2615	2601	2576	2581	2557	2474	2697	2485	2605	2526
2498	2611	2564	2646	2598	2621	2653	2576	2563	2642	2385	2627	2543
2559	2572	2559	2640	2600	2630	2640	2559	2578	2691	2491	2657	2535
2588	2610	2564	2590	2628	2561	2612	2576	2602	2706	2563	2599	2554
2605	2613	2528	2627	2606	2577	2581	2568	2578	2695	2588	2593	2539
2612	2637	2550	2586	2602	2550	2574	2521	2610	2737	2467	2604	2580
2583.8	**2604.5**	**2530.0**	**2589.0**	**2579.9**	**2584.1**	**2584.5**	**2547.7**	**2558.7**	**2685.0**	**2507.0**	**2613.9**	**2550.7**
53.46	**29.40**	**38.60**	**43.76**	**33.75**	**22.87**	**25.69**	**21.50**	**40.87**	**26.84**	**45.43**	**46.79**	**36.01**
2.07%	**1.13%**	**1.53%**	**1.69%**	**1.31%**	**0.88%**	**0.99%**	**0.84%**	**1.60%**	**1.00%**	**1.81%**	**1.79%**	**1.41%**

Figure 9. Results of high concentration copper measured by ICPMS (m/z 65). Each number 1-25 corresponds to a batch. The graph above each number shows the average, and the numbers below it show the individual sample data from the batch.

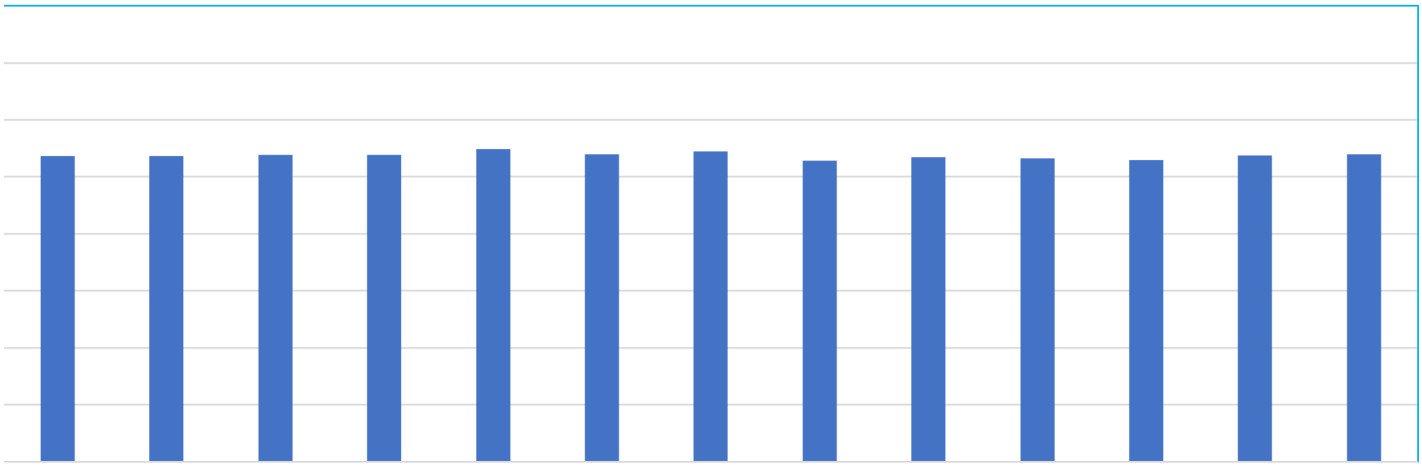
Zinc Inter and Intra-Assay Data – Low Concentration (625 data points)

(Each bar represents the average of 25 data points)



