

AIR SAMPLER EVALUATION (ANSI 104-1998)
Part I - SUMMARY of TESTS – A Chlorofluorocarbon (bp 15°C)

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. *Assay Technology Sampler No 548 incorporating a polyacetal Sampling Grid with four (4) tubular sampling channels, a 200 mg charcoal (coconut) wafer, and a Wafer Dish and Sampler Cap made of polyester.*

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 methylene chloride. Samplers were tested at several "spike" levels corresponding to levels expected for 8-hr Sampler exposures at 0.1-2.0 times the internal Exposure Limit (EL) of 300 ppm. An average recovery for this chlorofluorocarbon from the Assay Technology charcoal sampler was 96%, over the range of 50-200 µg/sample. Results in Table 6.2.

Table 6.2 % Recovery
(De-Sorption Efficiency)

Analyte Name	Amount Spiked	Amount Recovered	% DE	Date
	(ug/sample)	(ug/sample)		
Chlorofluorocarbon	50.0	37.0	74%	Mar-00
0.1 x EL	50.0	37.0	74%	Mar-00
"	50.0	40.0	80%	Mar-00
"	50.0	45.0	90%	Mar-00
"	50.0	44.0	88%	Mar-00
"	50.0	44.0	88%	Mar-00
Average recovery			82%	
Chlorofluorocarbon	253	252	100%	Mar-00
0.5 x EL	253	252	100%	Mar-00
	253	251	99%	Mar-00
	253	250	99%	Mar-00
Average recovery			96%	
Chlorofluorocarbon	496	486	98%	Mar-00
1.0 x EL	496	487	98%	Mar-00
	496	516	104%	Mar-00
	496	518	104%	Mar-00
	496	450	91%	Mar-00
	496	441	89%	Mar-00
Average recovery			97%	
Chlorofluorocarbon	908	971	107%	Mar-00
2.0 x EL	908	948	104%	Mar-00
	908	1058	117%	Mar-00
	908	1065	117%	Mar-00
	908	936	103%	Mar-00
	908	929	102%	Mar-00
Average recovery			108%	

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 AT548

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 EL of 300 ppm. For this evaluation, the sampling rate for this Chlorofluorocarbon using the Assay Technology sampler was determined to be 0.50 ml/minute. Results in Table 6.3.

Table 6.3 Uptake Rate Determination

Analyte: CFC (bp 15°C)

