

<p style="text-align: center;">AIR SAMPLER EVALUATION (ANSI 104-1998) SUMMARY of TESTS - Benzene, Toluene, Xylenes</p>

Methods described here are referenced to numbered documents which specify details of the methods. Statistical results of the tests are reported in the following sections.

Sections 1 - 4 of ANSI/SEI 104-1998 are as follows:

1. Purpose, Practice, Rationale and Scope
2. Determination of Standard Compliance
3. References
4. Definitions

Sections 5 and 6 describe the test method and procedures of validation. Descriptions and related data follow.

5. Test Apparatus & Method (Method AT-EXP-2)

Stock standard gas was created by static dilution from 100% analyte, mixed volumetrically with input air pumped at a pre-set flow rate through an inert polypropylene chamber containing Diffusive Samplers under test. Flow was verified by in-line rotameter and analyte concentrations were verified by charcoal tube samples continuously drawn from locations in the chamber bracketing the Samplers under test.

6.2 De-Sorption Efficiency (DE) (Method AT-DE-1)(forward)

Analyte recovery and de-sorption efficiency determined by analysis (Method AT541) of charcoal wafers "spiked" from standard analyte solutions in carbon disulfide. Samplers were tested at several "spike" levels corresponding to levels expected for 8-hr Sampler exposures at 0.5-2.0 times the OSHA PEL. Results in Table 6.2.

Table 6.2 %Recovery
(De-Sorption Efficiency)

Analyte Name	Amount Spiked	Amount Recovered	% DE	Date
	(ug/ml)	(ug/ml)		
Benzene	0.52	0.47	90%	08-Oct-98
"	0.52	0.54	103%	08-Oct-98
"	0.52	0.60	115%	08-Oct-98
"	2.62	2.42	92%	08-Oct-98
"	2.62	2.44	93%	08-Oct-98
"	2.62	2.50	95%	08-Oct-98
"	5.24	4.94	94%	08-Oct-98
"	5.24	4.98	95%	08-Oct-98
Toluene	10	10	97%	08-Oct-98
"	42	39	94%	08-Oct-98
"	61	50	83%	08-Oct-98
"	61	60	99%	08-Oct-98
"	61	60	99%	08-Oct-98
"	303	287	95%	08-Oct-98
"	303	290	96%	08-Oct-98
"	303	295	98%	08-Oct-98
"	606	576	95%	08-Oct-98
"	606	582	96%	08-Oct-98
"	606	586	97%	08-Oct-98
"	762	750	99%	08-Oct-98
Xylenes	56	55	97%	06-Oct-98
"	56	55	98%	06-Oct-98
"	280	264	94%	06-Oct-98
"	280	269	96%	06-Oct-98
"	280	272	97%	06-Oct-98
"	560	540	96%	06-Oct-98
"	560	531	95%	06-Oct-98
"	560	530	95%	06-Oct-98

Table 6.2 (a) De-Sorption Method = Forward
 (b) De-Sorption Solvent = 97% Carbon disulfide + 3% Benzyl alcohol
 (c) De-Sorption Volume = 2.0 ml
 (d) Media = Assay Technology Monitor AT541

6.3 Effect of Concentration/Time on Sampler Accuracy

Samplers were subject to chamber exposures as described in Section 5. then analyzed by Method AT541. Exposures were applied to Samplers in the range 1-8 hours and 0.1-2.0 times the OSHA PEL. Results in Table 6.3.

