Comparison of Tedlar Bag and Bottle-Vac Sampling and Analysis for VOC's in a Soil Gas Investigation Conducted by the Michigan Department of Environmental Quality

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Objectives

Introduction to Bottle-Vac Samplers and Micro-Valves

Advantages of Bottle-Vacs to Tedlar Bags

Demonstrate Sampling with Bottle-Vac vs Tedlar Bags

Overview of Analytical Equipment

Holding Time Study

Results of Field Data for Bottle-Vacs and Tedlar Bags

Conclusions

Canister Evolution

- **SUMMA to Fused Silica Lined Stainless (mid 90's)**
- **Why not FSL Stainless to "All Glass"?**

The “Almost” Disposable Bottle-Vac™ Sampler

- Indoor Air Quality
- Stack Gas
- Landfill Gas
- Remote Headspace
- Flux Chamber Sampling
- Industrial Hygiene
- Fenceline Monitoring
- Fugitive Emissions
- Mold Microbial VOCs
- Breath Analysis
- Odor Analysis
- Auto Exhaust
- Etc.

Checking Vacuum in the Bottle-Vac Sampler

Vacuum Tight Seal Made with New Micro-QT Valve

Micro-QT Valve Fittings

Micro Valve Grab and Critical Orifice Samplers

30-22510

Micro Valve Grab Sampler

30-22500

Micro Valve Filter-less Grab Sampler (SVOCS)

30-22530

30-22545

Micro Valve Dry-Wall Sampler

39-RS-QTx

Micro Valve Restricted Sampler

Advantages Of Bottle-Vacs Over Bags

	Canisters	Bags
Holding Times in weeks, not hours	Yes	No
Totally Impermeable to VOCs	Yes	No
Reusable	Yes	NR
Usable to part-per-trillion levels	Yes	No
Tested for background levels and recovery	Yes	No
Shippable by Air	Yes	NR
Prevents Photolytic Reactions	Yes	No
Relative Cost Per Lifetime	0.1-0.5	1*

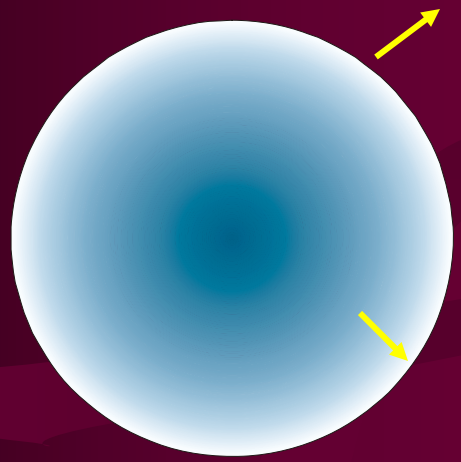
NR - Not Recommended

* - Based on 1 Tedlar bag samplings per lifetime

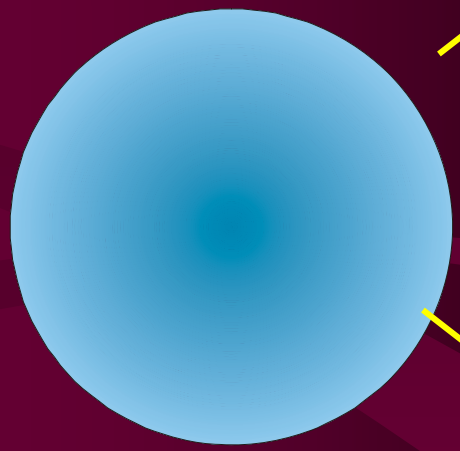
7500 Robotic Autosampler

- Introduces 0.1 to 1000cc of sample from canisters or vials to the 7100A, 8000, or directly to the GC via loop injection.
- Period of Contact with sample is 1000x shorter than with rotary valve based autosamplers (0.3-5 minutes rather than 1-5 days) which reduces memory effects.
- No inlet fitting. Silonite 1/16” line goes directly into Micro Valve
- Accommodates solid, liquid, and gas samples
- Detection limits 1000x lower than conventional loop injection headspace
- Supports analysis of semi-volatiles.

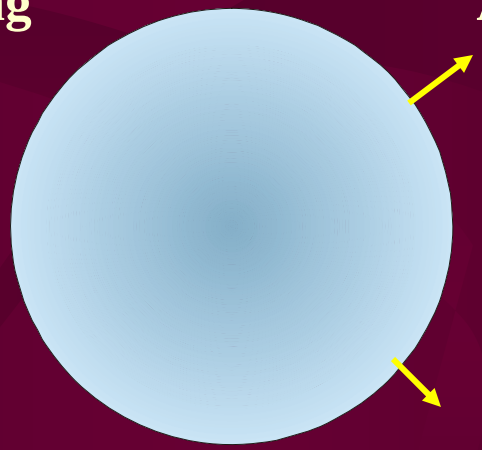
Eliminating Contamination in Sealing Viton O-rings