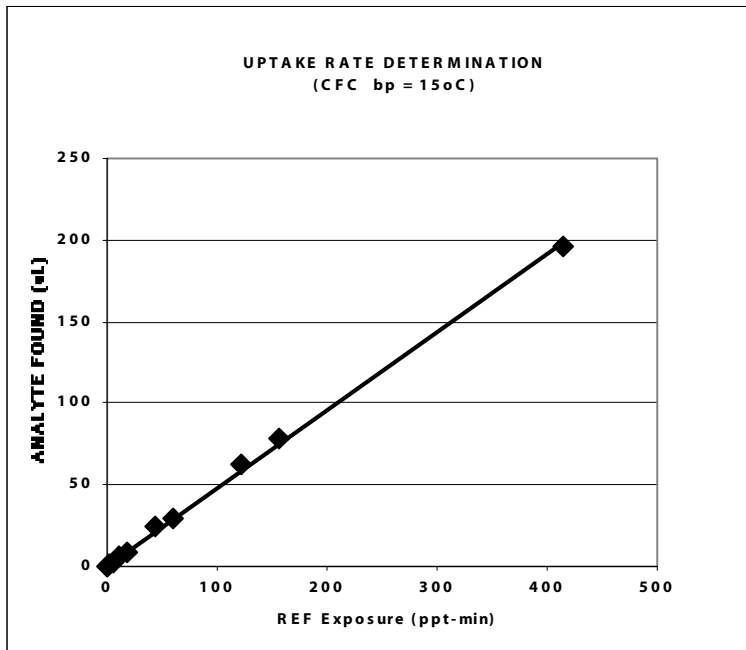
134 = MW

RUN AVE

RUN	TIME (min)	TIME (hr)	REF CONC (ppm)	Ref Exp (ppm-hr)	REF EXP (ppm-hr)	ug/MONITOR (ug)	REF EXP (ppt-min)	ANALYTE (uliter)
1	15	0.25	1366	342				
	15	0.25	1095	274				
	15	0.25	1011	253				
	15	0.25	1149	287	289	48	17.33	9
2	120	2.00	1044	2088				
	120	2.00	1018	2036				
	120	2.00	1007	2014				
	120	2.00	1009	2018	2039	347	122.34	63
3	464	7.73	1056	8166				
	464	7.73	967	7478				
	464	7.73	790	6109				
	464	7.73	719	5560				
	464	7.73	927	7169	6897	1087	413.80	196
4	15	0.25	189	47				
	15	0.25	172	43				
	15	0.25	173	43	45	8	2.67	2
5	120	2.00	101	202				
	120	2.00	92	184				
6	120	2.00	94	188				
	120	2.00	81	162				
	120	2.00	90	180	183	33	10.99	6
	450	7.50	106					
	450	7.50	101					
7	450	7.50	87	653				
	450	7.50	101	758				
8	450	7.50	105	788	733	133	43.95	24
	15	0.25	432	108				
9	15	0.25	389	97				
	15	0.25	342	86				
	15	0.25	358	90				
	15	0.25	378	95	95	15	5.70	3
	120	2.00	519	1038				
10	120	2.00	490	980				

	120	2.00	506	1012	1010	163	60.60	29
8	450	7.50	348	2610				
	450	7.50	353	2648				
	450	7.50	333	2498				
	450	7.50	355	2663				
9	450	7.50	359	2693	2618	458	157.05	83

Least Squares	
Calcns	
REF EXP (ppt-min)	Found (uliter)
17.33	8.51
122.34	62.58
2.67	1.40
6.36	5.88
43.95	23.96
5.70	2.79
60.60	29.56
157.05	78.60
Slope=	Slope=
0.50	0.51



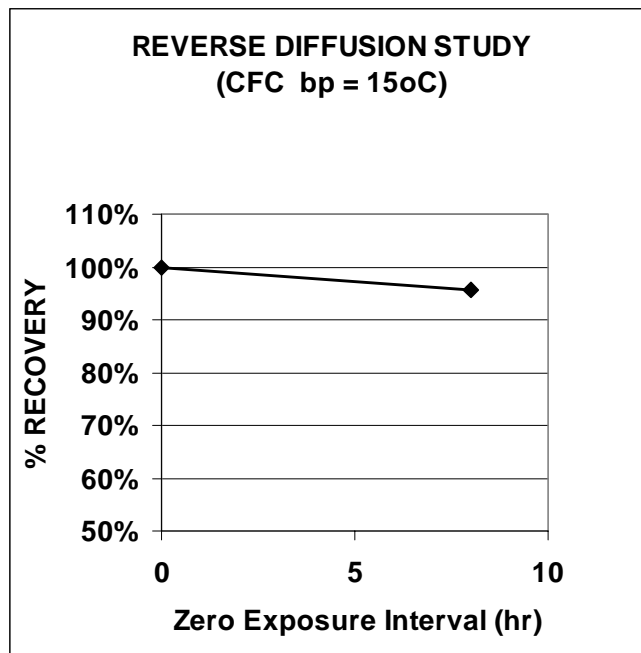
6.4 Bias Due to Reverse Diffusion

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 EL is applied for 25% of the duration of the RST (2 hr) followed by a Zero Exposure Period of 100% of the RST (8 hr). 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	8.00
Chlorofluorocarbon Found (ug) =	131.7	126.0
Std Deviation = +/-	5.75	5.96
Co-Eff Variation = +/-	4%	5%
Chlorofluorocarbon Recovery	100%	96%



6.5 Background (Blank) Determination

Unexposed Samplers analyzed by Method AT541 to determine background Analyte levels (if any) on the Sampler prior to sampling. For this evaluation, no significant background values were attributed to the sampler or analytical method for this Chlorofluorocarbon. In addition, the Claimed Detection Limit (CDL) for this Chlorofluorocarbon was determined to be 1.0 µg/sample, equivalent to 0.7 ppm for an 8 hour sampling period. Results in Table 6.5.

