Laboratory Validation of AT593 Mercury Vapor Sampler

Prepared by: C.R. Manning, PhD, CIH & B Quarles, PhD Revised: 11 May 2017

These tests for the evaluation of diffusive air samplers were conducted within the guidelines described in ANSI 104-1998.

AT593 Mercury Vapor Sampler

Assay Technology's 593 mercury vapor sampler consists of a proprietary mercury-collecting wafer encased within a 76-port polypropylene sampling grid fitted with a particle screen and contained within a polypropylene sampler body. Each wafer consists of a 0.5 mg pure gold film coated on a plastic disc.

1. Test Apparatus & Method

Exposures of mercury (Hg) vapor were created using two different methods:

A. Clean air was flowed over a mercury diffusion tube held in an oven at a fixed temperature (90.0 $\pm$ 0.2 ^{o}C). The diffusion tube contained pure mercury liquid stored beneath a "capillary" orifice (approx. 6 mm x 2 mm dia.) such that mercury diffused from the tube at a constant rate. Mercury diffusing from the tube was diluted by conditioned air (controlled temperature & humidity) generated by the Miller-Nelson 501 atmosphere conditioner utilizing a mass flow controller (MFC), then passed through an inert acrylic chamber containing diffusive samplers under test.

B. Nitrogen was passed through a 3-necked round bottom flask containing approx. 750 g mercury heated to ~70°C. The air was passed through a second flask of mercury (~750 g) held at a temperature of 26°C in a water bath, which generated an airstream containing a saturated mercury concentration. This airstream was diluted by conditioned air (controlled temperature & humidity) generated by the Miller-Nelson 501 atmosphere conditioner utilizing an MFC, then passed through an inert acrylic chamber containing diffusive samplers under test.

In all cases, MFC flow was verified by calibration. Nominal exposure levels were verified by Hopcalite tube samples continuously drawn from locations in the chamber bracketing the samplers under test. Active and diffusive samplers were analyzed by acid extraction followed by Cold Vapor Atomic Fluorescence (CVAF) Spectroscopy at the characteristic mercury wavelength (in-house method AT593, modified from OSHA 140).

2. Desorption Efficiency (DE)

Analyte recovery and desorption efficiency were determined by analysis of diffusive samplers and sampling tubes spiked from standard analyte solutions. Samplers were tested at spike levels corresponding to expected levels of exposure at 0.2-2 times the OEL (Occupational Exposure Limit) of 0.1 mg/M3.

Spike Level 1	Amt recovered (ppt)	DE
Liquid Spike (no media)	100	
Spike 1	83.1	83%
Spike 2	82.1	82%
Spike 3	80.0	80%
Spike 4	81.7	82%
	Spike Level Average DE:	81.7%

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Spike Level 2	Amt recovered(ppt)	DE
Liquid Spike (no media)	200	
Spike 1	156	78%
Spike 2	160	80%
Spike 3	160	80%
Spike 4	154	77%
	Spike Level Average DE:	78.8%

Spike Level 3	Amt recovered(ppt)	DE
Liquid Spike (no media)	300	
Spike 1	305	102%
Spike 2	311	104%
Spike 3	298	99%
Spike 4	319	106%
	Spike Level Average DE:	102.8%

AT593 DE:	87.7%

3. Determination of the Effect of Concentration and Time on Sampling Rate (verification of diffusive sampling rate)

Samplers were exposed to mercury vapor in an acrylic chamber as described in Section 1, and were then analyzed by Method AT593. Exposures were applied to samplers in the range of 0.2-2 times the OEL. Comparison of the concentration found on the samplers and concentration recovered from the tubes show a linear response, validating the sampling rate for AT593 (Table 1 and Figure 1).

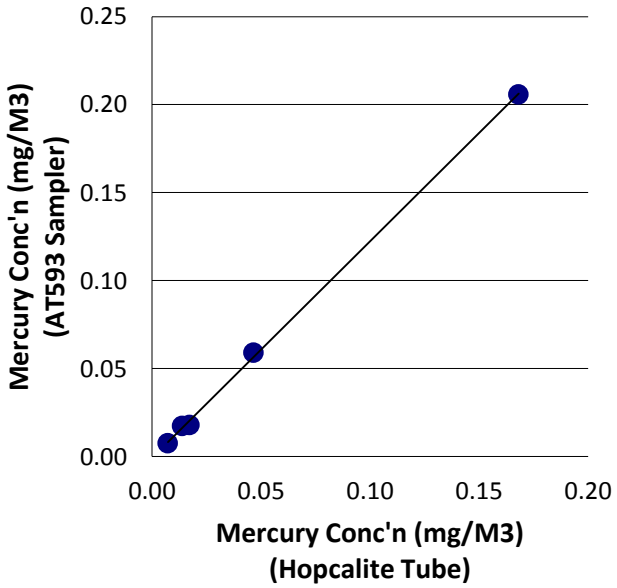

Figure 1. Performance of AT593 sampler vs reference method.