Table 6.3 Uptake Rate Test

RUN #	ANALYTE	TIME (min)	TIME (hr)	Ref CONC (ppm)	Ref EXP (ppm-hr)	RUN AVE	RUN AVE		
						Ref EXP (ppm-hr)	ug/SAMPLR (ug)		
VA4	BENZENE	15.36	0.26	0.61	0.16	0.15	0.505	Least Squares Calculations	
							0.631		
							0.442	REF EXP	DME Found
							0.568	(ppt-min)	(uliter)
							0.547	0.000	0.000
							0.526	0.009	0.166
VA4	BENZENE	121	2.02	0.554	1.12	1.12	1.73	Least Squares Calculations	
							1.89		
							1.76	0.067	0.561
							1.79	0.261	2.120
							1.94	3.720	27.729
							1.75	3.720	26.613
BZVAL 7	BENZENE	145	2.42	1.8	4.35	4.35	6.63	Slope=	Slope=
							6.73	SampRate =	7.49
							7.41	Corr =	0.998
							6.98	Accuracy =	101%
							6.53		
							6.78		
BZ126	BENZENE	240	4.00	15.5	62.00	62.00	89.50		
							85.90		
							95.00		
VA3A	TOLUENE	15.36	0.26	41.3	10.57	10.74	19.17	Least Squares Calculations	
							18.53		
							19.38	REF EXP	DME Found
							18.76	(ppt-min)	(uliter)
							17.64	0.000	0.000
							18.64	0.645	4.908
VA4A	TOLUENE	121	2.02	40.6	81.88	82.15	128.4	Least Squares Calculations	
							122.6		
							135.2	4.929	33.535
							121.8	3.684	23.953
							126.9	3.684	24.636
							131.2	Slope=	Slope=
TOL126	TOLUENE	240	4.00	15.35	61.40	61.40	91.20	Corr = 0.999	
							93.80	Accuracy =	1.05
		15.36	0.26	39.97	10.23		19.45		
							17.83		
							19.83		
							18.1		

		15.36	0.26	40.7	10.42		17.52		
VA3B	XYLENE	15.36	0.26	42.42	10.86	10.50	18.41	18.52	
							133.1		
							127.4		
							141.6		
		121	2.02	40.5	81.68		127		
		121	2.02	40.8	82.28		131		
VA4B	XYLENE	121	2.02	40.2	81.07	81.68	137.4	132.92	
							19.6		
							17.2		
							18.9		
		15.36	0.26	38.5	9.86		17.9		
		15.36	0.26	39.3	10.06		16.8		
VA3C	XYLENE	15.36	0.26	41.1	10.52	10.15	17.7	18.02	
							130.3		
							126.3		
							137.9		
		121	2.02	39.3	79.26		125.9		
		121	2.02	39.6	79.86		128.8		
VA4C	XYLENE	121	2.02	38.9	78.45	79.19	134.6	130.63	
		240	4.00	10.4	41.60	41.60		70.40	
		240	4.00	10.4	41.60	41.60		69.40	
								Least Squares Calculations	
							REF EXP (ppt-min)	DME Found (uliter)	
							0.000	0.000	
							0.630	3.856	
							4.901	27.670	
							0.609	3.751	
							4.751	27.194	
							2.496	14.655	
							2.496	14.447	
							Slope=	Slope=	
							SampRate =	5.65	
							Corr = 1.000		
							Accuracy =	102%	

