



**Validation of Single-use Passive Sampler
for Elemental Mercury Vapor
Cat. No. 520-04**

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Abstract

SKC Cat. No. 520-04, the new single-use passive sampler for elemental mercury vapors, was compared with the reusable SKC Cat. No. 520-03 capsule holder with sorbent capsule Cat. No. 520-02 to validate it as a comparable counterpart. The Cat. No. 520-04 passive sampler, which contains 750 mg Anasorb® C300, was determined to have a sampling rate of 21.2 ml/min with a relative standard deviation over the study of 5.7%. The new passive sampler has a desorption efficiency of 1.01 and no reverse diffusion effects. Studies were performed in mercury atmospheres ranging from 0.0006 to 0.05 ppm and face velocities from 30 to 300 ft/min. The results validate the Cat. No. 520-04 passive sampler as a single-use counterpart to the reusable Cat. No. 520-03 capsule holder with sorbent capsule Cat. No. 520-02 validated in OSHA Method ID 140.

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Introduction

The SKC Cat. No. 520-04 passive sampler for elemental mercury vapor is a pre-assembled monitor designed for single use and contains the same sorbent as the SKC Cat. No. 520-02 sorbent capsule in the reusable SKC Cat. No. 520-03 capsule holder validated in OSHA Method ID 140. The Cat. No. 520-04 passive sampler design removes the need for assembly in the field, reduces the work done in the lab, and makes the sorbent easily accessible; because it is disposable, no post-sampling cleaning is required. The sampler contains 750 mg of Anasorb® C300 sorbent. Validated in atmospheres ranging from 0.005 to 0.4 mg/m³, the sampler has a sampling rate of 21.2 ml/min when used at face velocities above 40 ft/min.

The purpose of this study was to validate the Cat. No. 520-04 passive sampler and compare it with the Cat. No. 520-03 sampler containing sorbent capsule Cat. No. 520-02 and validated in OSHA ID 140.

Experimental

A mercury vapor test atmosphere was generated using the method outlined in OSHA ID 140 (*see Figures 1 and 2 at the end of this report*). The atmosphere was tested in a chamber in which face velocity was created using adjustable rotational motion. Atmospheric levels were generated from 0.005 to 0.4 mg/m³. The concentration of the atmosphere within the sampling chamber for each test was verified using SKC Cat. No. 226-17-1A sorbent tubes. The disposable Cat. No. 520-04 passive sampler was used for the study. A Cat. No. 520-03 passive sampler containing sorbent capsule Cat. No. 520-02 was also present in the sampling chamber for each test. The samples were analyzed by an accredited third-party lab following OSHA ID 140 for the passive samplers and NIOSH Method 6009 for the sorbent tubes, with a reporting limit of 0.01 µg.

An initial sampler comparison study was conducted to ensure that SKC Cat. No. 520-04 is comparable to Cat. No. 520-03 containing sorbent capsule Cat. No. 520-02. This comparison was performed over three tests at two different atmospheric levels. For each test, the sampling chamber contained two Cat. No. 520-03 samplers with capsules and two Cat. No. 520-04 samplers. One test was conducted at a targeted atmospheric level of 0.2 mg/m³ and two tests were conducted at 0.4 mg/m³. All tests were run at a face velocity of 50 ft/min and at a temperature of 26 C with a relative humidity (RH) of 40% over a 3-hour exposure period.

SKC Cat. No. 520-04 was validated at 6 atmospheric levels ranging from 0.005 mg/m³ (0.0006 ppm) to 0.25 mg/m³ (0.03 ppm). These events were performed at 26 C, 40% RH, and a face velocity of 50 ft/min; and were sampled for 6 hours.

A sampling rate and capacity study was performed by exposing the sampler to the same targeted atmosphere over six sampling time frames. The exposure times tested were 15 minutes and 1, 2, 4, 6, and 8 hours. These tests were performed at an atmosphere of 0.2 mg/mg³, 55% RH, 26 C, and a face velocity of 50 ft/min. Sampling rate was calculated based on the ppm reported for the Cat. No. 226-17-1A sorbent tube used to verify the sampling environment. The final sampling rate was determined by averaging the sampling rate of all validated samples throughout the validation testing from each experiment in which the sampling rate was calculated. Those experiments include the initial sampler comparison, sampling rate versus atmospheric levels, sampling rate versus times, and sampling rate versus face velocities. Those results do not include low face velocity exposure of 31.5 ft/min.

Various face velocity exposures were conducted to determine the consistency of the sampling rate of the sampler. The face velocities selected for this test ranged from 30 to 300 ft/min. These experiments were performed at 0.1mg/m³, 26 C, and 50% RH; samples were exposed for a time frame of 2 hours.