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Table 1. Performance of AT593 sampler vs reference method

Sampler	Time (min)	Air Vol (L)	Hg (µg/L)	Hg (µg)	TWA (mg/M3)
AT593 Sampler	262	5.11	0.84	0.042	0.0082
AT593 Sampler	262	5.11	0.77	0.039	0.0075
AT593 Sampler	262	5.11	0.55	0.028	0.0054
AT593 Sampler	262	5.11	0.99	0.050	0.0097
				Average	**0.0077**
Hopcalite Tube	262	5.11	0.76	0.038	0.0074
Hopcalite Tube	262	5.11	0.93	0.047	0.0091
Hopcalite Tube	262	5.11	0.65	0.033	0.0064
Hopcalite Tube	262	5.11	0.80	0.040	0.0078
Hopcalite Tube	262	5.11	0.60	0.030	0.0059
				Average	**0.0073**
Sampler	**Time** (min)	**Air Vol** (L)	**Hg** (µg/L)	**Hg** (µg)	**TWA** (mg/M3)
Hopcalite Tube	62	0.62	0.53	0.027	0.0427
Hopcalite Tube	62	0.62	0.61	0.031	0.0492
Hopcalite Tube	62	0.62	0.56	0.028	0.0452
Hopcalite Tube	62	0.62	0.61	0.031	0.0492
				Average	**0.0466**
AT593 Sampler	62	1.209	1.40	0.070	0.0579
AT593 Sampler	62	1.209	1.43	0.072	0.0591
AT593 Sampler	62	1.209	1.38	0.069	0.0571
AT593 Sampler	62	1.209	1.51	0.076	0.0624
				Average	**0.0591**
Sampler	**Time** (min)	**Air Vol** (L)	**Hg** (µg/L)	**Hg** (µg)	**TWA** (mg/M3)
Hopcalite Tube	120	1.68	0.34	0.017	0.0101
Hopcalite Tube	120	1.68	0.68	0.034	0.0202
Hopcalite Tube	120	1.68	0.64	0.032	0.0190
Hopcalite Tube	120	1.68	0.21	0.011	0.0063
				Average	**0.0139**
AT593 Sampler	120	2.34	1.27	0.064	0.0271
AT593 Sampler	120	2.34	0.81	0.041	0.0173
AT593 Sampler	120	2.34	0.86	0.043	0.0184
AT593 Sampler	120	2.34	0.77	0.039	0.0165
				Average	**0.0198**

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Sampler	Time (min)	Air Vol (L)	Hg (µg/L)	Hg (µg)	TWA (mg/M3)
Hopcalite Tube	285	43.04	0.90	0.88	0.0204
Hopcalite Tube	285	43.32	0.99	0.97	0.0224
Hopcalite Tube	285	43.32	0.95	0.93	0.0215
Hopcalite Tube	285	42.46	0.93	0.91	0.0214
Hopcalite Tube	285	42.78	0.04	0.02	0.0005
				Average	**0.0172**
AT593 Sampler	285	4.90	0.14	0.13	0.0265
AT593 Sampler	285	4.90	0.11	0.10	0.0204
AT593 Sampler	285	4.90	0.12	0.11	0.0224
AT593 Sampler	285	4.90	0.04	0.03	0.0061
AT593 Sampler	285	4.90	0.08	0.07	0.0143
				Average	**0.0180**

Sampler	Time (min)	Air Vol (L)	Hg (µg/L)	Hg (µg)	TWA (mg/M3)
Hopcalite Tube	305	44.09	5.31	4.83	0.110
Hopcalite Tube	305	43.51	8.37	7.89	0.181
Hopcalite Tube	305	44.38	8.30	7.82	0.176
Hopcalite Tube	305	41.17	8.31	7.83	0.190
Hopcalite Tube	305	44.09	8.57	8.09	0.183
				Average	**0.168**
AT593 Sampler	305	5.25	1.35	1.09	0.208
AT593 Sampler	305	5.25	1.31	1.05	0.200
AT593 Sampler	295	5.07	1.48	1.22	0.240
AT593 Sampler	295	5.07	1.01	0.75	0.148
AT593 Sampler	295	5.07	1.44	1.18	0.233
				Average	**0.206**

4. Background (Blank) Determination

Unexposed samplers were analyzed by Method AT593 to determine background analyte levels (if any) on the sampler prior to sampling. No background response was detectable (< 0.02 µg).