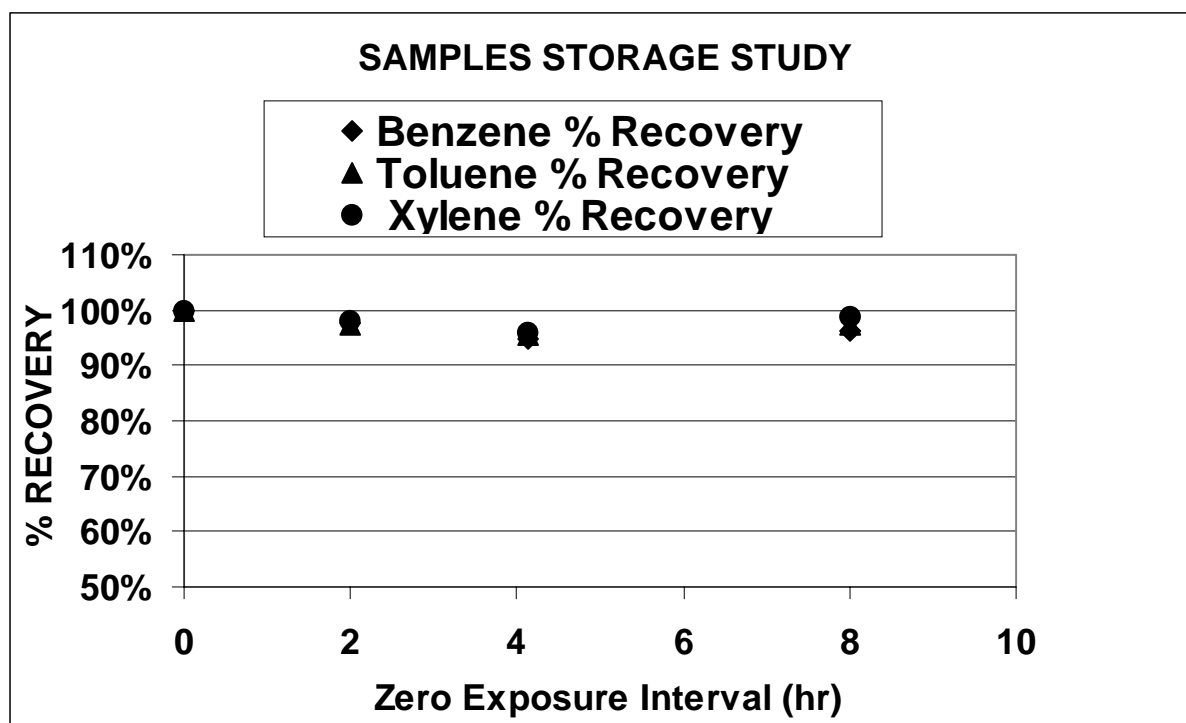
6.4 Bias Due to Reverse Diffusion

Samplers were subject to Exposure Pulse (\geq OSHA PEL) with a duration less than 50% of the Recommended Sampling Time (RST) followed by a Zero Exposure Period (ZEP) for the duration of the RST. The recovery of analyte from Samplers analyzed immediately following Exposure Pulse was compared with analyte recovery from identically-exposed Samplers analyzed at the end of the RST (i.e. following the Zero Exposure Period). The difference between these two recoveries is taken as the extent of Reverse Diffusion (i.e. evaporative loss as % of Sample) from the Sampler under the experimental conditions chosen.

In practice, Bias Due to Reverse Diffusion will depend on the extent and duration of actual Exposure Pulses in the environment being monitored which cannot be exactly predicted in a lab test. For this evaluation, Bias Due to Reverse Diffusion was estimated as the extent of Reverse Diffusion (evaporative loss as % of Sample) when an Exposure Pulse at 1.0 times the PEL is applied for 12% of the duration of the RST followed by a Zero Exposure Period of 100% of the RST. Results in Table 6.4.

Table 6.4 Recovery of Initial Vapor Spike
 After Zero Exposure Interval
 (% Loss = "Reverse Diffusion")

Hrs Exposure at 0.0 ppm =	0.00	2.00	4.13	8.00
BENZENE Found (ug) =	9.95	9.72	9.44	9.58
Std Deviation = +/-	0.29	0.18	0.50	0.27
Co-Eff Variation = +/-	3%	2%	5%	3%
Benzene % Recovery	100%	98%	95%	96%
TOLUENE Found (ug) =	77.07	75.01	73.65	75.07
Std Deviation = +/-	2.89	1.32	2.95	1.25
Co-Eff Variation = +/-	4%	2%	4%	2%
Toluene % Recovery	100%	97%	96%	97%
XYLENE Found (ug) =	64.58	63.31	61.92	63.70
Std Deviation = +/-	3.42	0.90	3.24	1.10
Co-Eff Variation = +/-	5%	1%	5%	2%
Xylene % Recovery	100%	98%	96%	99%



6.5 Background (Blank) Determination

Unexposed Samplers analyzed by Method AT541 to determine background Analyte levels (if any) on the Sampler prior to sampling.

6.6 Effects of Air Velocity & Orientation

Samplers exposed to atmospheres of benzene, toluene, and xylene for 2-4 hrs at 1-2 times the OSHA PEL (see Section 5) in a Chamber with 3 zones of different cross-sectional areas 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 were compared from the six locations (representing normal air velocity and orientation variation in workplaces), no significant differences were found among the six groups indicating the *absence of an effect of Air Velocity & Orientation on Sampling Rate in the range 15-150 cm/sec*. *This result is applicable to other organic vapors when the same Sampler is used.*