Desorption efficiency (DE) was determined by injecting known amounts of mercury into a vial containing 750 mg of sorbent. The vials sat overnight to equilibrate before being analyzed for spike recovery. The vials were spiked at four levels in groups of four for a total of 16 samples. The spiking levels were based on an 8-hour time weighted average at a sampling rate of 20 ml/min at 0.25, 0.5, 1.0, and 2.0 times the PEL.

A reverse diffusion study was conducted by placing three Cat. No. 520-04 passive samplers and one assembled Cat. No. 520-03 passive sampler into a 0.025-ppm atmosphere for 3 hours, and then into a 0-ppm atmosphere for another 3 hours. This test was conducted at 50% RH and 25 C.

A storage study was performed by spiking 20 passive samplers with 1 ug of mercury, representing an 8-hour exposure at the PEL and allowing them to equilibrate overnight at ambient temperatures (22 C). Four samplers were analyzed on day 1. The remaining passive samplers were then split into two groups, in which eight were stored in ambient (22 C) conditions and the other eight in cold storage (< 4 C). Four passive samplers from each group were analyzed on days 14 and 21.

Results and Discussion

The tables showing results are at the end of this report.

The initial comparison study of the two passive samplers showed that the average sampling rates of the SKC Cat. No. 520-04 passive sampler and Cat. No. 520-03 passive sampler containing sorbent capsule Cat. No. 520-02 were comparable with a

difference of less than 1%. *See Table 1 for the results of the comparison study of the two samplers for mercury.*

The Cat. No. 520-04 passive sampler maintains consistent sampling over the tested time frame of 15 minutes to 480 minutes. As shown in Table 2, the new passive sampler had a sampling rate of 20.8 ml/min with a standard deviation of 1.0 and a percent relative standard deviation of 4.7%.

The atmospheric level testing demonstrated the passive sampler's capability to provide consistent sample collection in atmospheres of varying concentrations as low as 0.005 to 0.25mg/m³ (0.00061 to 0.03 ppm). The sampling rate over six atmospheres results in an average sampling rate of 21.9 ml/min with a standard deviation of 1.4 and a percent relative standard deviation of 6.2%. *See Table 3 for the results for sampling rate at varying mercury concentrations from 0.0051 to 0.24 mg/m³.*

The effect of face velocity on the ability of the Cat. No. 520-04 sampler to collect mercury was also analyzed. The sampler was exposed to face velocity speeds from 31.5 to 312 ft/min. *See the results in Table 4.*

From 42 to 312 ft/min, the sampling rate was consistent with an average sampling rate of 20.9 ml/min, a standard deviation of 2.0, and a percent relative standard deviation of 9.5%.

At a face velocity less than 42 ft/min, the sampling rate was negatively affected. Sampling rate decreased by 21.4% at a face velocity of 31.5 ft/min, which is comparable to the loss seen in OSHA ID 140 at this lower velocity. The average sampling rate in this study does not include the results from the 31.5 ft/min study, as there is a known drop-off at this level. The Cat. No. 520-04 passive sampler was able to sample consistently down to a face velocity of 42 ft/min.

The sampling rate of the Cat. No. 520-04 passive sampler was determined by combining the validated sampling rate data collected from the comparison, sampling rate and capacity, sampling rate at varying mercury concentrations, and sampling rate at varied face velocity studies. Over the range of the 55 passive samplers analyzed for these studies, the average sampling rate was 21.2 ml/min with a standard deviation of 1.2 and a percent relative standard deviation of 5.7%. The only data point from these studies not used to calculate this value was the 31.5 ft/min face velocity, as there is a known and observed decrease in sampling rate at this level.

The results of the DE study are shown in Table 5. The passive sampler was spiked at 0.25, 0.5, 1.0, and 2.0 ug, corresponding to 0.25, 0.5, 1, and 2 times the current PEL of 0.1 mg/m³ based on an 8-hour sample sampling at 20 ml/min. At an average DE of 1.01, the results indicate that a DE correction does not need to be made.

Reverse diffusion of mercury back into the atmosphere was verified by exposing three of the samplers to a 0.025-ppm atmosphere for 3 hours and then to a 0-ppm atmosphere for 3 hours. Testing of the passive samplers indicated a similar performance to that of the SKC Cat. No. 520-03 passive samplers containing sorbent capsule Cat. No. 520-02 present in the chamber, which in OSHA ID 140 was noted to not have significant sample loss. *See Table 6 for reverse diffusion test results.*

The storage study indicates that the passive sampler is stable for 21 days after sample collection and should be analyzed within that time frame. The passive samplers show no appreciable sample loss when stored at ambient conditions within this time frame.

