

Supplemental Material

for

Performance of a Robotic Weighing System and Quality Practices for Gravimetric Mass Measurements

by

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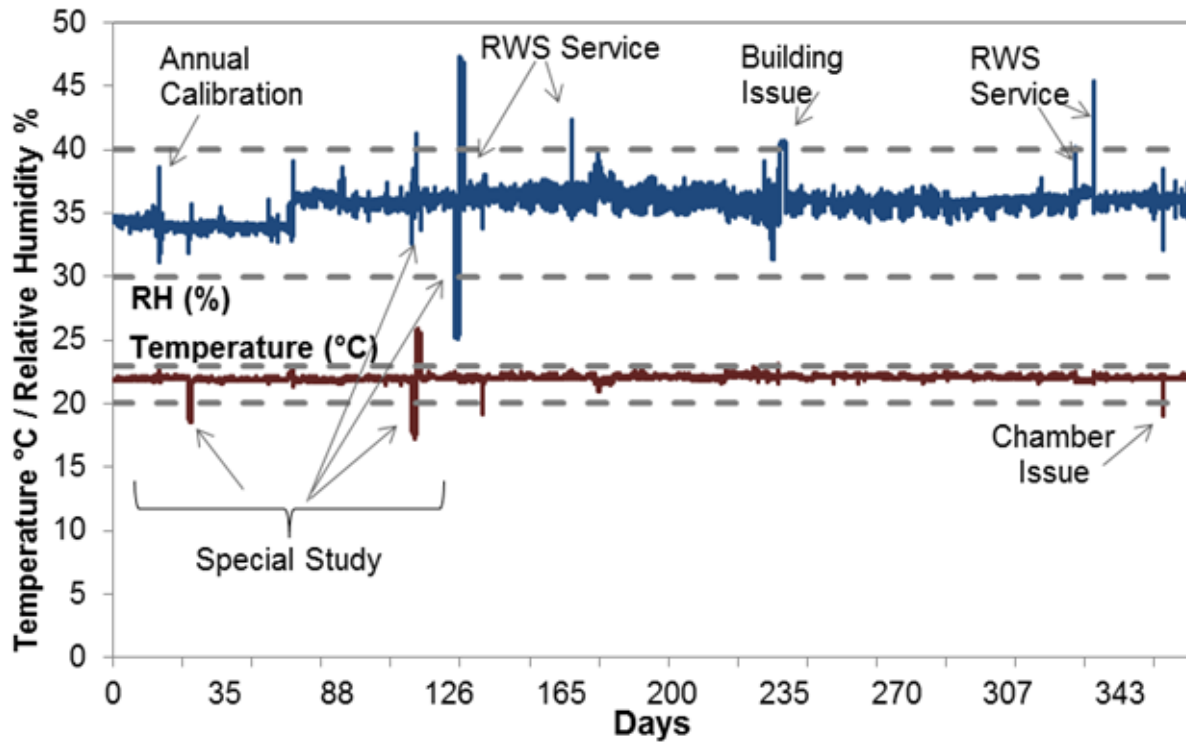


Figure S1. Environmental condition tracking for the RTI Gravimetry Laboratory (solid lines) with QA Handbook, Vol II (U.S.EPA, 2014) criteria shown in dashed lines. The laboratory suspended all weighing activities for planned and unplanned environmental condition episodes.