6.7 Effect of Temperature & Humidity

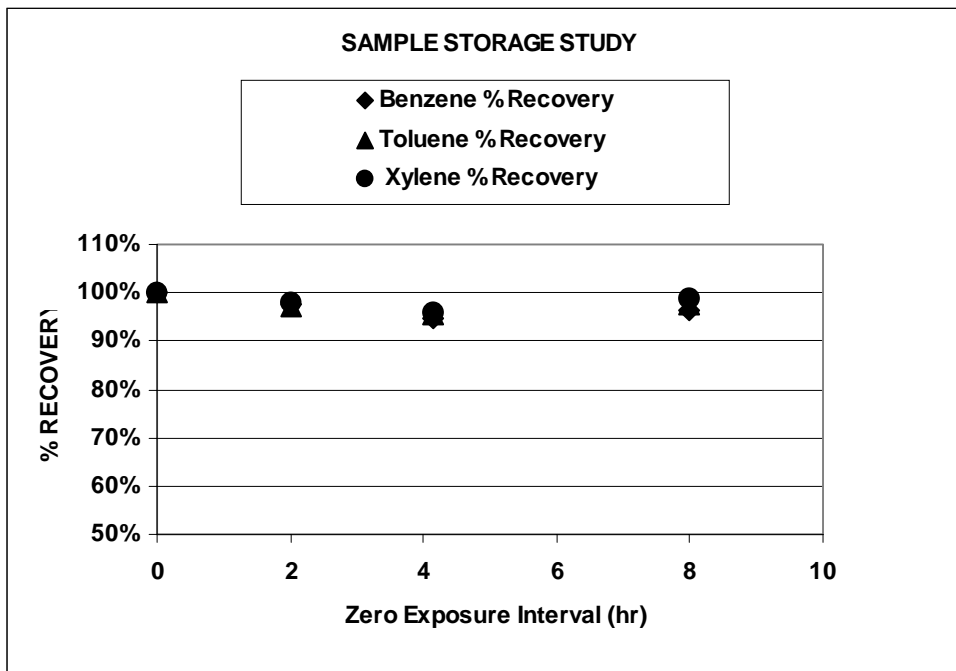
Samplers were exposed to atmospheres of benzene, toluene, and xylene for 2-4 hrs at 1-2 times the OSHA PEL (as per Section 5.) in several Chamber runs in which nearly identical exposures were applied with variations in temperature and humidity as follows: 22°C/50%RH, 10°C/50%RH, 30°C/30%RH, 30°C/70% 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 result is applicable to other organic vapors when the same Sampler is used.*

6.8 Effect of Storage

Two identical sets of Samples exposed (see Section 5) to Humidity (> 80%RH) overnight prior to exposure to Analyte concentrations at the OSHA PEL for at least 50% of the RST at 20-25°C. One set analyzed immediately, and the 2nd set after storage at prescribed intervals. Results in Table 6.8.

Table 6.8 Storage Stability
(after sampling)

Days of Storage =	0.00	4.01	7.01	14.01
BENZENE Found (ug) =	13.74	13.63	13.61	13.24
Std Deviation = +/-	0.76	0.07	0.35	0.33
Co-Eff Variation = +/-	6%	1%	3%	2%
Benzene % Recovery	100%	99%	99%	96%
TOLUENE Found (ug) =	73.62	80.38	79.09	78.61
Std Deviation = +/-	4.38	0.80	1.76	1.83
Co-Eff Variation = +/-	6%	1%	2%	2%
Toluene % Recovery	100%	109%	107%	107%
XYLENE Found (ug) =	63.19	71.66	72.42	69.46
Std Deviation = +/-	3.83	1.03	1.42	2.10
Co-Eff Variation = +/-	6%	1%	2%	3%
Xylene % Recovery	100%	113%	115%	110%



6.9 Sampler 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.*

6.10 Interferences (Method AT541)

Monitors 541 and 546 incorporate a collection wafer made from coconut charcoal demonstrated to collect upwards of 200 volatile organic compounds. The likelihood of a Sampler's collecting interfering substances is addressed by an analytical method (capillary gas chromatography similar to OSHA 7) which can separate and analyze 100's of VOCs. Method AT541 features co-injection of analytical sample onto dual, high-resolution capillary columns (60 m x 0.32mm) providing identification of each analyte from its characteristic emergence time on two analytical columns and quantitation of analytes. A list of VOCs analyzed by this method are included in Table 6.10. *This Table applicable to the VOCs listed when analysis is performed using Method AT 541.*