	1	2	3	4	5	6	7	8	9	10	11	12
	274	262	256	268	269	263	269	272	272	275	270	267
	275	269	266	274	270	266	272	271	260	275	268	262
	272	267	259	267	263	257	266	271	267	270	269	271
	266	269	258	271	273	264	266	274	264	275	268	259
	274	271	258	268	270	265	272	273	265	268	263	267
	269	268	262	268	267	265	267	274	263	276	271	269
	268	271	267	270	254	262	263	270	270	271	269	270
	263	271	258	267	255	260	266	273	267	269	270	270
	270	269	258	262	269	260	269	269	267	273	267	268
	269	268	266	271	254	261	267	270	265	271	268	263
	266	266	260	261	271	252	265	266	270	268	269	268
	267	266	262	262	260	260	265	268	264	269	269	261
	274	267	263	264	263	259	264	260	259	266	266	263
	262	267	262	274	264	261	261	264	264	272	269	266
	267	274	263	265	261	260	264	260	267	274	267	263
	268	276	266	261	260	261	270	270	265	270	264	270
	267	271	266	267	265	259	267	275	268	271	268	271
	268	265	261	266	260	253	259	272	267	271	266	262
	266	268	261	264	264	257	260	273	271	271	265	266
	274	260	265	266	267	257	259	271	261	272	267	262
	275	266	268	265	267	267	263	265	270	270	267	272
	261	273	262	268	259	258	261	269	269	269	264	265
	266	272	261	266	256	250	265	271	257	267	260	257
	270	267	266	262	263	259	267	264	262	269	270	263
	270	269	269	264	267	264	260	274	267	268	274	260
Ave.	**268.8**	**268.6**	**262.5**	**266.5**	**263.6**	**260.1**	**265.0**	**269.5**	**265.7**	**270.7**	**267.6**	**265.3**
SD	**3.93**	**3.43**	**3.44**	**3.54**	**5.29**	**4.18**	**3.68**	**4.12**	**3.71**	**2.72**	**2.76**	**4.13**
CV	**1.46%**	**1.28%**	**1.31%**	**1.33%**	**2.01%**	**1.61%**	**1.39%**	**1.53%**	**1.40%**	**1.01%**	**1.03%**	**1.55%**

Zinc Inter and Intra-Assay Data – Low Concentration (625 data points) *(Continued)*