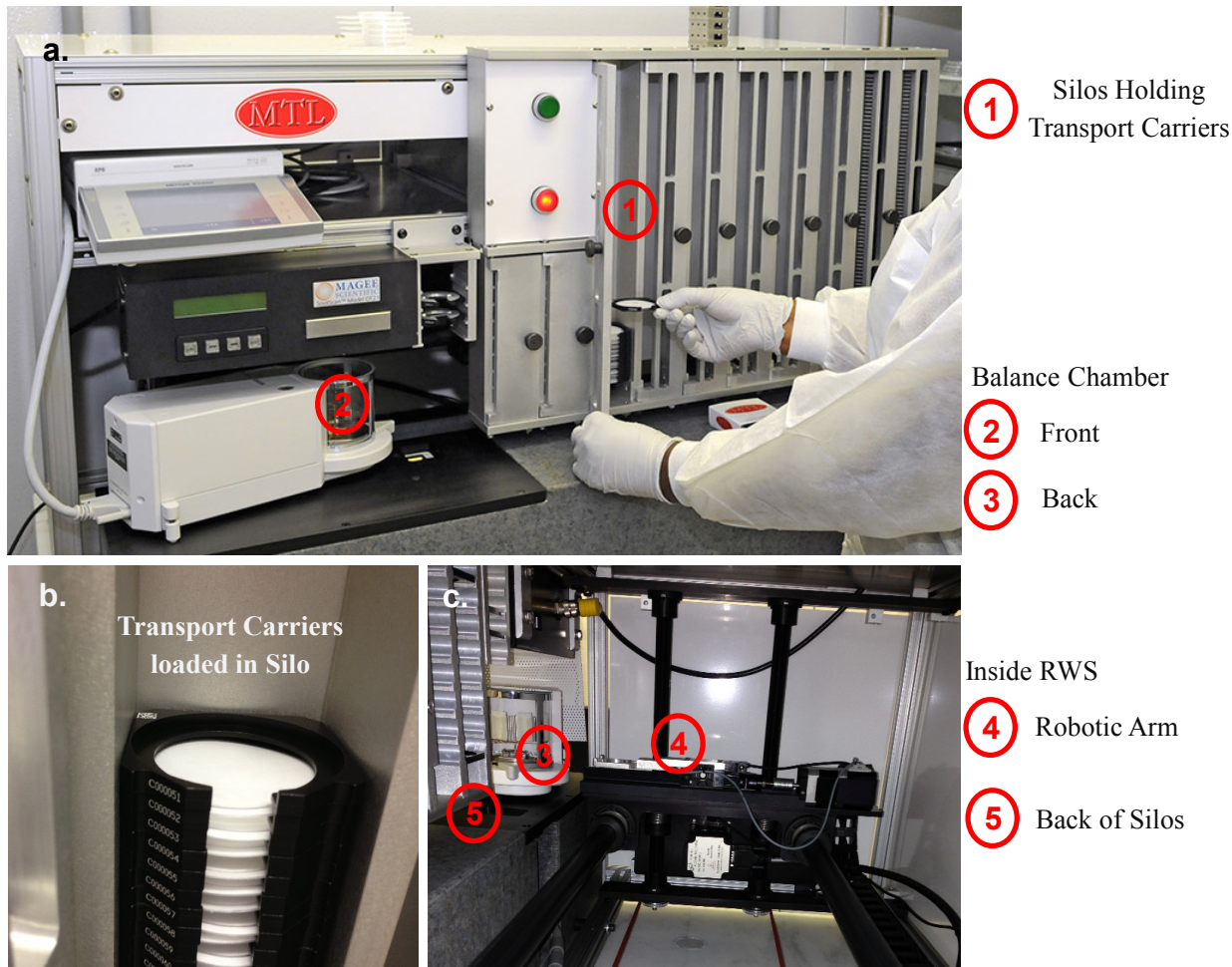


Figure S2. (a.) Photograph of the MTL Robotic Weighing System highlighting the balance and silos. (b.) Photograph of filter transport carriers loaded into Silo. (c.) Photograph of inside the RWS showing the robotic arm in the 'home' position and the back of the Silos where carriers are removed.