5. Atmospheric Effects

Air Velocity & Orientation – Previous studies demonstrated that there is no significant effect of air velocity and orientation on sampling rate.

Temperature and Humidity – Previous studies demonstrated the absence of an effect of temperature and humidity on sampling rate in the range 0 – 50°C and 10 – 80% RH.

6. Capacity

Mercury is attracted to a gold wafer because it forms an amalgam (bi-molecular complex) with the gold atoms in a ratio of approximately 1 gold atom to 1 mercury atom. Since two species have similar molecular weights, a gold film should have the capacity to collect and amalgamate a mass of mercury equal to the mass of gold in the film. The maximum mercury capacity required for 8-hr workplace

sampling should therefore be approximately 1.0 µg of mercury sampled (138% of the OSHA Ceiling Level or 0.0138 mg/m3 for an 8-hr sample or 5.5 times the Cal OSHA PEL of 0.025 mg/M3 on an 8-hr TWA basis).

In recent laboratory vapor exposure studies, more than 1.0 µg of mercury was collected, retained, and recovered from the 593 Sampler.

7. Sampling Rate Verification Studies

According to internal specifications, periodic testing on the 593 samplers is performed to verify product performance and published sampling rate (Table 2).

Table 2. Reverification of AT593 mercury sampling rate, Hg spike = 0.5 mg/M3; August 2011

Media	Amt Recovered (□g)	Vol (L)	Time (min)	Concentration mg/M3
J593A - 6B11-0.03125 MG/M3-1	0.21	0.447	30	0.46
J593A - 6B11-0.03125 MG/M3-2	0.28	0.447	30	0.63
J593A - 6B11-0.03125 MG/M3-3	0.24	0.447	30	0.55
J593A - 6B11-0.03125 MG/M3-4	0.41	0.447	30	0.91
J593A - 6B11-0.03125 MG/M3-5	0.22	0.447	30	0.49
J593A - 6B11-0.03125 MG/M3-6	0.25	0.447	30	0.55
J593A - 6B11-0.03125 MG/M3-7	0.26	0.447	30	0.58
			Average	**0.54**
			CV	**11%**
				% Recovery = 109%
J593A - 6B11-0.0625MG/M3-1	0.40	0.894	60	0.45
J593A - 6B11-0.0625MG/M3-2	0.36	0.894	60	0.41
J593A - 6B11-0.0625MG/M3-3	0.42	0.894	60	0.47
J593A - 6B11-0.0625MG/M3-4	0.41	0.894	60	0.46
J593A - 6B11-0.0625MG/M3-5	0.42	0.894	60	0.47
J593A - 6B11-0.0625MG/M3-6	0.41	0.894	60	0.46
J593A - 6B11-0.0625MG/M3-7	0.45	0.894	60	0.5
			Average	**0.46**
			CV	**6%**
				% Recovery = 92%
J593A - 6B11-0.125MG/M3-1	0.88	1.79	120	0.49
J593A - 6B11-0.125MG/M3-2	0.97	1.79	120	0.54
J593A - 6B11-0.125MG/M3-3	0.82	1.79	120	0.46
J593A - 6B11-0.125MG/M3-4	0.88	1.79	120	0.49
J593A - 6B11-0.125MG/M3-5	0.78	1.79	120	0.44
J593A - 6B11-0.125MG/M3-6	0.96	1.79	120	0.54
J593A - 6B11-0.125MG/M3-7	0.97	1.79	120	0.55
			Average	**0.50**
			CV	**9%**
				% Recovery = 100%

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8. Summary Comments

Sampler AT593 has been evaluated, and is recommended for sampling mercury vapor under the following conditions.

Concentration Range	0.2 – 2.0 times the OEL
Sampling Time	1 – 8 hour
Air Velocity	15 – 150 cm/sec
Temperature	0 – 50°C
Humidity	10 – 80% RH

It is recommended that Sampler AT593 be used within the envelope of conditions specified above, but, in general, minor excursions outside these limits would be expected to have only minor effects. Longer or shorter sampling times are possible but have not been evaluated here.

The recommended maximum holding time after sampling is 28 days at room temperature.