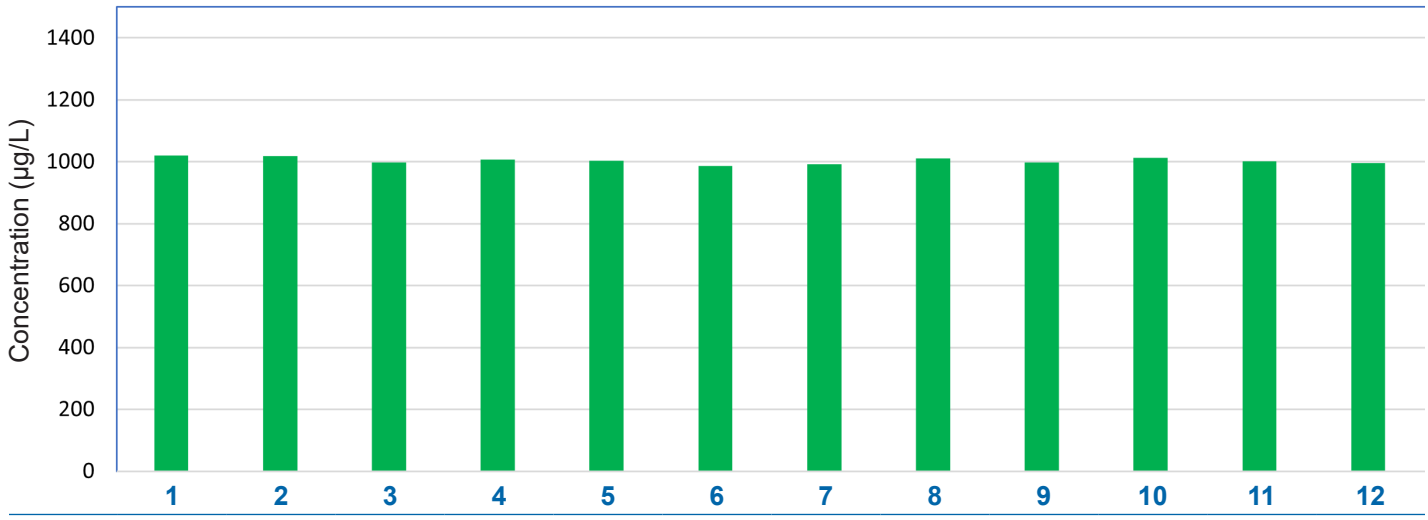


13	14	15	16	17	18	19	20	21	22	23	24	25
268	264	266	267	274	276	275	269	272	261	259	265	272
276	264	266	273	287	269	270	266	269	268	270	286	268
268	265	266	263	273	276	279	262	270	266	260	261	271
268	265	273	267	280	269	265	272	267	266	262	271	270
273	269	274	266	281	269	279	273	267	272	269	266	270
260	271	269	269	276	262	288	265	264	264	270	265	264
273	267	270	273	276	271	279	262	265	266	266	269	269
264	266	273	273	277	272	278	270	267	268	260	265	268
270	269	259	264	273	269	279	263	268	261	273	266	268
270	271	269	262	271	267	271	258	264	260	261	261	267
264	271	270	266	275	272	274	257	265	266	264	265	270
258	269	269	270	276	271	268	261	266	269	268	274	270
268	266	272	268	281	272	274	268	265	268	266	264	265
269	268	271	272	274	266	273	261	275	268	266	266	272
274	271	274	268	268	274	271	264	271	267	273	270	272
271	269	270	272	275	268	276	262	264	270	268	270	276
269	272	269	269	275	265	261	263	274	268	260	270	273
273	271	271	273	272	271	275	270	267	270	262	269	264
269	270	270	272	275	272	275	262	267	265	271	274	271
271	272	272	270	272	272	267	265	267	264	261	272	269
272	268	272	264	267	269	269	257	266	271	264	269	268
270	270	266	273	277	266	271	261	263	263	258	272	269
265	266	263	269	258	274	264	267	261	262	270	270	268
256	267	269	265	275	266	266	266	265	269	263	268	271
267	268	272	276	268	262	266	263	265	266	257	269	277
268.3	**268.4**	**269.4**	**269.0**	**274.3**	**269.6**	**272.5**	**264.4**	**267.0**	**266.3**	**264.8**	**268.8**	**269.7**
4.81	**2.46**	**3.49**	**3.72**	**5.40**	**3.59**	**5.87**	**4.27**	**3.34**	**3.11**	**4.77**	**4.96**	**3.06**
1.79%	**0.92%**	**1.29%**	**1.38%**	**1.97%**	**1.33%**	**2.15%**	**1.61%**	**1.25%**	**1.17%**	**1.80%**	**1.85%**	**1.14%**

Figure 10. Results of low concentration zinc measured by ICPMS (m/z 66). Each number 1-25 corresponds to a batch. The graph above each number shows the average, and the numbers below it show the individual sample data from the batch.

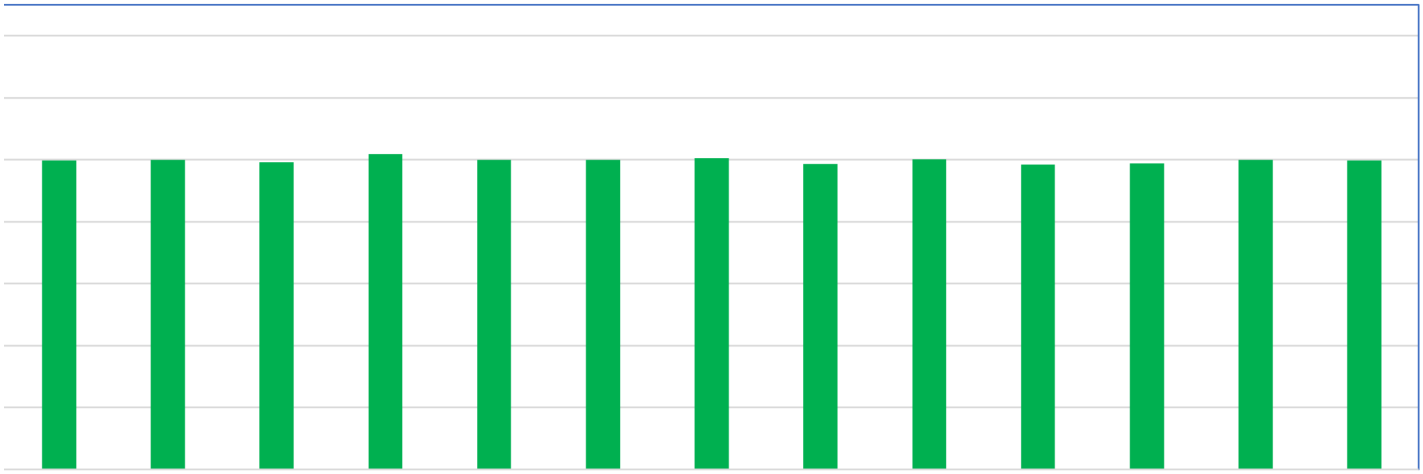
Zinc Inter and Intra-Assay Data – Normal Concentration (625 data points)