Table 6.5 Background (Blank) Determination

Replicate NO.	ANALYTE CONCN	EXPOSURE TIME	Chlorofluorocarbon	
			FOUND in MONITOR	(ppm) 8hr TWA
1	0	0	<1.0	<0.7
2	0	0	<1.0	<0.7
3	0	0	<1.0	<0.7
4	0	0	<1.0	<0.7
5	0	0	<1.0	<0.7
6	0	0	<1.0	<0.7

6.6 Effects of Air Velocity & Orientation

Samplers exposed to atmospheres of this Chlorofluorocarbon for 2 hrs at 1.0 times the EL (see Section 5) in a Chamber with 3 zones of different cross-sectional areas such that linear velocities of 20, 100, and 200 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 these locations (representing normal air velocity and orientation variation in workplaces), no significant differences were found among the groups indicating the *absence of an effect of Air Velocity & Orientation on Sampling Rate in the range 20-200 cm/sec*. Results in Table 6.6.

Table 6.6 Effects of Air Velocity and Orientation

RUN NO.	SAMPLE ID	ANALYTE CONC (ppm) (Ref Method)	EXPOSURE TIME (hr)	EVALUATION PARAMETERS Air Velocity and Orientation	TEST RESULTS from MONITORS			% OF REFERENCE (%)
					Values (ppm)	Ave (ppm)	(%)(+/-)(CV)	
1	Sample 1	-	-		308	-	-	87%
	Sample 2	-	-	20 cm/sec	307	-	-	86%
	Sample 3	-	-	air velocity	305	-	-	86%
	Sample 4	-	-	parallel to	366	-	-	103%
	Sample 5	-	-	Monitor face	304	-	-	86%
	Sample 6	-	-		325	-	-	92%
			355	2.0		-	319	7.59
							Reference Value =	355
2	Sample 1	-	-		346	-	-	97%
	Sample 2	-	-	100 cm/sec	336	-	-	95%
	Sample 3	-	-	air velocity	326	-	-	92%
	Sample 4	-	-	parallel to	331	-	-	93%
	Sample 5	-	-	Monitor face	383	-	-	108%
	Sample 6	-	-		346	-	-	97%
			355	2.0		-	345	5.91
							Reference Value =	355
3	Sample 1	-	-		393	-	-	111%
	Sample 2	-	-	200 cm/sec	361	-	-	102%
	Sample 3	-	-	air velocity	372	-	-	105%
	Sample 4	-	-	parallel to	364	-	-	103%
	Sample 5	-	-	Monitor face	352	-	-	99%
	Sample 6	-	-		555	-	-	156%
			355	2.0		-	400	20.90
							Reference Value =	355
4	Sample 1	-	-		2001	-	-	102%
	Sample 2	-	-	20 cm/sec	2082	-	-	106%
	Sample 3	-	-	air velocity	1813	-	-	92%
	Sample 4	-	-	parallel to	2159	-	-	110%
	Sample 5	-	-	Monitor face	1748	-	-	89%
	Sample 6	-	-		1878	-	-	96%
			1966	2.0		-	1947	8.23
							Reference Value =	1966

RUN NO.	SAMPLE ID	ANALYTE CONCEN (ppm) (Ref Method)	EXPOSURE TIME (hr)	EVALUATION PARAMETERS Air Velocity and Orientation	TEST RESULTS from MONITORS		% OF REFERENCE (%)
					Values (ppm)	Ave (ppm) (%)(+/-)(CV)	

							Reference Value =	1966
5	Sample 1	-	-		1940	-	-	99%
	Sample 2	-	-	20 cm/sec	2014	-	-	102%
	Sample 3	-	-	air velocity	2026	-	-	103%
	Sample 4	-	-	perpendicular to	1751	-	-	89%
	Sample 5	-	-	Monitor face	1961	-	-	100%
	Sample 6	-	-		1896	-	-	96%
		1966	2.0		-	1931	5.20	98%

