Authors: Patrick Messina, Libbie Smith

Automated Blood Pb Sample Preparation into 96-Well Plates with 16-Second ICPMS Analysis

Transitioning whole blood lead (Pb) testing from individual tubes to 96-well plates provides significant operational and economic benefits for clinical laboratories. The **TRAX**Station Clinical automated sample preparation platform processes large batches with minimal operator intervention while reducing the need for tubes, caps, racks, and other consumables. Once prepared, FASTFluidic FilterProbe rapidly introduces samples to ICPMS. Automated 200x dilutions prepared directly into 2 mL 96-well plates creates a standardized, high-throughput format for ICPMS analysis while reducing overall costs through lower-cost consumables and decreased labor.

Advances in ICPMS sensitivity have made larger sample dilutions both practical and beneficial for blood Pb testing. Modern instruments can accurately measure lead at clinically relevant concentrations following 200x dilution, significantly reducing the amount of matrix introduced into the instrument. Higher dilution factors also minimize matrix effects, reduce potential mass spectral interferences, and improve long-term method robustness and instrument uptime. Benefits include decreased deposition on cones, lenses, reduced maintenance requirements and extending component lifetime.

After samples are prepared using **TRAX**Station Clinical, high-throughput analysis using 96-well plates are automated with the *FAST*Fluidic FilterProbe sample introduction system. This enables sample-to-sample analysis times of less than 20 seconds while maintaining or improving analytical performance. When combined with **TRAX**Station Clinical automated preparation and 200x dilutions, laboratories can substantially increase daily sample capacity, reduce turnaround times, and maximize instrument utilization without increasing staffing requirements.

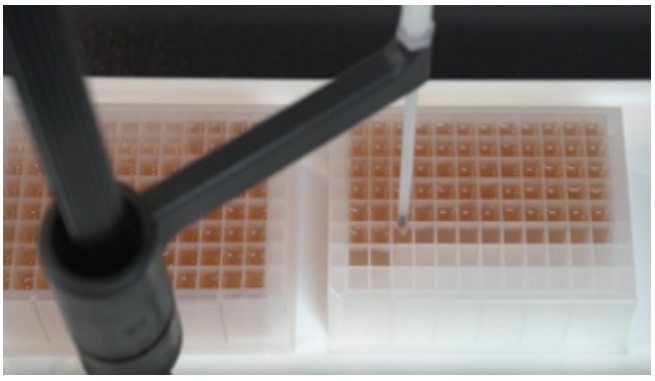
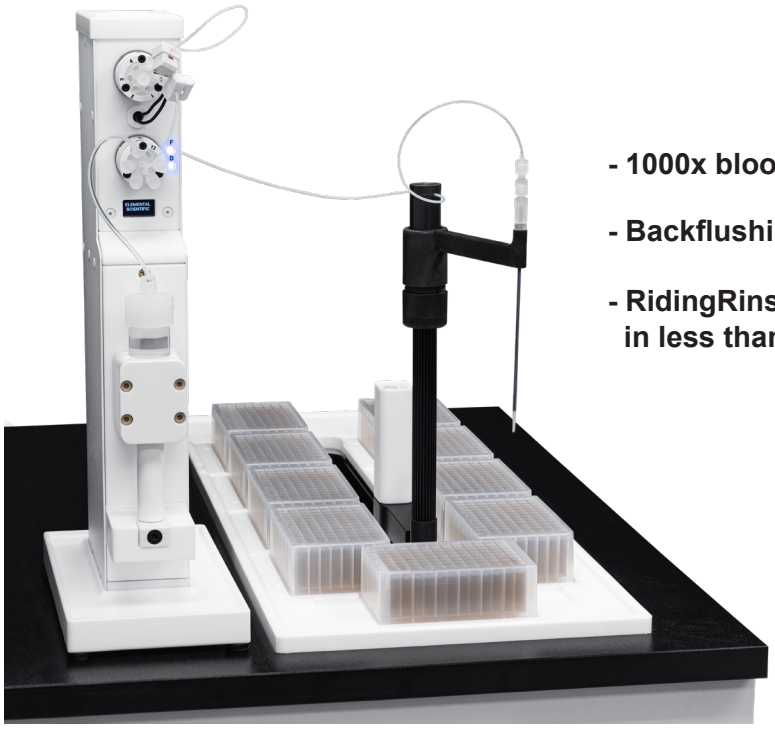


Figure 1. **TRAX**Station Clinical automatically preparing 200x diluted whole blood into a 96-well plate.