(Each bar represents the average of 25 data points)



	1	2	3	4	5	6	7	8	9	10	11	12
	1019	1023	1000	1005	1012	948	995	999	996	1014	1014	1000
	1023	1039	1020	1016	1009	993	998	1020	1010	1011	1007	1008
	1017	1001	997	1007	1013	991	998	1029	1001	1036	1012	1019
	1019	1019	1015	998	1010	994	984	1031	1001	1015	1003	1015
	1000	1028	980	1008	1000	991	988	1010	1002	1013	1001	988
	1027	1004	993	1021	1002	979	989	1018	1010	1013	986	980
	1014	1023	1010	1005	1020	989	985	1011	1004	998	999	993
	1017	1027	1005	1015	1014	997	982	1014	1010	1000	1003	1000
	1026	1022	1008	993	1014	1001	995	1012	1012	1016	1001	978
	1022	1028	1014	994	1012	988	1001	1018	1011	1012	1007	1006
	1026	1028	993	1010	1000	981	987	1020	998	1009	997	999
	1033	1026	1014	1015	999	987	1000	1021	1010	1029	1011	994
	1038	1019	1011	1019	1001	973	995	993	1006	997	996	1000
	1022	1022	1008	1011	1015	976	1011	1021	1008	1017	1019	994
	1019	1027	995	1021	997	983	991	1009	987	1016	990	981
	1033	1024	988	1010	1002	991	1009	1010	998	1006	1010	994
	1032	1030	1013	1004	1004	980	1000	1025	988	1022	1007	984
	1034	1014	1006	999	997	1001	992	1009	1004	1025	1001	1011
	1037	1017	996	1019	1009	991	991	1007	1007	1019	993	993
	1009	1026	999	1018	1003	993	1008	1003	1009	1009	998	1026
	1020	1025	990	991	1003	986	980	1011	984	1020	1006	983
	1036	993	1006	999	1010	1017	1020	1019	971	1025	997	985
	1020	1033	986	1003	1005	984	1003	1016	985	1016	1005	981
	993	990	954	994	972	963	970	979	984	1000	983	989
	978	967	965	983	974	969	947	982	963	984	975	986
Ave.	**1020.5**	**1018.1**	**998.7**	**1006.3**	**1003.8**	**985.8**	**992.7**	**1011.5**	**998.3**	**1012.9**	**1000.9**	**995.5**
SD	**13.74**	**15.59**	**15.30**	**10.15**	**10.94**	**13.36**	**14.08**	**12.55**	**12.81**	**11.00**	**9.83**	**12.69**
CV	**1.35%**	**1.53%**	**1.53%**	**1.01%**	**1.09%**	**1.35%**	**1.42%**	**1.24%**	**1.28%**	**1.09%**	**0.98%**	**1.27%**

Zinc Inter and Intra-Assay Data – Normal Concentration (625 data points) *(Continued)*

