

**Laboratory Evaluation of AT574 Diffusive Air Sampler
using dynamically-generated HAGS Test Atmospheres**
in accordance with guidelines described in ANSI/ISEA 104-1998 (R2009)

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

Date: 25 July 2013

These tests for Evaluation of Diffusive Air Samplers were conducted within the guidelines described in ANSI 104-1998 (R2009).

1. Test Apparatus & Method

Vapor exposures of HAGS (halogenated anesthetic gases) including desflurane (suprane), enflurane (ethrane), halothane, isoflurane (forane), and sevoflurane (ultane) were created by dynamic dilution from a liquid phase containing the five pure analytes in solution. The liquid analyte mixture was injected into a flowing stream of air at a fixed rate via a syringe pump (Harvard), then dynamically mixed with flow-controlled input air provided by the Miller-Nelson 401 atmosphere conditioner. The controlled mixture was passed through an inert acrylic chamber containing Diffusive Samplers under test. Flows were verified by calibration, and exposure concentrations were verified by charcoal tube samplers mounted in the chamber and bracketing the Samplers under test. Active and diffusive samplers were analyzed by Gas Chromatography on 0.32mm x 60 M dual capillary columns (Restek RT-1 and RT-volatiles).

2. De-Sorption Efficiency (DE)

Analyte recovery (de-sorption efficiency) was determined by analysis (Method AT574) of charcoal wafers "spiked" from standard analyte solutions. Samplers were tested at "spike" levels corresponding to expected levels of exposure in the vicinity of the NIOSH REL. DE Results are presented in Table 1.

3. Verification of Diffusive Sampling Rate

Samplers were exposed to exposure concentrations in Chambers as described above, then analyzed by Method AT574. Exposures were applied to Samplers in the vicinity of the NIOSH REL. Results for the five halogenated anesthetics (HAGS) are reported in Tables 2A, 2B, 3A, and 3B, respectively.

4. Background (Blank) Determination

Unexposed Samplers analyzed by Method AT574 to determine background Analyte levels (if any) on the Sampler prior to sampling. No background peaks were detectable ($< 0.1 \mu\text{g}$).

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 Sampler using analytes other than the ones 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 Sampler using analytes other than the ones in this study, was not repeated in this study.



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7. Effect of Sampler Storage After Sampling (Analyte Stability)(Holding Time)

Identical sets of Samplers were exposed as described in Section 1 to Analyte concentrations in the vicinity of the NIOSH REL. One set of Samples was stored at -20°C as a control, then compared to others sets of concomitantly-exposed Samplers after storage at room temperature. All five halogenated anesthetics were found to be stable on the AT574 Sampler when stored at Room Temperature. Results are incorporated in Tables 2B and 3B.

8. Sampler Package Integrity

Ethylene Oxide Samplers (Monitor 502) in sealed packaging exposed to >10 ppm ethylene oxide for >2 hours, then analyzed as directed in the Instructions for Use. Results from analysis were not significantly different from results for un-exposed Samplers (blank values) demonstrating the integrity of Sampler packaging. This result with ethylene oxide (which has highest permeability through plastics and pinholes of all analytes tested) is applicable to all Samplers manufactured by Assay Technology and packaged in its standard aluminum foil pouch.

9. Summary Comments

Sampler AT574 has been evaluated for sampling five halogenated anesthetics. The overall system accuracy expressed as Maximum Total Error (95% confidence) is estimated at $\leq 25\%$

Concentration Range	0.1-2.0 times the NIOSH REL of 2 ppm
Sampling Time	0.5 - 8 hour
Air Velocity	15-150 cm/sec
Temperature	Room Temperature
Humidity	10-80% RH

It is recommended that Sampler 574 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.

The recommended maximum Holding Times after sampling are 14 days at room temperature.