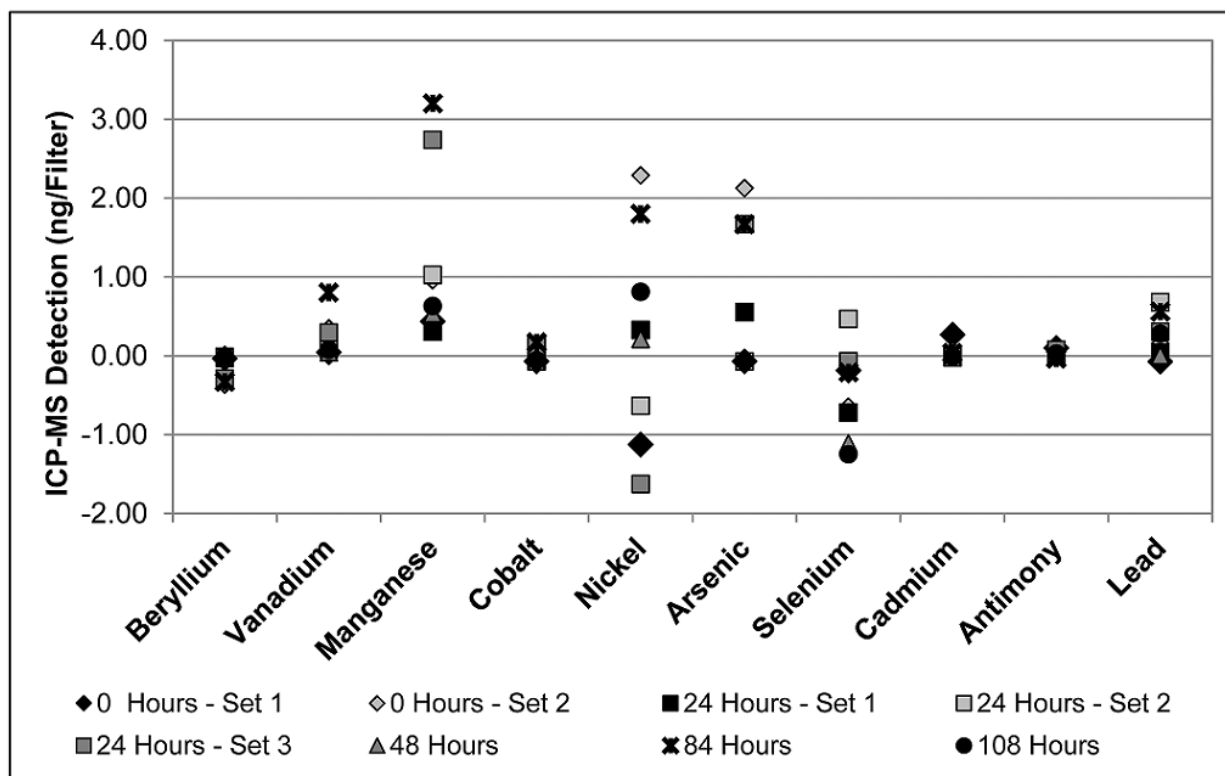


Figure S3. Trace metal concentrations analyzed by ICP-MS. The detection limit for each metal was 5 ng/Filter.

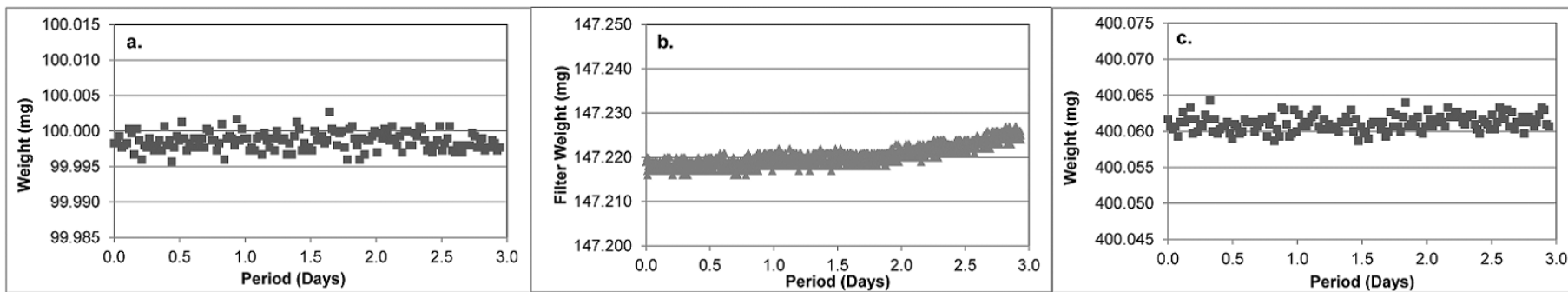


Figure S4. Variation in weight of (a) 100 mg Standard Weight, (b) Filter Weight, (c) 400 mg Standard Weight for single filter repetitive weighings over a three day period. Stability of standard weights (a), (c) indicates drift (b) is due to filter media not instrument.