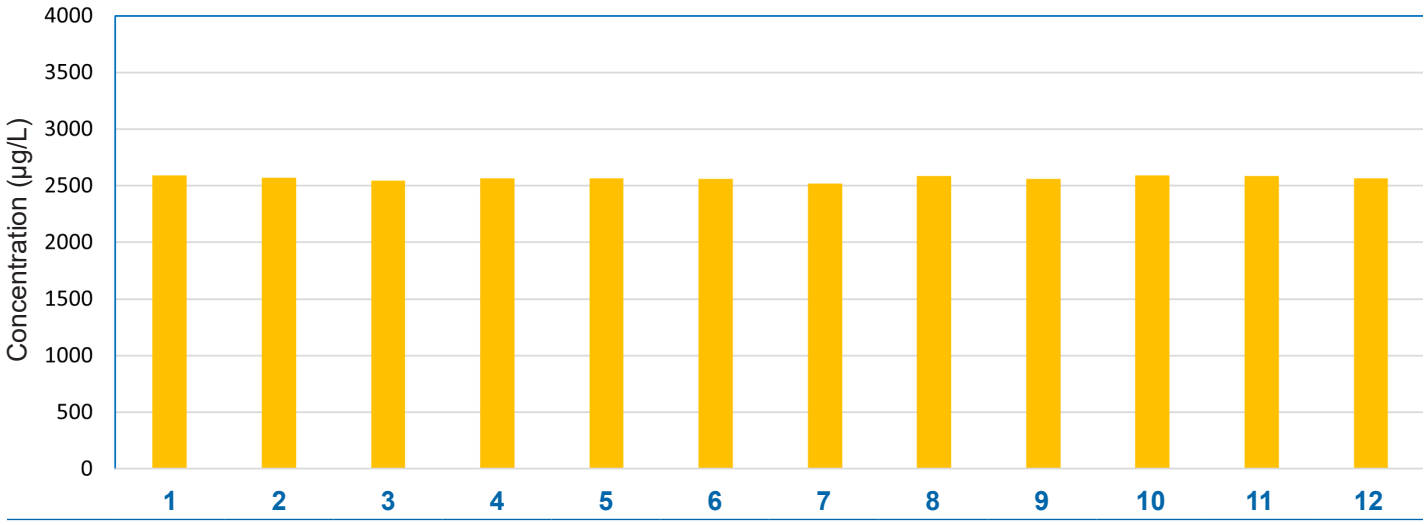


13	14	15	16	17	18	19	20	21	22	23	24	25
999	1002	1013	1002	1006	1002	1013	994	994	985	990	988	1004
1008	1017	1015	1028	1009	1020	1026	1003	1008	1019	1012	1024	1012
1007	1003	1019	1027	1022	1020	1008	997	997	988	984	1007	997
1014	1024	1010	1030	1009	1017	1020	980	1015	1000	1000	1008	1001
989	1007	1010	1016	966	998	999	988	1003	970	983	999	989
997	968	1005	1019	992	1002	1018	982	993	981	992	983	996
983	1002	1007	1013	992	987	997	984	1003	989	1008	998	990
994	992	1026	1010	986	993	1011	966	989	986	989	999	986
1004	999	1012	1003	990	1010	1000	987	997	1000	994	994	997
1001	1006	992	1017	997	938	993	985	992	972	976	1010	1006
980	1008	986	1022	1010	1013	1011	984	984	995	998	1000	997
1010	1008	970	1034	1018	1002	1015	966	995	1009	988	991	993
999	1009	990	1039	995	989	1011	997	996	1005	967	1007	994
980	1007	982	1017	1018	1020	1012	997	1002	978	1001	1001	1010
997	992	994	1036	1004	1000	1016	987	980	982	998	1003	995
1001	1000	989	1019	999	1001	1016	996	1024	980	984	980	1005
988	998	995	1026	1004	1012	994	1011	1031	969	971	1004	997
1019	1007	976	1026	994	986	1015	983	1013	990	988	1011	1007
1010	981	985	1004	1004	1002	1011	1000	1007	983	975	1011	1001
1028	1004	986	1030	981	987	989	986	1007	982	983	996	986
999	1001	970	1018	992	1012	1005	987	1008	972	999	993	1004
995	999	946	1012	1010	998	1008	981	1007	967	985	1014	1024
984	993	1000	1022	1010	998	1002	993	1009	975	1012	1007	1007
986	990	967	989	991	993	988	977	984	970	980	985	969
979	969	944	980	989	977	974	971	977	965	947	978	967
998.0	**999.4**	**991.5**	**1017.6**	**999.6**	**999.0**	**1006.1**	**987.2**	**1000.6**	**984.5**	**988.2**	**999.6**	**997.4**
12.43	**12.51**	**20.87**	**13.73**	**12.53**	**16.84**	**11.76**	**10.68**	**12.77**	**13.75**	**14.17**	**11.15**	**12.05**
1.25%	**1.25%**	**2.10%**	**1.35%**	**1.25%**	**1.69%**	**1.17%**	**1.08%**	**1.28%**	**1.40%**	**1.43%**	**1.12%**	**1.21%**

Figure 11. Results of normal concentration zinc measured by ICPMS (m/z 66). Each number 1-25 corresponds to a batch. The graph above each number shows the average, and the numbers below it show the individual sample data from the batch.

