

## Laboratory Evaluation of AT593 Mercury Vapor Sampler (using dynamically generated mercury atmospheres)

in accordance with guidelines described in ANSI/ISEA 104-1998.

Prepared by: C.R. Manning, PhD, CIH

Compiled: 20 Nov 2012

These tests for Evaluation of Diffusive Air Samplers were conducted within the guidelines described in ANSI 104-1998.

### 1. Test Apparatus & Method

Exposures of Mercury vapor were created by flowing clean air over a mercury diffusion tube held in an oven at a fixed temperature ( $90.0 \pm 0.2$  °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 401 atmosphere conditioner utilizing a mass flow controller (MFC), then passed through an inert acrylic chamber containing Diffusive Samplers under test. MFC Flow was verified by calibration, while 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 Adsorption or Cold Vapor Atomic Fluorescence Spectrometry at the characteristic mercury wavelength.

### 2. De-Sorption Efficiency (DE)

Analyte recovery and de-sorption efficiency determined by analysis (AT593, similar to OSHA 140) 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.

### 3. Determination of the Effect of Concentration and Time on Sampling Rate

(Verification of Diffusive Sampling Rate) Samplers were exposed to exposure concentrations in Chambers as described in Section 1, then analyzed by Method AT593. Exposures were applied to Samplers in the range of 0.2-2 times the OEL. Results shown in Table 1 & 2 and Fig 1.

### 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. Effects of Air Velocity & Orientation

Samplers were exposed to atmospheres for 2-4 hrs at 1-2 times the OEL in a Chamber such that linear velocities of 15, 50, and 150 cm/sec, respectively, were generated. Samplers were placed in each zone with *50% of samplers placed normal to and 50% of Samplers perpendicular to the flow direction*. When data from different locations and flows were compared (representing normal air velocity and orientation variation in workplaces), no significant differences were found among the groups indicating the *absence of a significant effect of Air Velocity & Orientation on Sampling Rate*. *This test, performed previously on the same Sampler using analytes other than the one in this study, was not repeated in this study.*

### 6. Effect of Temperature & Humidity

Samplers were exposed to atmospheres for 2-4 hrs at 1-2 times the OEL in several Chamber runs in which nearly identical exposures were applied with variations in temperature and humidity as follows: 22°C/50%RH, 10°C/50%RH, 30°C/30%RH, 30°C/70% RH. Data from the four conditions (representing normal temperature & humidity variation) showed no significant differences among the groups indicating the *absence of an effect of Temperature & Humidity on Sampling Rate in the range 10-30°C and 30-70% RH*. *This test, performed previously on the same Sampler using analytes other than the one in this study, was not repeated in this study.*



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**7. 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	Room Temperature
Humidity	30-70% 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 7 days at room temperature. The Holding Time could likely be extended if further studies were conducted.

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**Table 1**  
**Performance of AT593 Sampler**  
(versus Reference Method)

Sample No.	Run #	Sampler	Time (min)	Air Vol (L)	Hg (µg/L)	Ext Vol (mL)	Hg (µg)	TWA (mg/M3)
2000041141	1	AT593 Sampler	262	5.11	0.84	50	0.042	0.0082
2000041143	1	"	262	5.11	0.77	50	0.039	0.0075
2000041144	1	"	262	5.11	0.55	50	0.028	0.0054
	1	"		5.11	0.99	50	0.050	0.0097

**0.0077**

	1	Hopc Samplg Tube		5.109	0.76	50	0.038	0.0074
	1	"		5.109	0.93	50	0.047	0.0091
	1	"		5.109	0.65	50	0.033	0.0064
2000041155	1	"	262	5.109	0.80	50	0.040	0.0078
2000041157	1	"		5.109	0.60	50	0.030	0.0059