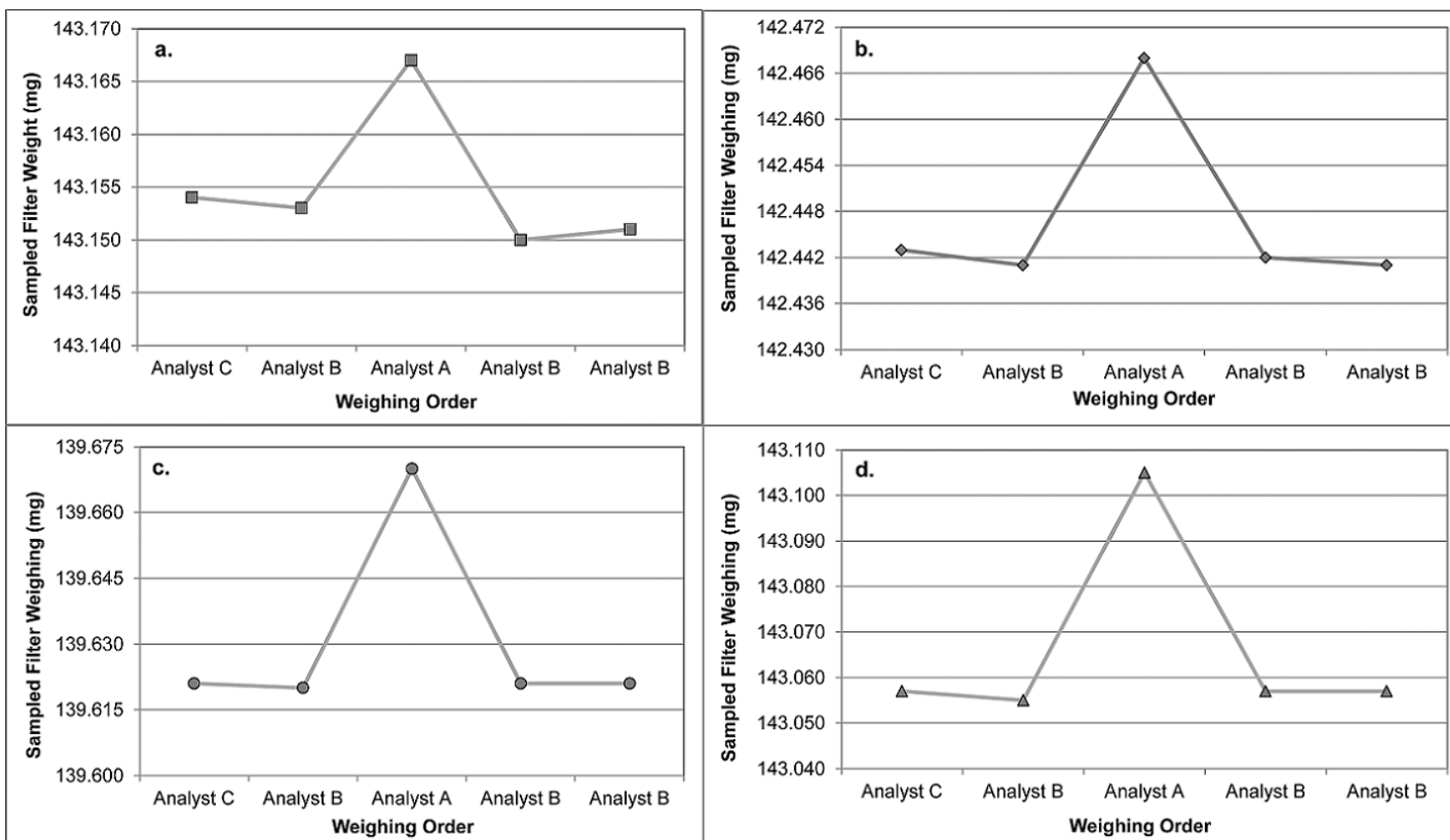


Figure S5. Additional experiments completed determining cause of high Laboratory Blank weighings. Sampled filter was weighed by analyst C and analyst B to ensure weight prior to analyst A. The filter again spiked in weight during weighing by analyst A, and then it would decrease back to original weight when QC checked by third analyst (B) the next day.