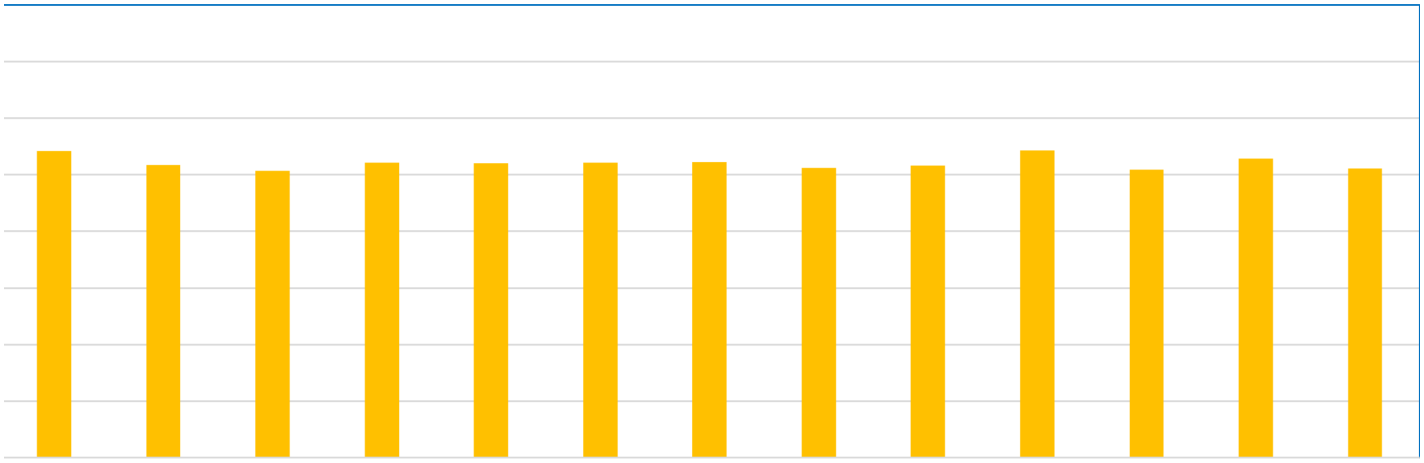
Zinc Inter and Intra-Assay Data – High Concentration (625 data points)

(Each bar represents the average of 25 data points)



	1	2	3	4	5	6	7	8	9	10	11	12
	2592	2598	2570	2579	2500	2533	2550	2587	2557	2605	2582	2520
	2573	2582	2602	2562	2565	2517	2546	2629	2568	2594	2582	2554
	2566	2527	2575	2564	2576	2554	2510	2480	2496	2597	2571	2554
	2576	2532	2555	2553	2552	2581	2546	2583	2570	2578	2568	2571
	2597	2568	2540	2572	2586	2520	2564	2577	2372	2588	2584	2571
	2591	2558	2540	2565	2620	2563	2453	2570	2544	2633	2575	2560
	2620	2507	2556	2563	2555	2561	2506	2600	2541	2537	2570	2563
	2575	2564	2526	2583	2525	2574	2403	2564	2560	2636	2589	2578
	2633	2552	2559	2593	2584	2560	2507	2646	2521	2598	2568	2586
	2600	2603	2564	2576	2553	2561	2520	2581	2527	2638	2598	2576
	2602	2603	2460	2591	2551	2549	2495	2343	2527	2583	2603	2564
	2591	2572	2590	2581	2604	2589	2491	2603	2581	2548	2550	2582
	2535	2558	2575	2569	2554	2559	2543	2597	2598	2582	2623	2554
	2585	2552	2547	2480	2571	2522	2527	2602	2601	2558	2597	2545
	2618	2568	2524	2505	2458	2640	2512	2452	2543	2579	2577	2558
	2594	2566	2567	2425	2567	2559	2548	2591	2549	2628	2570	2535
	2580	2553	2500	2557	2577	2578	2542	2573	2620	2591	2565	2545
	2614	2552	2545	2596	2544	2599	2508	2604	2549	2600	2578	2588
	2623	2609	2566	2612	2609	2471	2530	2616	2571	2606	2613	2579
	2644	2606	2538	2586	2563	2587	2570	2621	2601	2594	2591	2688
	2577	2584	2550	2566	2611	2571	2525	2672	2573	2629	2602	2519
	2588	2611	2558	2570	2559	2586	2518	2632	2603	2587	2590	2557
	2620	2577	2458	2598	2610	2541	2448	2643	2615	2526	2627	2534
	2527	2557	2502	2596	2548	2584	2566	2628	2652	2601	2621	2564
	2506	2593	2569	2604	2610	2582	2488	2620	2578	2612	2593	2611
Ave.	**2589.1**	**2570.1**	**2545.3**	**2565.9**	**2566.0**	**2561.7**	**2516.8**	**2584.5**	**2560.7**	**2593.0**	**2587.4**	**2566.2**
SD	**31.554**	**26.378**	**34.623**	**40.134**	**36.074**	**32.458**	**38.419**	**67.477**	**51.907**	**28.540**	**19.257**	**32.489**
CV	**1.22%**	**1.03%**	**1.36%**	**1.56%**	**1.41%**	**1.27%**	**1.53%**	**2.61%**	**2.03%**	**1.10%**	**0.74%**	**1.27%**