Prior to Baking



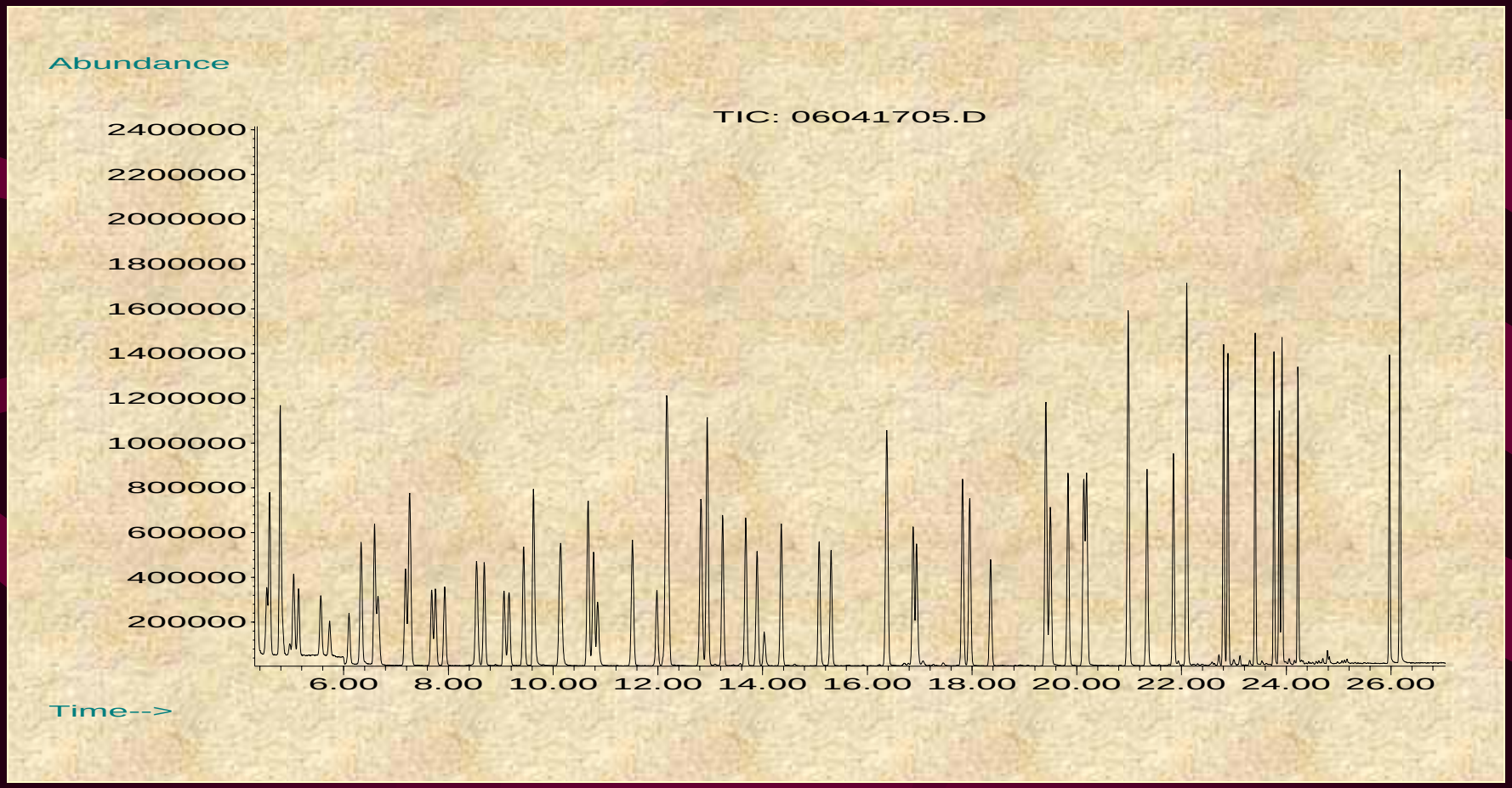
After 4 Hour Purge Baking



Over-night Vacuum Baking
At 70 deg. C

Vacuum Baking Micro-Valves before Reuse Eliminates Carry-Over from High Concentration Samples