**0.0073**

Sample No.	Run #	Sampler	Time (min)	Air Vol (L)	Hg (µg/L)	Ext Vol (mL)	Hg (µg)	TWA (mg/M3)
2000041181	2	Hopc Samplg Tube	30	0.585	0.63	50	0.032	0.0538
2000041183	2	"	30	0.585	0.21	50	0.011	0.0179
2000041184	2	"	30		ND	50	ND	ND
2000041185	2	"	30	0.585	0.27	50	0.014	0.0231
2000041186	2	"	30	0.585	0.36	50	0.018	0.0308

**0.0314**

2000041176	2	AT593 Sampler	30	0.59	ND	50	ND	0.0300
2000041177	2	"	30	0.59	ND	50	ND	0.0300
2000041178	2	"	30	0.59	ND	50	ND	0.0300
2000041180	2	"	30	0.59	ND	50	ND	0.0300

**0.0300**

Sample No.	Run #	Sampler	Time (min)	Air Vol (L)	Hg (µg/L)	Ext Vol (mL)	Hg (µg)	TWA (mg/M3)
2000040162	3	Hopc Samplg Tube	62	0.62	0.53	50	0.027	0.0427
2000040163	3	"	62	0.62	0.61	50	0.031	0.0492
2000040164	3	"	62	0.62	0.56	50	0.028	0.0452
2000040165	3	"	62	0.62	0.61	50	0.031	0.0492

**0.0466**

2000040166	3	AT593 Sampler	62	1.209	1.40	50	0.070	0.0579
2000040167	3	"	62	1.209	1.43	50	0.072	0.0591
2000040168	3	"	62	1.209	1.38	50	0.069	0.0571
2000040169	3	"	62	1.209	1.51	50	0.076	0.0624

**0.0591**

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**Table 2**  
Performance of AT593 Sampler  
(versus Reference Method)

Sample No.	Run #	Sampler	Time (min)	Air Vol (L)	Hg (µg/L)	Ext Vol (mL)	Hg (µg)	TWA (mg/M3)
2000040196	4	Hopc Sampling Tube	120	1.68	0.34	50	0.017	0.0101
2000040197	4	"	120	1.68	0.68	50	0.034	0.0202
2000040198	4	"	120	1.68	0.64	50	0.032	0.0190
2000040199	4	"	120	1.68	0.21	50	0.011	0.0063
<b>0.0139</b>								
2000040184	4	AT593 Sampler	120	2.34	1.27	50	0.064	0.0271
2000040185	4	"	120	2.34	0.81	50	0.041	0.0173
2000040186	4	"	120	2.34	0.86	50	0.043	0.0184
2000040187	4	"	120	2.34	0.77	50	0.039	0.0165
<b>0.0198</b>								
Sample No.	Run #	Sampler	Time (min)	Air Vol (L)	Hg (µg/L)	Ext Vol (mL)	Hg (µg)	TWA (mg/M3)
972244	5	Hopc Sampling Tube		43.04	0.90	0.02	0.88	0.0204
972245	5	"		43.32	0.99	0.02	0.97	0.0224
972246	5	"		43.32	0.95	0.02	0.93	0.0215
972247	5	"		42.46	0.93	0.02	0.91	0.0214
972248	5	"		42.78	0.04	0.02	0.02	0.0005
<b>0.0172</b>								
972241	5	AT593 Sampler	285	4.90	0.14	0.01	0.13	0.0265
972242	5	"	285	4.90	0.11	0.01	0.10	0.0204
972243	5	"	285	4.90	0.12	0.01	0.11	0.0224
972252	5	"	285	4.90	0.04	0.01	0.03	0.0061
972253	5	"	285	4.90	0.08	0.01	0.07	0.0143
<b>0.0180</b>								
Sample No.	Run #	Sampler	Time (min)	Air Vol (L)	Hg (µg/L)	Ext Vol (mL)	Hg (µg)	TWA (mg/M3)
972773	6	Hopc Sampling Tube		44.09	5.31	0.48	4.83	0.110
972774	6	"		43.51	8.37	0.48	7.89	0.181
972775	6	"		44.38	8.30	0.48	7.82	0.176
972776	6	"		41.17	8.31	0.48	7.83	0.190
972777	6	"		44.09	8.57	0.48	8.09	0.183
<b>0.168</b>								
972761	6	AT593 Sampler	305	5.25	1.35	0.26	1.09	0.208
972762	6	"	305	5.25	1.31	0.26	1.05	0.200
972764	6	"	295	5.07	1.48	0.26	1.22	0.240
972765	6	"	295	5.07	1.01	0.26	0.75	0.148
972766	6	"	295	5.07	1.44	0.26	1.18	0.233
<b>0.206</b>								