Zinc Inter and Intra-Assay Data – High Concentration (625 data points) *(Continued)*



13	14	15	16	17	18	19	20	21	22	23	24	25
2737	2612	2450	2593	2578	2552	2602	2543	2587	2717	2533	2639	2540
2732	2564	2453	2612	2621	2606	2650	2551	2580	2728	2526	2638	2599
2707	2568	2513	2593	2602	2609	2630	2541	2605	2708	2538	2642	2555
2769	2611	2553	2572	2566	2607	2622	2559	2599	2787	2557	2635	2605
2697	2585	2511	2591	2558	2560	2590	2574	2594	2692	2548	2625	2590
2775	2583	2532	2517	2619	2639	2602	2560	2600	2738	2528	2695	2585
2693	2597	2556	2623	2556	2616	2596	2541	2608	2736	2572	2687	2582
2701	2545	2527	2633	2619	2601	2580	2547	2609	2677	2414	2684	2481
2740	2475	2559	2605	2609	2600	2633	2557	2580	2699	2560	2650	2623
2529	2570	2495	2633	2605	2613	2632	2570	2566	2673	2490	2553	2622
2735	2597	2527	2556	2579	2614	2639	2567	2599	2731	2483	2618	2577
2663	2622	2571	2636	2586	2604	2610	2585	2589	2684	2557	2665	2394
2762	2562	2571	2647	2615	2628	2586	2568	2594	2728	2525	2635	2561
2588	2638	2580	2629	2612	2636	2616	2591	2595	2747	2567	2521	2478
2725	2579	2524	2610	2581	2633	2586	2577	2426	2725	2542	2665	2616
2712	2610	2534	2572	2591	2549	2557	2510	2564	2723	2540	2568	2488
2719	2598	2464	2470	2534	2619	2599	2503	2569	2710	2522	2667	2557
2732	2621	2508	2614	2646	2611	2613	2559	2588	2663	2542	2739	2610
2773	2560	2513	2635	2632	2649	2605	2570	2592	2670	2553	2711	2629
2744	2582	2578	2625	2645	2574	2600	2548	2505	2724	2679	2631	2533
2635	2596	2572	2684	2617	2669	2653	2590	2588	2661	2514	2667	2579
2698	2560	2561	2637	2630	2654	2659	2557	2596	2700	2580	2673	2415
2717	2594	2580	2608	2634	2570	2624	2583	2611	2746	2561	2625	2562
2729	2594	2523	2622	2613	2584	2623	2561	2594	2721	2621	2630	2541
2760	2588	2570	2608	2599	2571	2568	2558	2618	2782	2527	2642	2593
2710.8	**2584.4**	**2532.9**	**2605.0**	**2602.0**	**2606.7**	**2611.0**	**2558.8**	**2582.3**	**2714.8**	**2543.2**	**2644.3**	**2556.6**
55.836	**31.505**	**38.107**	**42.506**	**28.378**	**30.978**	**25.470**	**20.844**	**38.450**	**32.620**	**46.556**	**46.276**	**61.129**
2.06%	**1.22%**	**1.50%**	**1.63%**	**1.09%**	**1.19%**	**0.98%**	**0.81%**	**1.49%**	**1.20%**	**1.83%**	**1.75%**	**2.39%**

Figure 12. Results of high concentration zinc measured by ICPMS (m/z 66). Each number 1-25 corresponds to a batch. The graph above each number shows the average, and the numbers below it show the individual sample data from the batch.