6.7 Effect of Temperature & Humidity

Samplers were exposed to atmospheres of this Chlorofluorocarbon for 2 hrs at 1.0 times the EL in several Chamber runs in which nearly identical exposures were applied with variations in temperature and humidity as follows: 10°C/10%RH, 10°C/70%RH, 40°C/10%RH, 40°C/70% RH. When data from the four conditions (representing normal temperature & humidity variation) were compared, no significant differences among the groups were found, indicating the *absence of an effect of Temperature & Humidity on Sampling Rate in the range 10-40°C and 10-70% RH*. Results in Table 6.7.

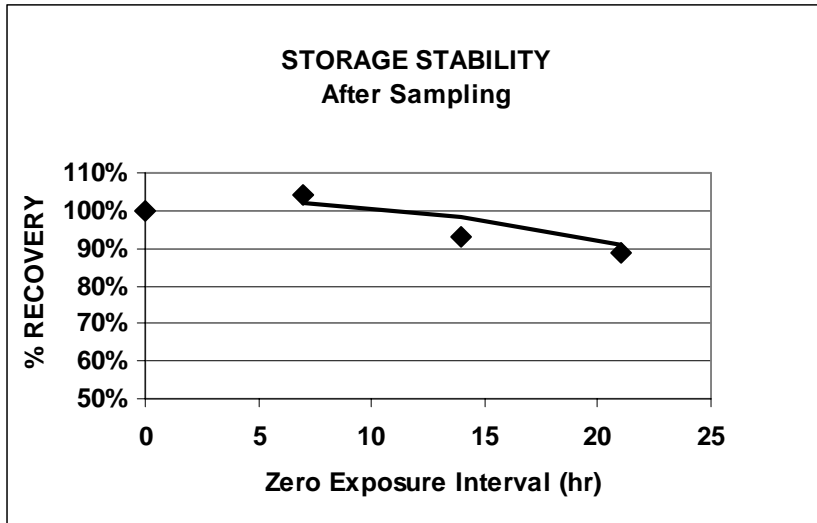
Table 6.7 Effects of Temperature & Humidity

RUN NO.	SAMPLE ID	ANALYTE CONC (ppm) (Ref Method)	EXPOSURE TIME (hr)	EVALUATION PARAMETERS Temperature & Humidity	TEST RESULTS from MONITORS		% OF REFERENCE (%)	
					Values (ppm)	Ave (ppm) (%) (+-)(CV)		
Reference Value = 837								
1	Sample 1	-	-	T = 10oC	757	-	90%	
	Sample 2	-	-		884	-	106%	
	Sample 3	-	-	RH = 10%	802	-	96%	
	Sample 4	-	-		845	-	101%	
	Sample 5	-	-		751	-	90%	
	Sample 6	-	-		821	-	98%	
		837	2.0		-	810	6.34	97%
Reference Value = 381								
2	Sample 1	-	-	T = 10oC	477	-	125%	
	Sample 2	-	-		430	-	113%	
	Sample 3	-	-	RH = 70%	379	-	99%	
	Sample 4	-	-		478	-	125%	
	Sample 5	-	-		546	-	143%	
	Sample 6	-	-		448	-	118%	
		381	2.0		-	460	12.16	121%
Reference Value = 426								
1	Sample 1	-	-	T = 40oC	374	-	88%	
1	Sample 2	-	-		447	-	105%	
1	Sample 3	-	-	RH = 10%	400	-	94%	
1	Sample 4	-	-		488	-	115%	
1	Sample 5	-	-		404	-	95%	
1	Sample 6	-	-		431	-	101%	
1		426	2.0		-	424	9.52	100%
Reference Value = 472								
1	Sample 1	-	-	T = 40oC	545	-	115%	
1	Sample 2	-	-		528	-	112%	
1	Sample 3	-	-	RH = 70%	466	-	99%	
1	Sample 4	-	-		456	-	97%	
1	Sample 5	-	-		573	-	121%	
1	Sample 6	-	-		470	-	100%	
1	Monitor 541	472	2.0		-	506	107%	