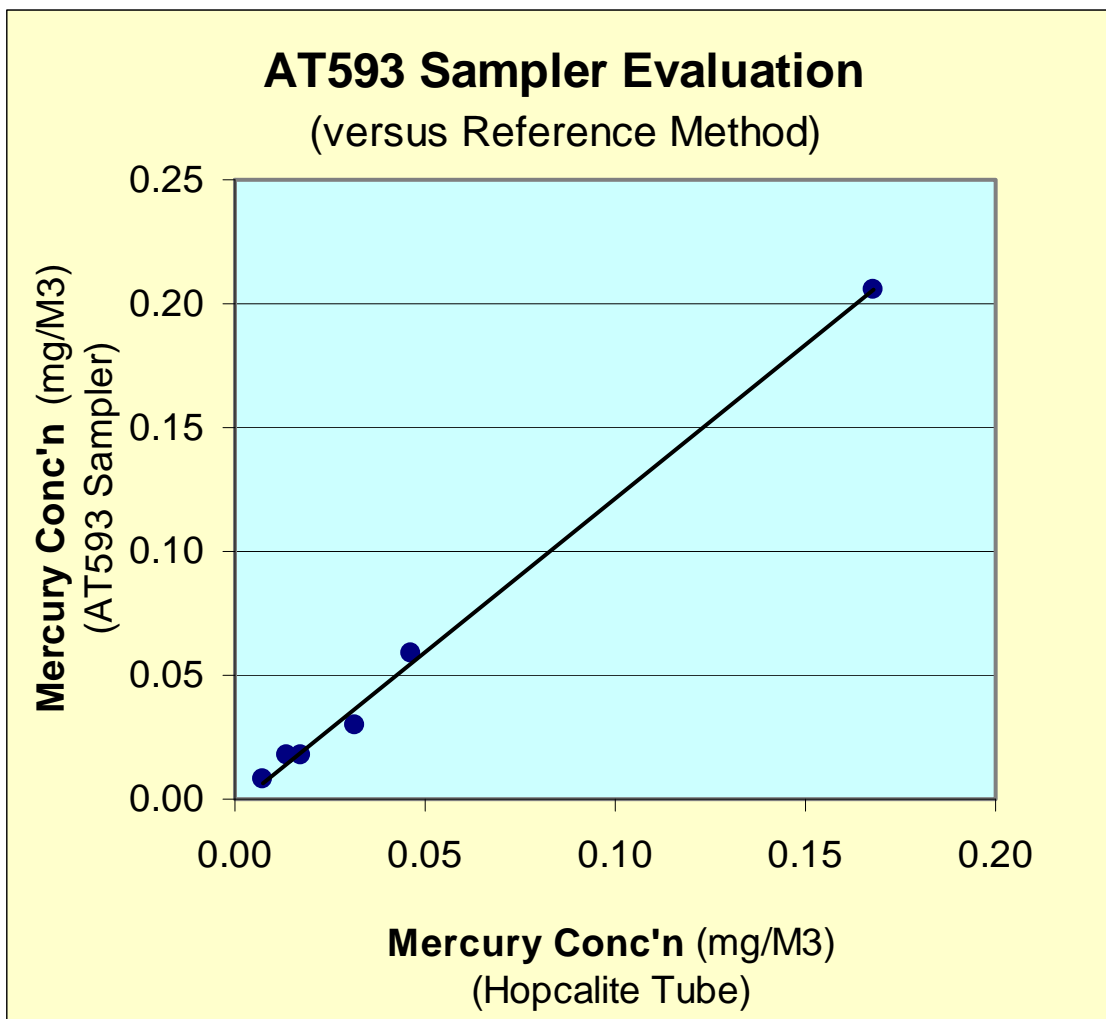
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**Fig. 1**