Conclusion

The SKC Cat. No. 520-04 passive sampler was tested and found to be a comparable counterpart to SKC Cat. No. 520-03 passive sampler with sorbent capsule Cat. No. 520-02, validated in OSHA ID 140. The Cat. No. 520-04 passive sampler has a sampling rate of 21.2 ml/min with a standard deviation of 1.2 and percent relative standard deviation of 5.7% over the course of the study. The sampler maintained consistent sampling rates at face velocities down to 42 ft/min and showed a decrease of 21.4% when tested at 31.5 ft/min. This data is in line with the results for OSHA ID 140. The Cat. No. 520-04 passive sampler and Cat. No. 520-03 passive sampler containing sorbent capsule Cat. No. 520-02 reported similar results to the atmosphere as determined by sorbent tube Cat. No. 226-17-1A. The Cat. No. 520-04 sampler had a DE of 1.01 and reverse diffusion results that were comparable to those of Cat. No. 520-03 containing sorbent capsule Cat. No. 520-02.

The SKC Cat. No. 520-04 passive sampler for elemental mercury vapor is a comparable single-use counterpart to the reusable Cat. No. 520-03 passive sampler containing sorbent capsule Cat. No. 520-02, but with a higher sampling rate.

References

1. *Occupational Safety and Health Administration. (1991). Mercury vapor in workplace atmospheres (Method No. ID-140). US Department of Labor. [id140 combined.pdf](#)*
2. *National Institute for Occupational Safety and Health. (1994). Mercury (Method 6009). In NIOSH manual of analytical methods (4th ed.). US Department of Health and Human Services, Centers for Disease Control and Prevention. [National Institute for Occupational Safety and Health | NIOSH | CDC](#)*

**Table 1. Comparison Study of SKC Cat. Nos. 520-04 and 520-02 Passive Samplers
for Mercury**

0.024 ppm (0.2 mg/m ³)				
520-04		520-02/520-03		226-17-1A
Atmosphere ppm	Sampling rate* (ml/min)	Atmosphere ppm	Sampling rate* (ml/min)	Atmosphere ppm
0.021	22.008	0.023	24.040	0.025
0.021	22.347	0.025	25.394	

0.050 ppm (0.4 mg/m ³)				
520-04		520-02/520-03		226-17-1A
Atmosphere ppm	Sampling rate* (ml/min)	Atmosphere ppm	Sampling rate* (ml/min)	Atmosphere ppm
0.049	19.751	0.043	18.340	0.048
0.049	19.751	0.046	19.751	

0.050 ppm (0.4 mg/m ³)				
520-04		520-02/520-03		226-17-1A
Atmosphere ppm	Sampling rate* (ml/min)	Atmosphere ppm	Sampling rate* (ml/min)	Atmosphere ppm
0.049	21.162	0.042	16.929	0.048
0.047	19.751	0.049	19.751	

520-04		520-02/520-03	
Avg Sampling Rate*	20.795 ml/min	Avg Sampling Rate*	20.701 ml/min
Standard Deviation (SD)	1.207	SD	3.310
%Relative Standard Deviation (RSD)	5.804	%RSD	15.989

*Calculated based on reported ppm of sorbent tube 226-17-1A.

Table 2. Sampling Rate and Capacity Study

226-17-1A	Time (min)*	520-04	
Concentration ppm (mg/m³)		Mass (ug)	Sampling Rate** (ml/min)
0.023 (0.19)	15	0.057	20.137
		0.057	20.137
		0.054	19.07
0.024 (0.2)	60	0.25	21.160
		0.26	22.007
		0.25	21.160
		0.24	20.314
0.022 (0.18)	120	0.46	21.237
		0.44	20.314
		0.44	20.314
0.020 (0.17)	240	0.85	21.583
		0.88	22.345
		0.89	22.599
0.022 (0.18)	360	1.3	20.010
		1.3	20.010
		1.3	20.010
0.022 (0.18)	480	1.9	21.930
		1.7	19.622
		1.8	20.776
Average sampling rate*			20.776
SD			0.978
%RSD			4.708

**Applies to 226-17-1A sorbent tube and 520-04 passive sampler.*

***Calculated based on reported ppm of sorbent tube 226-17-1A.*

**Table 3. Sampling Rate at Varying Mercury Concentrations
from 0.0051 to 0.24 mg/m³**

226-17-1A	520-04	
Concentration ppm (mg/m³)	Mass (ug)	Sampling Rate* (ml/min)
0.00062 (0.0051)	0.039	21.297
	0.041	22.389
	0.040	21.843
0.0032 (0.027)	0.20	21.160
	0.20	21.160
	0.21	22.219
0.0097 (0.08)	0.59	20.593
	0.57	19.895
	0.56	19.546
0.011 (0.09)	0.69	21.237
	0.75	23.084
	0.69	21.237
0.015 (0.12)	1.0	22.571
	1.1	24.828
	1.0	22.571
0.029 (0.24)	1.9	22.182
	2.1	24.517
	1.9	22.182
Average Sampling Rate*		21.917
SD		1.368
%RSD		6.243

*Calculated based on reported ppm of sorbent tube 226-17-1A.