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**Table 1
De-Sorption Efficiency
(solvent = toluene)**

	Desflurane	Enflurane	Halothane	Isoflurane	Sevoflurane
Qty Applied (µg)	60	84	104	80	82
% Recovery (ave of 4) Trial A	96.9%	95.9%	93.2%	94.6%	95.6%
% Recovery (ave of 4) Trial B	98.9%	97.5%		96.4%	96.4%
Average	97.9%	96.7%	93.2%	95.5%	96.0%
Qty Applied (µg)	120	168	200	160	165
% Recovery (ave of 4) Trial A	92.3%	90.5%	90.6%	90.1%	89.8%
% Recovery (ave of 4) Trial B	90.2%	89.8%		89.3%	89.1%
Average	91.3%	90.2%	90.6%	89.7%	89.5%
Qty Applied (µg)	225	325	400	310	320
% Recovery (ave of 4) Trial A	100.4%	97.1%	95.3%	96.4%	97.3%
% Recovery (ave of 4) Trial B	101.1%	96.3%		95.9%	97.5%
Average	100.8%	96.7%	95.3%	96.2%	97.4%
% Recovery (Grand Average)	96.6%	94.5%	93.0%	93.8%	94.3%

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**Table 2A
Verification of Sampling Rates
(4 hr test)**

Sample Description	Chemical Analyte	Qty (µg)(a)	Volume (L)	Time (min)	Concn ppm
4 hr Exposure 1 - Sampler A	DESFLURANE	24.7	2.05	240	1.75
	ENFLURANE	34.3	1.96	240	2.32
	HALOTHANE	213	2.09	240	12.6
	ISOFLURANE	40.0	1.89	240	2.81
	METHOXYFLURANE	26.0	1.90	240	2.02
	SEVOFLURANE	45.0	1.89	240	2.90
4 hr Exposure 1 - Sampler B	DESFLURANE	28.0	2.05	240	1.98
	ENFLURANE	32.9	1.96	240	2.23
	HALOTHANE	213	2.09	240	12.61
	ISOFLURANE	36.7	1.89	240	2.57
	METHOXYFLURANE	27.0	1.90	240	2.10
	SEVOFLURANE	45.0	1.89	240	2.90
4 hr Exposure 1 - Sampler C	DESFLURANE	26.0	2.05	240	1.84
	ENFLURANE	32.9	1.96	240	2.23
	HALOTHANE	213	2.09	240	12.6
	ISOFLURANE	40.0	1.89	240	2.81
	METHOXYFLURANE	26.0	1.90	240	2.02
	SEVOFLURANE	50.0	1.89	240	3.23
4 hr Exposure 1 - Sampler D	DESFLURANE	18.7	2.05	240	1.32
	ENFLURANE	30.0	1.96	240	2.03
	HALOTHANE	200	2.09	240	11.9
	ISOFLURANE	33.3	1.89	240	2.34
	METHOXYFLURANE	26.0	1.90	240	2.02
	SEVOFLURANE	35.0	1.89	240	2.26
Sample Description	Chemical Analyte	Qty (µg)(a)	Time (min)	Concn ppm	% of Reference
4 hr Exposure 1 - Average of Personal Monitoring Badges	DESFLURANE	24.3	240	1.72	94%
	ENFLURANE	33	240	2.20	90%
	HALOTHANE	209	240	12.4	98%
	ISOFLURANE	38	240	2.63	101%
	METHOXYFLURANE	26	240	2.04	93%
	SEVOFLURANE	44	240	2.82	100%
4 hr Exposure 1 - Average of Charcoal Tubes	DESFLURANE	73	240	1.83	100%
	ENFLURANE	105	240	2.43	100%
	HALOTHANE	587	240	12.67	100%
	ISOFLURANE	113	240	2.60	100%
	METHOXYFLURANE	85	240	2.20	100%
	SEVOFLURANE	137	240	2.83	100%

(a) Qty (Quantity Recovered) has been corrected for de-sorption efficiency.