6.8 Effect of Storage Identical sets of Samples were exposed for 2 hours at 1.0 times the EL and 70% RH. One set was analyzed immediately, followed by subsequent analysis of samples stored under ambient (22°C) conditions at 7, 14 and 21 days. When data were compared from the four storage periods, no significant differences were found among the four groups *indicating no detectable loss of analyte occurs for up to 21 days under ambient storage. Recommended Sample Holding Time = up to 7 days. See Table 6.8.*

Table 6.8 Effects of Storage
(CFC bp = 15°C)

RUN NO.	SAMPLE ID	ANALYTE CONC (ppm) (Ref Method)	EXPOSURE TIME (hr)	EVALUATION PARAMETERS	TEST RESULTS from MONITORS		% OF REFERENCE (%)	
					Storage After Sampling	Values (ppm)		Ave (ppm)
							Reference Value =	426
1	Sample 1				414	-	-	97%
1	Sample 2				466	-	-	109%
1	Sample 3			NO STORAGE	374	-	-	88%
1	Sample 4				434	-	-	102%
1	Sample 5				436	-	-	102%
1	Sample 6			TIME (Days)	429	-	-	101%
1			2.00	0	-	426	7.14	100%
							Reference Value =	426
1	Sample 1				488	-	-	115%
1	Sample 2			TEMP	466	-	-	109%
1	Sample 3			22oC	397	-	-	93%
1	Sample 4				412	-	-	97%
1	Sample 5				459	-	-	108%
1	Sample 6			TIME (days)	438	-	-	103%
1			2.00	7	-	443	7.76	104%
							Reference Value =	426
1	Sample 1				386	-	-	91%
1	Sample 2			TEMP	422	-	-	99%
1	Sample 3			22oC	365	-	-	86%
1	Sample 4				380	-	-	89%
1	Sample 5				414	-	-	97%
1	Sample 6			TIME (days)	402	-	-	94%
1	Monitor 541		2.00	14	-	395	5.48	93%
							Reference Value =	426
1	Sample 1				329	-	-	77%
1	Sample 2			TEMP	425	-	-	100%
1	Sample 3			22oC	376	-	-	88%
1	Sample 4				365	-	-	86%
1	Sample 5				394	-	-	92%
1	Sample 6			TIME (days)	379	-	-	89%
1	Monitor 541		2.00	21	-	378	8.40	89%



6.9 Sampler Integrity

Samplers in sealed *standard aluminum foil pouch* packaging exposed to 1.0 times the EL for 2 hours, then analyzed. Results from analysis were not significantly different from results for un-exposed Samplers (blank values) demonstrating the integrity of Sampler packaging. Results in Table 6.9.

Table 6.9 Sampler Integrity

Replicate NO.	ANALYTE CONCN (ppm)	EXPOSURE TIME (hr)	Chlorofluorocarbon FOUND in MONITOR	
			(ug/sample)	(ppm) 8hr TWA
1	198	2	<1.0	<0.7
2	198	2	<1.0	<0.7
3	198	2	<1.0	<0.7
4	198	2	<1.0	<0.7
5	198	2	<1.0	<0.7
6	198	2	<1.0	<0.7

Summary Comments

Sampler 548 was evaluated for sampling this Chlorofluorocarbon, because preliminary experiments suggested that Samplers 541 and 546 would not retain this very volatile compound (bp $\approx 15^{\circ}\text{C}$) during reverse diffusion tests. The overall accuracy expressed as Maximum Total Error (95% confidence) for sampling using Monitor 548 was $\pm 15\%$.

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	10-40 $^{\circ}\text{C}$
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 $\pm 7\%$, less than 5% of the Maximum Total Error is attributed to Bias (i.e. systematic error). We have estimated the Bias Due to Reverse Diffusion as $< 5\%$.

It is recommended that Sampler 548 be used within the envelope of conditions studied, but, in general, minor excursions outside these limits would be expected to have only minor effects. Due to the detection limit of PFP, 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 error.

Prepared by: CR Manning, PhD, May 2000
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