*FAST*Fluidic FilterProbe Clinical

The *FAST*Fluidic FilterProbe sample introduction system enables ultra-high-throughput ICPMS analysis of whole blood samples prepared in 2 mL 96-well plates. The system delivers rapid sample introduction with exceptional rinse and washout efficiency, significantly reducing carryover between complex whole blood specimens. The integrated FilterProbe design allows direct aspiration from 96-well plates while minimizing sample uptake delays and providing stable aerosol generation for reliable analytical performance. The *FAST*Fluidic system supports sample-to-sample analysis times as low as 16 seconds while maintaining excellent precision and accuracy, making it an ideal solution for high-volume laboratories.



- 1000x blood Pb rinseout

- Backflushing CTFE FilterProbe prevents clogs

- RidingRinse mobile rinse station accessed in less than 0.5 seconds

Figure 2. *FAST*Fluidic FilterProbe Clinical configured with nine 96-well plates.

Experimental

To evaluate the performance and reproducibility of the automated workflow, a 5x10 precision study was designed using three levels of whole blood samples for Pb analysis. The study is intended to assess the ability of the **TRAX**Station Clinical automated sample preparation platform to perform 200x dilutions into 2 mL 96-well plates using small 10 µL sample aliquots. Following sample preparation, diluted samples will be analyzed using the *FAST*Fluidic FilterProbe sample introduction system coupled to ICPMS. This will evaluate performance with sample-to-sample times targeted at less than 20 seconds. Precision performance will be assessed to determine the suitability of these systems for high-volume, high dilution, and fast turn-around-time laboratories.