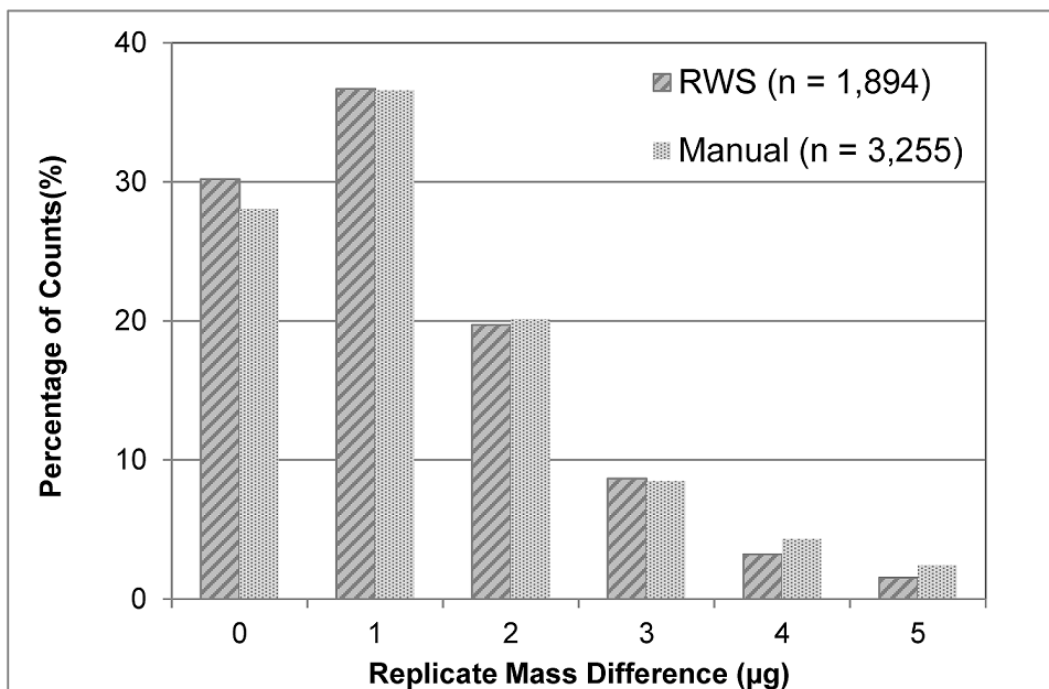


Figure S6. Normalized histogram of differences from 0 to 5 µg of robotically and manually weighed tared and post-sampled filters illustrating when laboratories implement high labor quality control measures that exceed the FRM for manually weighed filters the precision between the analysts and RWS is negligible.

Table ST1. Laboratory Blank QC tracking by analyst during 2010 with and without analyst A's Laboratory Blank weighings shows the net mass differences outside the $\pm 15 \mu\text{g}$ acceptance limit were attributed to weighings by analyst A thus static effects seen in Figures 6 and S5.

2010 Including Lab Blanks Weighed by Analyst A						
Analyst:	Analyst A	Analyst B	Analyst C	Analyst D	Analyst E	Total
Count	616	519	57	338	497	2,027
Avg	2.75	2.8	3.37	0.49	1.42	2.08
Max	20	26	9	11	46	46
Min	-41	-29	-4	-54	-55	-55
Range	61	55	13	65	101	101
Std Dev	5.11	4.77	3.43	6.72	5.89	5.56
# Out	4	9	0	11	8	32
% Out	0.60%	1.70%	0.00%	3.30%	1.60%	1.6%
2010 Excluding Lab Blanks Weighed by Analyst A						
Analyst:	Analyst A	Analyst B	Analyst C	Analyst D	Analyst E	Total
Count	Data Removed for the Comparison	507	57	331	481	1,376
Avg		2.8	3.37	1.19	1.62	1.38
Max		13	9	11	13	13
Min		-11	-4	-27	-26	-27
Range		24	13	38	39	40
Std Dev		3.53	3.43	4.41	3.7	3.88
# Out		0	0	4	1	5
% Out		0.0%	0.0%	1.2%	0.2%	0.4%

References

U.S.EPA (2014). QA Handbook Volume II, Appendix D - Measurement Quality Objectives and Validation Templates, Research Triangle Park, NC.