Table 6.10 VOCs Sampled on Monitor 541/546/548
Analyzed by Dual-Column GC

CAS	CHEMICAL NAME	GROUP	CAS	CHEMICAL NAME	GROUP
			141-79-7	Mesityl oxide	OV-A
67-64-1	Acetone	OV-A	109-86-4	Methoxyethanol (Me Cellosolve)	OV-A
75-05-8	Acetonitrile	OV-A	110-49-6	Methoxyethyl acetate(MeCSAc)	OV-A
107-13-1	Acrylonitrile	OV-A	96-33-3	Methyl acrylate	OV-A
107-18-6	Allyl Alcohol	OV-A	67-56-1	Methyl alcohol (methanol)	OV-A
107-5-1	Allyl Chloride	OV-A	71-55-6	Methyl chloroform (1,1,1-TCA)	OV-A
628-63-7	Amyl acetate	OV-A	108-87-2	Methyl cyclohexane	OV-A
71-43-2	Benzene	OV-A	78-93-3	Methyl ethyl ketone(2-butanone)	OV-A
106-99-0	Butadiene	OV-A	107-31-3	Methyl formate	OV-A
71-36-3	Butanol	OV-A	110-12-3	Methyl isoamyl ketone	OV-A
75-65-0	Butanol	OV-A	108-11-2	Methyl isobutyl carbinol	OV-A
78-92-2	Butanol (sec-butyl alcohol)	OV-A	108-10-1	Methyl isobutyl ketone (hexone)	OV-A
111-76-2	Butoxyethanol(ButylCellosolve)	OV-A	80-62-6	Methyl methacrylate	OV-A
123-86-4	Butyl acetate	OV-A	107-87-9	Methyl propyl ketone (2-pentanone)	OV-A
540-88-5	Butyl acetate	OV-A	109-87-5	Methylal (dimethoxymethane)	OV-A
141-32-2	Butyl acrylate	OV-A	108-87-2	Methylcyclohexane	OV-A
1634-04-4	Butyl methyl ether (MTBE)	OV-A	75-09-2	Methylene chloride	OV-A
56-23-5	Carbon tetrachloride	OV-A	91-20-3	Naphthalene	OV-A
108-90-7	Chlorobenzene	OV-A	111-84-2	Nonane	OV-A
74-97-5	Chlorodifluoromethane	OV-A	111-65-9	Octane	OV-A
67-66-3	Chloroform	OV-A	109-66-0	Pentane	OV-A
126-99-8	Chloroprene	OV-A	127-18-4	Perchloroethylene (PCE)	OV-A
98-82-8	Cumene	OV-A	108-65-6	Prop. Glyc. methyl ether acetate	OV-A
110-82-7	Cyclohexane	OV-A	109-60-4	Propyl acetate	OV-A
108-93-0	Cyclohexanol	OV-A	71-23-8	Propyl alcohol	OV-A
108-94-1	Cyclohexanone	OV-A	106-94-5	Propyl bromide	OV-A
123-42-2	Diacetone Alcohol	OV-A	78-87-5	Propylene dichloride	OV-A
1717-00-6	Dichloro-1-fluoroethane (HCFC141b)	OV-A	107-98-2	Propylene glycol methyl ether	OV-A
75-71-8	Dichlorodifluoromethane (CFC12)	OV-A	110-86-1	Pyridine	OV-A
75-34-3	Dichloroethane	OV-A	100-42-5	Styrene	OV-A
107-06-2	Dichloroethane (EDC)	OV-A	76-12-0	Tetrachloro-1,2-difluoroethane	OV-A
540-59-0	Dichloroethylene	OV-A	76-11-9	Tetrachloro-2,2-difluoroethane	OV-A
75-43-4	Dichlorofluoromethane (CFC21)	OV-A	109-99-9	Tetrahydrofuran(THF)	OV-A
76-14-2	Dichlorotetrafluoroethane (CFC114)	OV-A	108-88-3	Toluene	OV-A
68-12-2	Dimethyl formamide (DMF)	OV-A	79-00-5	Trichloroethane	OV-A
123-91-1	Dioxane	OV-A	71-55-6	Trichloroethane (methylchloroform)	OV-A
106-89-8	Epichlorohydrin	OV-A	79-01-6	Trichloroethylene (TCE)	OV-A
110-80-5	Ethoxyethanol(Cellosolve)	OV-A	76-13-1	Trichlorotrifluoroethane(CFC113)	OV-A
111-15-9	Ethoxyethyl acetate(EthylCell)	OV-A	108-67-8	Trimethylbenzene (mesitylene)	OV-A
141-78-6	Ethyl acetate	OV-A	108-05-4	Vinyl acetate	OV-A
140-88-5	Ethyl acrylate	OV-A	593-60-2	Vinyl bromide	OV-A
64-17-5	Ethyl alcohol (ethanol)	OV-A	75-01-4	Vinyl chloride	OV-A
60-29-7	Ethyl ether	OV-A	75-35-4	Vinylidene Chloride(1,1 DCE)	OV-A
687-47-8	Ethyl lactate	OV-A	1330-20-7	Xylenes	OV-A
100-41-4	Ethylbenzene	OV-A			
107-07-3	Ethylene chlorohydrin	OV-A	100-44-7	Benzyl chloride	OV-B
106-93-4	Ethylene dibromide	OV-A	2426-08-6	Butyl(n)glycidyl ether	OV-B
110-71-4	Ethylene glycol dimethyl ether	OV-A	76-22-2	Camphor	OV-B
75-69-4	Fluorotrichloromethane (CFC11)	OV-A	2039-87-4	Chloro(o)styrene	OV-B
142-82-5	Heptane	OV-A	95-49-8	Chloro(o)toluene	OV-B
110-43-0	Heptanone(methyl amyl ketone)	OV-A	106-46-7	Dichlorobenzene	OV-B
110-54-3	Hexane	OV-A	95-50-1	Dichlorobenzene	OV-B
591-78-6	Hexanone(MBK)	OV-A	111-44-4	Dichloroethyl ether	OV-B
123-92-2	Isoamyl acetate	OV-A	77-73-6	Dicyclopentadiene	OV-B
123-51-3	Isoamyl alcohol	OV-A	108-83-8	Diisobutylketone	OV-B
110-19-0	Isobutyl acetate	OV-A	34590-94-8	Dipropylene Glycol Methyl Ether	OV-B
78-83-1	Isobutyl alcohol	OV-A	78-59-1	Isophorone	OV-B
108-21-4	Isopropyl acetate	OV-A	4016-14-2	Isopropyl glycidyl ether(IGE)	OV-B
67-63-0	Isopropyl alcohol	OV-A	98-83-9	Methyl Styrene	OV-B
108-20-3	Isopropyl ether	OV-A	101-84-8	Phenyl ether	OV-B
5989-27-5	Limonene (as dipentene)	OV-A	25013-15-4	Vinyl toluene (methyl styrene)	OV-B