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**Table 2B
Verification of Analyte Stability on the Sampler
(4 hr test)**

Sample Description	Chemical Analyte	Qty (µg)(a)	Volume (L)	Time (min)	Concn ppm
4 hr Exposure 1 - Sampler E Stored 1 wk at Room Temp	DESFLURANE	28.0	2.05	240	1.98
	ENFLURANE	32.9	1.96	240	2.23
	HALOTHANE	200	2.09	240	11.9
	ISOFLURANE	38.3	1.89	240	2.69
	METHOXYFLURANE	26.0	1.90	240	2.02
	SEVOFLURANE	47.5	1.89	240	3.07
4 hr Exposure 1 - Sampler F Stored 1 wk at Room Temp	DESFLURANE	29.3	2.05	240	2.08
	ENFLURANE	35.7	1.96	240	2.42
	HALOTHANE	225	2.09	240	13.35
	ISOFLURANE	40.0	1.89	240	2.81
	METHOXYFLURANE	27.0	1.90	240	2.10
	SEVOFLURANE	47.5	1.89	240	3.07
4 hr Exposure 1 - Sampler G Stored 1 wk at Room Temp	DESFLURANE	26.0	2.05	240	1.84
	ENFLURANE	32.9	1.96	240	2.23
	HALOTHANE	200	2.09	240	11.9
	ISOFLURANE	38.3	1.89	240	2.69
	METHOXYFLURANE	25.0	1.90	240	1.95
	SEVOFLURANE	45.0	1.89	240	2.90
4 hr Exposure 1 - Sampler H Stored 1 wk at Room Temp	DESFLURANE	28.7	2.05	240	2.03
	ENFLURANE	32.9	1.96	240	2.23
	HALOTHANE	200	2.09	240	11.9
	ISOFLURANE	40.0	1.89	240	2.81
	METHOXYFLURANE	25.0	1.90	240	1.95
	SEVOFLURANE	45.0	1.89	240	2.90
Sample Description	Chemical Analyte	Qty (µg)(a)	Time (min)	Concn ppm	% of Reference
4 hr Exposure 1 - Average Personal Monitoring Badges Stored 1 wk at Room Temp	DESFLURANE	28.0	240	1.98	108%
	ENFLURANE	34	240	2.27	93%
	HALOTHANE	206	240	12.2	97%
	ISOFLURANE	39	240	2.75	106%
	METHOXYFLURANE	26	240	2.00	91%
	SEVOFLURANE	46	240	2.98	105%
4 hr Exposure 1 - Average of Charcoal Tubes	DESFLURANE	73	240	1.83	100%
	ENFLURANE	105	240	2.43	100%
	HALOTHANE	587	240	12.67	100%
	ISOFLURANE	113	240	2.60	100%
	METHOXYFLURANE	85	240	2.20	100%
	SEVOFLURANE	137	240	2.83	100%

(a) Qty (Quantity Recovered) has been corrected for de-sorption efficiency.

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**Table 3A
Verification of Sampling Rates
(2 hr test)**

Sample Description	Chemical Analyte	Qty (µg)(a)	Volume (L)	Time (min)	Concn ppm
2 hr Exposure 2 - Sampler A	DESFLURANE	14.6	1.03	120	2.07
	ENFLURANE	22.9	0.98	120	3.10
	HALOTHANE	125	1.04	120	14.8
	ISOFLURANE	22.9	0.94	120	3.21
	METHOXYFLURANE	15.6	0.95	120	2.42
	SEVOFLURANE	24.3	0.95	120	3.13
2 hr Exposure 2 - Sampler B	DESFLURANE	12.6	1.03	120	1.79
	ENFLURANE	21.4	0.98	120	2.90
	HALOTHANE	120	1.04	120	14.24
	ISOFLURANE	21.4	0.94	120	3.01
	METHOXYFLURANE	14.4	0.95	120	2.25
	SEVOFLURANE	21.4	0.95	120	2.77
2 hr Exposure 2 - Sampler C	DESFLURANE	15.4	1.03	120	2.18
	ENFLURANE	25.7	0.98	120	3.48
	HALOTHANE	138	1.04	120	16.3
	ISOFLURANE	25.7	0.94	120	3.61
	METHOXYFLURANE	16.7	0.95	120	2.60
	SEVOFLURANE	25.7	0.95	120	3.32
2 hr Exposure 2 - Sampler D	DESFLURANE	15.6	1.03	120	2.21
	ENFLURANE	25.7	0.98	120	3.48
	HALOTHANE	150	1.04	120	17.8
	ISOFLURANE	25.7	0.94	120	3.61
	METHOXYFLURANE	17.8	0.95	120	2.77
	SEVOFLURANE	28.6	0.95	120	3.69