Calibration Linearity

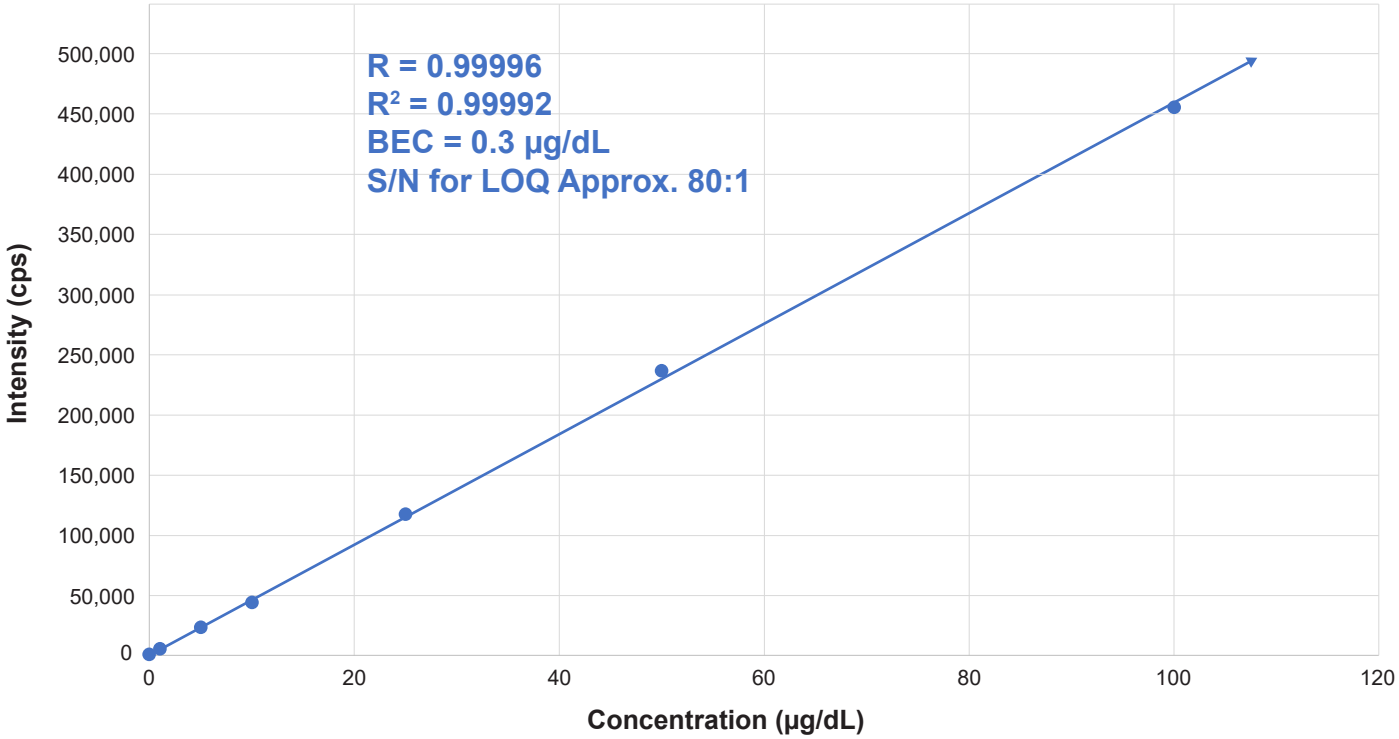


Figure 3. A calibration curve generated from standards prepared using **TRAX**Station Clinical and analyzed using *FAST*Fluidic FilterProbe demonstrated excellent linearity across the analytical measurement range, with a correlation coefficient (R) of 0.99996. These results confirm that automated 200x dilution into 96-well plates provides accurate and reliable quantitation for blood lead analysis.

200x Dilution Precision Data

Table 1. Precision results (%RSD) for the Level 1 whole blood lead pool (~2 µg/dL) for 5 runs of 10 samples each demonstrated excellent reproducibility across the study. Despite the low analyte concentration and 200x dilution factor, the automated workflow maintained consistently low %CV values.

	1	2	3	4	5
1	2.1	2.1	2.1	2.2	2.0
2	1.9	2.1	1.9	2.0	2.1
3	1.8	1.9	2.0	2.1	1.9
4	1.8	1.9	2.0	2.1	2.0
5	1.8	2.1	1.9	2.0	2.1
6	1.8	2.0	2.0	2.1	2.0
7	1.8	2.0	1.9	2.1	1.9
8	1.8	1.9	1.9	2.0	2.0
9	1.9	1.9	1.9	2.1	2.0
10	1.8	2.0	1.9	2.0	1.9
AVE	1.86	1.98	1.94	2.07	1.99
SD	0.08	0.09	0.08	0.06	0.06
CV	4.49%	4.77%	3.92%	3.02%	2.89%

200x Dilution Precision Data *(cont.)*

Table 2. Precision results (%RSD) for the Level 2 whole blood lead pool (~15 µg/dL) for 5 runs of 10 samples each demonstrated excellent reproducibility across the study.

	1	2	3	4	5
1	15.0	14.9	14.8	15.8	15.3
2	15.0	14.6	15.7	15.9	15.4
3	14.2	14.4	15.2	15.9	16.0
4	15.2	14.3	15.3	15.5	15.6
5	15.1	14.8	15.2	15.9	16.6
6	14.7	14.8	14.8	16.8	15.3
7	14.2	13.6	14.1	16.2	15.2
8	14.6	14.8	15.4	16.0	15.9
9	14.8	14.5	15.1	16.1	15.7
10	14.6	14.6	14.9	15.8	15.6
AVE	14.74	14.53	15.05	15.99	15.67
SD	0.36	0.37	0.43	0.34	0.42
CV	2.47%	2.57%	2.87%	2.15%	2.69%

Table 3. Precision results (%RSD) for the Level 3 whole blood lead pool (~47.5 µg/dL) for 5 runs of 10 samples each demonstrated excellent reproducibility across the study.

	1	2	3	4	5
1	45.2	46.3	46.3	48.5	49.3
2	45.9	49.8	46.5	49.0	49.3
3	43.4	48.1	46.7	45.7	46.9
4	47.4	50.2	48.3	47.9	47.1
5	46.9	50.3	47.2	49.3	50.0
6	46.5	47.6	47.5	49.6	48.4
7	45.7	49.2	47.5	50.3	46.1
8	45.2	46.9	47.6	48.5	46.2
9	43.4	48.9	47.0	49.5	48.8
10	45.8	49.5	47.6	49.1	48.0
AVE	45.52	48.68	47.22	48.74	48.02
SD	1.34	1.40	0.59	1.26	1.38
CV	2.94%	2.87%	1.25%	2.58%	2.87%

Conclusion

The results of this study demonstrate that the combination of **TRAX**Station Clinical automated sample preparation and *FAST*Fluidic FilterProbe ultra-high-throughput ICPMS analysis provides a highly effective solution for clinical blood lead testing laboratories. Automated 200x dilutions of 10 µL whole blood aliquots into 2 mL 96-well plates were performed with excellent precision and reproducibility, while maintaining outstanding calibration linearity and analytical sensitivity. With 16 second sample-to-sample analysis times, the integrated workflow significantly increases throughput.