6.11 Shelf Life

Two groups of Samplers (one group freshly manufactured and one group manufactured 16 months previously) were subject to three exposure tests (see Section 5.) each including benzene, toluene, and xylene for 2-4 hrs at 1-2 times the PEL. The two groups were compared in each of the three exposures. No significant differences found between the two groups indicating the absence of any effect of Sampler stability when stored at room temperature for up to 16 months. *This result applicable to other volatile organic analytes sampled on Monitors 541 and 546.*

6.13 Lot-to-Lot Variation

Three groups of Samplers from separate manufacturing Lots subject to three exposure tests (see Section 5.) including benzene, toluene, and xylene for 2-4 hrs at 1-2 times the PEL. When data from the three Lots were compared in each of the three exposures, no significant differences were found among the groups indicating the absence of differences among different Lots of Samplers. *This result applicable to other volatile organic analytes sampled on Monitors 541 and 546.*

Summary Comments

Samplers 541 and 546 have been evaluated for sampling benzene, toluene, and xylenes together on a single sampler. The overall accuracies expressed as Maximum Total Error (95% confidence) are as follows. Benzene = $\pm 13\%$; Toluene = $\pm 17\%$; Xylene = $\pm 14\%$

Concentration Range	0.1-2.0 times the OSHA PEL; 0.2-5.0 times the OSHA STEL
Sampling Time	15 min - 8 hour
Air Velocity	15-150 cm/sec
Temperature	10-30°C
Humidity	30-70% RH

Based on estimated Sampler-to-Sampler variation of $\pm 5\%$, Laboratory variation of $\pm 3\%$, and Exposure Chamber Variation of Error $\pm 8\%$, less than 5% or the Maximum Total Error is attributed to Bias (i.e. systematic error). We have estimated the Bias Due to Reverse Diffusion as +0%.

It is recommended that Samplers 541 and 546 be used within the envelope of conditions specified, but, in general, minor excursions outside these limits would be expected to have only minor effects. Due to the detection limit of Benzene, lower levels or shorter sampling times could not be accommodated. Due to lack of detectable Reverse Diffusion for 8 hr zero exposure interval, increases in Concentration, Sampling Time, or Humidity above the limits described here could probably be tolerated with minimal.