Sample Description	Chemical Analyte	Qty (µg)(a)	Time (min)	Concn ppm	% of Reference
2 hr Exposure 2 - Average Personal Monitoring Badges	DESFLURANE	14.6	120	2.06	92%
	ENFLURANE	24	120	3.24	108%
	HALOTHANE	133	120	15.8	102%
	ISOFLURANE	24	120	3.36	105%
	METHOXYFLURANE	16	120	2.51	102%
	SEVOFLURANE	25	120	3.23	92%
2 hr Exposure 2 - Average Charcoal Tubes	DESFLURANE	47	120	2.25	100%
	ENFLURANE	69	120	3.00	100%
	HALOTHANE	380	120	15.50	100%
	ISOFLURANE	74	120	3.20	100%
	METHOXYFLURANE	49	120	2.45	100%
	SEVOFLURANE	87	120	3.50	100%

(a) Qty (Quantity Recovered) has been corrected for de-sorption efficiency.

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**Table 3B
Verification of Analyte Stability on the Sampler
(2 hr test)**

Sample Description	Chemical Analyte	Qty (µg)(a)	Volume (L)	Time (min)	Concn ppm
2 hr Exposure 2 - Sampler E Stored 1 wk at Room Temp	DESFLURANE	11.4	0.70	120	2.38
	ENFLURANE	14.6	0.66	120	2.94
	HALOTHANE	86	0.74	120	14.4
	ISOFLURANE	15.8	0.66	120	3.17
	METHOXYFLURANE	10.0	0.66	120	2.25
	SEVOFLURANE	16.7	0.64	120	3.20
2 hr Exposure 2 - Sampler F Stored 1 wk at Room Temp	DESFLURANE	10.6	0.70	120	2.22
	ENFLURANE	13.1	0.66	120	2.63
	HALOTHANE	79	0.74	120	13.22
	ISOFLURANE	15.0	0.66	120	3.00
	METHOXYFLURANE	10.0	0.66	120	2.25
	SEVOFLURANE	15.8	0.64	120	3.04
2 hr Exposure 2 - Sampler G Stored 1 wk at Room Temp	DESFLURANE	10.8	0.70	120	2.27
	ENFLURANE	13.2	0.66	120	2.65
	HALOTHANE	77	0.74	120	13.0
	ISOFLURANE	13.6	0.66	120	2.73
	METHOXYFLURANE	10.4	0.66	120	2.35
	SEVOFLURANE	13.2	0.64	120	2.54
2 hr Exposure 2 - Sampler H Stored 1 wk at Room Temp	DESFLURANE	9.0	0.70	120	1.88
	ENFLURANE	15.7	0.66	120	3.16
	HALOTHANE	90	0.74	120	15.1
	ISOFLURANE	16.0	0.66	120	3.20
	METHOXYFLURANE	12.3	0.66	120	2.76
	SEVOFLURANE	17.3	0.64	120	3.33
Summary Data					
Sample Description	Chemical Analyte	Qty (µg)(a)	Time (min)	Concn ppm	% of Reference
2 hr Exposure 2 - Average Personal Monitoring Badges Stored 1 wk at Room Temp	DESFLURANE	14.8	120	2.19	106%
	ENFLURANE	10	120	2.85	88%
	HALOTHANE	15	120	13.9	88%
	ISOFLURANE	10	120	3.03	90%
	METHOXYFLURANE	14	120	2.40	96%
	SEVOFLURANE	83	120	3.03	94%
2 hr Exposure 2 - Average of Charcoal Tubes	DESFLURANE	47		2.25	100%
	ENFLURANE	69		3.00	100%
	HALOTHANE	380		15.50	100%
	ISOFLURANE	74		3.20	100%
	METHOXYFLURANE	49		2.45	100%
	SEVOFLURANE	87.0		3.5	100%

(a) Qty (Quantity Recovered) has been corrected for de-sorption efficiency.