assay technology

Laboratory Evaluation of AT574 Halogenated Anesthetic Gases Sampler

Prepared by: CR Manning, PhD, CIH and BJ Quarles, PhD   Revised: 19 April 2018

These tests for evaluation of diffusive air samplers were conducted within the guidelines described in ANSI 104-1998 (R2009).

Halogenated Anesthetic Gases (HAGs) Sampler

Assay Technology's 574 HAGs sampler consists of a wafer of activated carbon in a PTFE binder contained in a polypropylene sampler body with a 76-port polypropylene sampling grid. The HAGs sampler can be used to collect the following anesthetic gases:

Desflurane	Isoflurane
Enflurane	Methoxyflurane
Halothane	Sevoflurane

1. Test Apparatus & Method

Vapor exposures of a mixture of the HAGs listed above were created by dynamic dilution from a liquid phase containing the pure analytes in solution. The liquid analyte mixture was injected into a flowing stream of air at a fixed rate via a syringe pump, and was then dynamically mixed with flow-controlled input air provided by the Miller-Nelson 501 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 sampling tubes mounted in the chamber, bracketing the samplers under test. Active and diffusive samplers were analyzed by gas chromatography.

2. Desorption Efficiency (DE)

Analyte recovery from the wafer (desorption efficiency) was determined by analysis (Method AT574) of charcoal wafers spiked from standard analyte solutions. Samplers were tested at spike levels corresponding to levels of expected exposure in the vicinity of the NIOSH REL. By utilizing toluene as the desorption solvent, it was found that DEs greatly improved compared to the more commonly used carbon disulfide; in some cases DEs went up more than 20 – 30%. The DE results from the study are presented in Table 1.

Table 1. Desorption efficiencies (in toluene) for HAGs on the AT574 sampler

	Desflurane	Enflurane	Halothane	Isoflurane	Sevoflurane
Level 1 Spike (µg)	60	84	104	80	82
Avg % Recovery Trial A	96.9%	95.9%	93.2%	94.6%	95.6%
Avg % Recovery Trial B	98.9%	97.5%		96.4%	96.4%
Average	97.9%	96.7%	93.2%	95.5%	96.0%
Level 2 Spike (µg)	120	168	200	160	165
Avg % Recovery Trial A	92.3%	90.5%	90.6%	90.1%	89.8%
Avg % Recovery Trial B	90.2%	89.8%		89.3%	89.1%
Average	91.3%	90.2%	90.6%	89.7%	89.5%
Level 3 Spike (µg)	225	325	400	310	320
Avg % Recovery Trial A	100.4%	97.1%	95.3%	96.4%	97.3%
Avg % Recovery Trial B	101.1%	96.3%		95.9%	97.5%
Average	100.8%	96.7%	95.3%	96.2%	97.4%
% Recovery (Grand Avg)	96.6%	94.5%	93.0%	93.8%	94.3%

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3. Verification of Diffusive Sampling Rate

Samplers were tested in 2- and 4-hour studies according to the procedure described in Section 1. Then they were analyzed by Method AT574. Exposures were applied to samplers in the vicinity of the NIOSH REL. Results for verification of the HAGs sampling rates are reported in Tables 2A and 2B.

Table 2A. Verification of sampling rates in a 4-hour test; using published sampling rate to determine concentration on AT574 Samplers, values should be in line with the concentrations found on tubes

Sample Description	Chemical Analyte	Qty (µg)	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)	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	
	ENFLURANE	105	240	2.43	
	HALOTHANE	587	240	12.67	
	ISOFLURANE	113	240	2.60	
	METHOXYFLURANE	85	240	2.20	
	SEVOFLURANE	137	240	2.83	

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Table 2B. Verification of sampling rates in a 2-hour test; using published sampling rate to determine concentration on AT574 Samplers; values should be the same as tube concentrations

Sample Description	Chemical Analyte	Qty (µg)	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)	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	
	ENFLURANE	69	120	3.00	
	HALOTHANE	380	120	15.50	
	ISOFLURANE	74	120	3.20	
	METHOXYFLURANE	49	120	2.45	
	SEVOFLURANE	87	120	3.50	

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4. Background (Blank) Determination
Unexposed samplers were analyzed by Method AT574 to determine background analyte levels (if any) on the sampler prior to sampling. No background peaks were detectable (< 0.1 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. Reverse Diffusion
Reverse diffusion studies were also performed with the media. Two experiments were conducted to analyze for any reverse diffusion of the analyte after absorbing to the media. Recoveries of analyte from samplers subject to the ZEP were compared with recoveries of analyte from samplers analyzed immediately. Any difference between these two recoveries is taken as the extent reverse diffusion.