Performance of AT593 Sampler  
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**Table 3**  
Re-Verification of AT593 Mercury Sampling Rate

08/04/11

Sample	Media	Lot / Ser No.	Analyte	QTY (mcg)	Vol (L)	Time (min)	Concentration mg/M3	
2011028248	J593A - 6B11-0.03125 MG/M3-1	6B11 - HW1252	Hg	0.21	0.447	30	0.46	
2011028249	J593A - 6B11-0.03125 MG/M3-2	6B11 - HW1659	Hg	0.28	0.447	30	0.63	
2011028250	J593A - 6B11-0.03125 MG/M3-3	6B11 - HW1484	Hg	0.24	0.447	30	0.55	
2011028251	J593A - 6B11-0.03125 MG/M3-4	6B11 - HW0544	Hg	0.41	0.447	30	0.91	
2011028252	J593A - 6B11-0.03125 MG/M3-5	6B11 - HW1435	Hg	0.22	0.447	30	0.49	
2011028254	J593A - 6B11-0.03125 MG/M3-6	6B11 - HW0673	Hg	0.25	0.447	30	0.55	
2011028255	J593A - 6B11-0.03125 MG/M3-7	6B11 - HW0974	Hg	0.26	0.447	30	0.58	<b>CV =</b>
<b>Mercury Spike = 0.5 mg/M3</b>				<b>% Recovery =</b>	<b>109%</b>		<b>0.54</b>	<b>11%</b>
2011028257	J593A - 6B11-0.0625MG/M3-1	6B11 - HW0728	Hg	0.4	0.894	60	0.45	
2011028258	J593A - 6B11-0.0625MG/M3-2	6B11 - HW0410	Hg	0.36	0.894	60	0.41	
2011028259	J593A - 6B11-0.0625MG/M3-3	6B11 - HW1067	Hg	0.42	0.894	60	0.47	
2011028261	J593A - 6B11-0.0625MG/M3-4	6B11 - HW0796	Hg	0.41	0.894	60	0.46	
2011028262	J593A - 6B11-0.0625MG/M3-5	6B11 - HW0895	Hg	0.42	0.894	60	0.47	
2011028263	J593A - 6B11-0.0625MG/M3-6	6B11 - HW0483	Hg	0.41	0.894	60	0.46	
2011028265	J593A - 6B11-0.0625MG/M3-7	6B11 - HW0661	Hg	0.45	0.894	60	0.5	<b>CV =</b>
<b>Mercury Spike = 0.5 mg/M3</b>				<b>% Recovery =</b>	<b>92%</b>		<b>0.46</b>	<b>6%</b>
2011028266	J593A - 6B11-0.125MG/M3-1	6B11 - HW1161	Hg	0.88	1.79	120	0.49	
2011028268	J593A - 6B11-0.125MG/M3-2	6B11 - HW0412	Hg	0.97	1.79	120	0.54	
2011028269	J593A - 6B11-0.125MG/M3-3	6B11 - HW0635	Hg	0.82	1.79	120	0.46	
2011028270	J593A - 6B11-0.125MG/M3-4	6B11 - HW1000	Hg	0.88	1.79	120	0.49	
2011028271	J593A - 6B11-0.125MG/M3-5	6B11 - HW0598	Hg	0.78	1.79	120	0.44	
2011028272	J593A - 6B11-0.125MG/M3-6	6B11 - HW1586	Hg	0.96	1.79	120	0.54	
2011028273	J593A - 6B11-0.125MG/M3-7	6B11 - HW1691	Hg	0.97	1.79	120	0.55	<b>CV =</b>
<b>Mercury Spike = 0.5 mg/M3</b>				<b>% Recovery =</b>	<b>100%</b>		<b>0.50</b>	<b>9%</b>