Conclusion

The **TRAX**Station Clinical Automated Multifunctional Liquid Handling System demonstrated performance that surpassed expected analytical targets for both accuracy and precision. Measured values consistently aligned over extended periods of time indicating minimal systematic error and confirming high method accuracy. Replicate analyses showed very low variability, with relative standard deviations well below acceptance criteria, reflecting exceptional precision. Collectively, the data provide strong evidence of method robustness and reliability, exceeding established quality benchmarks and reinforcing confidence in both the measurement process and resulting conclusions.

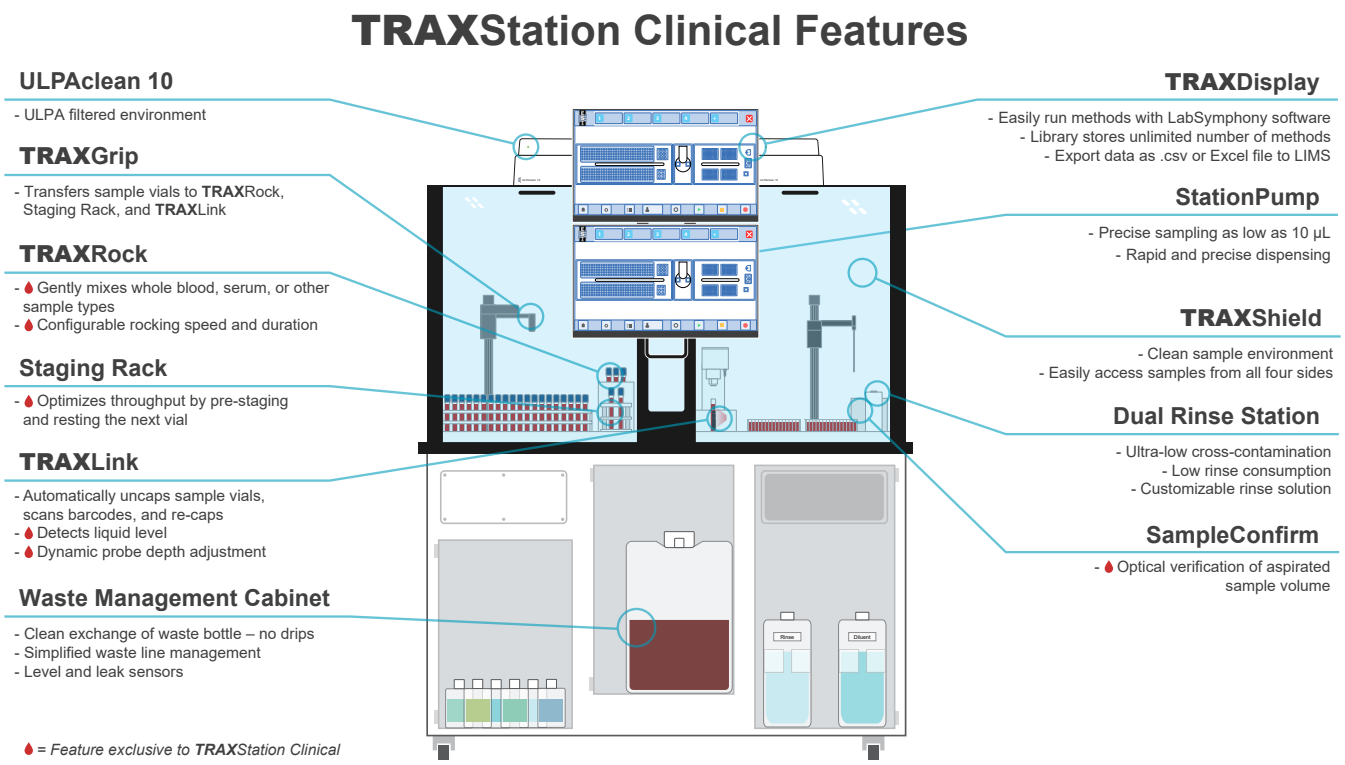


Figure 13. **TRAX**Station Clinical features diagram. **TRAX**Station Clinical is available in several form-factors to match laboratory throughput requirements. These include **TRAX**Station 221, 422, and 442.