The two experiments were:
- Samplers exposed to challenge analytes for 2 h, then held in the chamber with air flow only for 6 hours (a zero exposure period (ZEP))
- Samplers exposed to challenge analytes for 4 h, then held in the chamber with air flow only for an additional 4 hours (ZEP)

For samplers subject to a ZEP, recoveries were within 10% compared to samplers analyzed immediately after exposure. Thus, no significant bias due to reverse diffusion was observed. Results are shown in Tables 3.

Table 3. Reverse diffusion data on AT555 for 2- and 4-hour exposures

Sample Description	Chemical Analyte	Qty (μg)	Concentration (ppm)	% of Initial
2-h exposure/immediate collection	DESFLURANE	11	1.5	
	ENFLURANE	10	1.4	
	HALOTHANE	57	6.8	
	ISOFLURANE	9	1.3	
	SEVOFLURANE	10	1.3	
2-h exposure/6 h air only	DESFLURANE	10	1.4	93%
	ENFLURANE	10	1.4	100%
	HALOTHANE	56	6.6	97%
	ISOFLURANE	11	1.5	115%
	SEVOFLURANE	10	1.3	100%

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Sample Description	Chemical Analyte	Qty (µg)	Concentration (ppm)	% of Initial
4-hr exposure/immediate collection	DESFLURANE	28	1.9	
	ENFLURANE	29	2	
	HALOTHANE	159	9.5	
	ISOFLURANE	30	2.1	
	SEVOFLURANE	28	1.8	
4-h exposure/4 h air only	DESFLURANE	27	1.9	100%
	ENFLURANE	29	2	100%
	HALOTHANE	159	9.4	99%
	ISOFLURANE	30	2.1	100%
	SEVOFLURANE	28	1.8	100%

7. Analyte Stability (storage post-sampling)

A challenge test to assess the stability of the collected analyte on the media after sampling was conducted by exposing a set of samplers to the challenge concentration (as described in Section 1). Samples were divided into five different groups with various storage times and conditions:
-initial samples collected immediately following the exposure to HAGs
-samples stored at room temperature for 1 week
-samples stored at room temperature for 2 weeks
-samples stored under refrigeration (3°C) for 2 weeks
-samples stored in a freezer (-10°C) for 2 weeks

The samples were found to be stable at room temperature (i.e. no special storage precautions after sampling) for up to two weeks (recommended maximum holding time). Table 4 summarizes the results.

Table 4. Verification of analyte stability on the sampler after a 4-hour test.

Sample Description	Chemical Analyte	Qty (µg)	Concentration (ppm)	% of Initial
4-hr exposure-immediate collection	DESFLURANE	28	2.0	
	ENFLURANE	29	2.0	
	HALOTHANE	160	9.5	
	ISOFLURANE	31	2.2	
	SEVOFLURANE	28	1.8	
4-hr exposure-1 week storage at RT	DESFLURANE	29	2.0	104%
	ENFLURANE	28	1.9	96%
	HALOTHANE	154	9.2	97%
	ISOFLURANE	30	2.1	98%
	SEVOFLURANE	27	1.8	97%

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Sample Description	Chemical Analyte	Qty (µg)	Concentration (ppm)	% of Initial
4-hr exposure-2 week storage at RT	DESFLURANE	30	2.1	109%
	ENFLURANE	29	1.9	96%
	HALOTHANE	158	9.4	99%
	ISOFLURANE	30	2.1	97%
	SEVOFLURANE	28	1.8	100%
4-hr exposure-2 week storage at 3°C	DESFLURANE	31	2.2	112%
	ENFLURANE	29	2.0	99%
	HALOTHANE	160	9.5	100%
	ISOFLURANE	3028	2.1	98%
	SEVOFLURANE	28	1.8	101%
4-hr exposure-2 week storage at -10°C	DESFLURANE	30	2.1	108%
	ENFLURANE	29	2.0	99%
	HALOTHANE	162	9.6	101%
	ISOFLURANE	30	2.1	98%
	SEVOFLURANE	28	1.8	100%

8. Summary Comments

Sampler AT574 has been evaluated for sampling halogenated anesthetic gases. 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	0 – 50°C
Humidity	10 – 80% RH

The recommended maximum holding time after sampling is 14 days at room temperature.

It is recommended that AT574 samplers 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.