Table 4. Sampling Rate at Varying Face Velocities

226-17-1A	520-04		
Concentration ppm (mg/m³)	Face Velocity (ft/min)	Mass (ug)	Sampling Rate* (ml/min)
0.013 (0.11)	31.5	0.20	15.626
		0.21	16.408
		0.22	17.189
0.012 (0.1)	42	0.24	20.314
		0.24	20.314
		0.23	19.468
0.012 (0.099)	102	0.25	21.160
		0.25	21.160
		0.26	22.001
0.012 (0.1)	200	0.25	21.160
		0.26	22.007
		0.25	21.160
0.012 (0.096)	312	0.25	21.160
		0.24	20.314
		0.24	20.314
Average Sampling Rate**			20.878
SD**			1.989
%RSD			9.526

*Calculated based on reported ppm of sorbent tube 226-17-1A.

**Results do not include 31.5 ft/min data.

Table 5. Desorption Efficiency (DE)

Level*	Sample #	Spike Level	ug Recovered	DE
0.25x PEL	1	0.25 ug/750 mg	0.26	1.04
	2		0.26	1.04
	3		0.25	1.00
	4		0.26	1.04
0.5x PEL	5	0.5 ug/750 mg	0.47	0.94
	6		0.48	0.96
	7		0.50	1.00
	8		0.55	1.10
1.0x PEL	9	1.0 ug/750 mg	0.97	0.97
	10		0.96	0.96
	11		1.0	1.00
	12		1.1	1.10
2.0x PEL	13	2.0 ug/750 mg	2.0	1.00
	14		2.0	1.00
	15		1.9	0.95
	16		2.0	1.00
			Average DE	1.01
			SD	0.02
			%RSD	1.63

*PEL of 0.1mg/m³

Table 6. Reverse Diffusion of Mercury Using SKC Cat. No. 520-04 Passive Sampler

226-17-1A	520-04	
Atmosphere ppm (mg/m ³)	Mass (ug)	PPM (mg/m ³)
0.025 (0.2)	0.65	0.022 (0.18)
	0.68	0.023 (0.19)
	0.65	0.022 (0.18)
Average Atmosphere SD %RSD		0.022 (0.18)
		0.001
		2.585

Figure 1. Atmosphere Generator

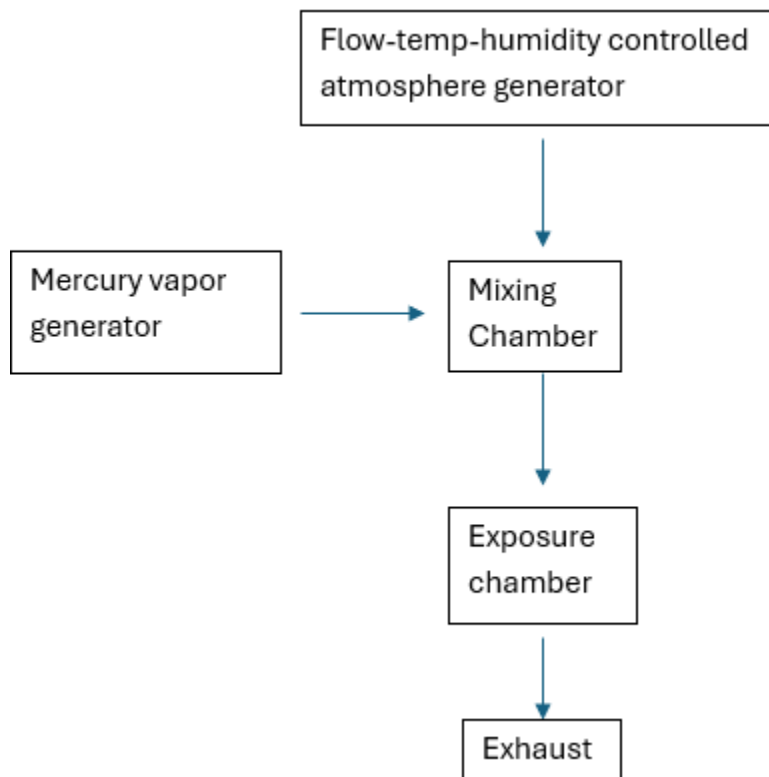


Figure 2. Mercury Vapor Generator