10 ppbv TO15 in a Bottle-Vac, 30 Day Storage Time



	Canister % Recovery				Bottle-Vac %Recovery	
	2 week	3 week	4 Month		2 week	30 Day
Analyte						
Propene	99	97	89		100	91
Dichlorodifluoromethane	94	95	92		102	95
Chloromethane	93	93	90		95	85
Dichlorotetrafluoromethane	87	91	91		95	96
Acetaldehyde	99	96	96		96	104
Vinyl Chloride	95	93	90		96	95
1,3-Butadiene	96	94	86		95	100
Bromomethane	96	95	94		97	101
Chloroethane	95	95	90		96	93
Bromoethene	94	95	91		97	93
Trichlorofluoromethane	95	95	92		97	94
Acetone	91	91	83		103	102
Propanal	93	92	82		100	87
Isopropyl Alcohol	90	96	92		99	116
1,1-Dichloroethene	96	95	90		95	98
1,1,2-Trichloro-1,2,2-Trifluoroethane	95	95	91		98	98
Methylene Chloride	96	96	92		99	99
Allyl Chloride	95	94	86		98	92
Carbon Disulfide	98	97	92		97	99
trans-1,2-Dichloroethene	95	94	88		96	97
Methyl-tert-Butyl Ether	89	90	84		93	92
1,1-Dichloroethane	96	95	91		95	96
Vinyl Acetate	88	87	76		94	92
2-Butanone	89	87	77		109	104
Hexane	97	96	89		99	99
cis-1,2-Dichloroethene	94	93	88		97	89
Ethyl Acetate	88	87	76		93	94

Chloroform	95	95	92		95	95
Tetrahydrofuran	91	91	81		94	128
1,1,1-Trichloroethane	95	95	92		94	94
1,2-Dichloroethane	94	93	89		96	94
Benzene	96	94	90		100	102
Carbon Tetrachloride	95	94	92		95	93
Cyclohexane	98	97	92		97	98
2,2,4-Trimethylpentane	97	98	97		96	96
Heptane	97	98	97		97	96
1,2-Dichloropropane	96	97	97		98	94
Trichloroethene	95	95	95		97	94
Bromodichloromethane	97	97	95		95	96
1,4-Dioxane	110	105	74		97	94
cis-1,3-Dichloropropene	91	92	81		97	91
4-Methyl-2-Pentanone	101	103	56		96	94
trans-1,3-Dichloropropane	82	81	62		97	97
Toluene	96	96	98		100	100
1,1,2-Trichloroethane	96	96	97		96	97
2-Hexanone	97	98	45		112	100
Dibromochloromethane	96	97	93		97	93
1,2-Dibromoethane	92	91	83		99	96
Tetrachloroethene	96	96	78		99	94
Chlorobenzene	96	95	93		102	95
Ethylbenzene	97	96	96		100	93
Bromoform	96	100	90		99	97
Styrene	93	92	81		100	99
o-Xylene	98	98	99		101	96
1,1,2,2-Tetrachloroethane	100	100	100		99	103
4-Ethyltoluene	97	100	93		102	92
1,3,5-Trimethylbenzene	99	97	100		106	98
1,2,4-Trimethylbenzene	99	97	100		99	95
1,3-Dichlorobenzene	99	96	91		97	93
Benzyl Chloride	93	96	65		99	83
1,4-Dichlorobenzene	96	91	80		98	95
1,2-Dichlorobenzene	104	100	103		96	94
1,2,4-Trichlorobenzene	102	92	110		82	75
Hexachlorobutadiene	112	102	120		89	84

12/07/2006

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Columbia
12/07/2006

Bottle-Vac and Tedlar Bag Duplicates (PPBv)

Sample ID:	VP-2SD	VP-2SD
Container/Collection Method:	Vacuum Bottle	Tedlar/Air Pump
Analytical Method:	TO-15	TO-15
Laboratory:	Ace	Ace
Sample Duration:	Grab	Grab
Collection Time:	0925	0908
Date:	7-Dec-2006	7-Dec-2006
Tetrachloroethene	9.7	6.0
Trichloroethene	8.2	5.9
1,1-Dichloroethene	<1.0	<1.0
1,2-Dichlorobenzene	<0.5	<0.5
1,2-Dichloroethane	<1.0	<1.0
1,1,1-Trichloroethane	42	37
1,1,2-Trichloro-1,2,2-trifluoroethane	<1.0	<1.0
1,1,2-Trichloroethane	<1.0	<1.0
1,1-Dichloroethane	<1.0	<1.0
Carbon Tetrachloride	<1.0	<1.0
Chlorobenzene	<0.5	<0.5
Chloroethane	<1.0	<1.0
Chloroform	<1.0	<1.0
cis-1,2-Dichloroethene	3.0	1.7
trans-1,2-Dichloroethene	<1.0	<1.0
Methylene chloride	<1.0	<1.0
Vinyl Chloride	<1.0	<1.0
1,2-Dichloropropane	<1.0	<1.0
1,4-Dichlorobenzene	<0.5	<0.5
Dichlorodifluoromethane	<1.0	<1.0
Trichlorofluoromethane	<1.0	<1.0
Benzene	6.5	4.3
Toluene	12	8.6
Ethylbenzene	1.6	1.5
m,p-Xylene	4.5	4.9
o-Xylene	1.6	1.8
Acetone	140	10
Methyl ethyl ketone	32	<4.0
2-Butanone	<2.0	<2.0
2-Hexanone	<1.0	<1.0

Bottle-Vac and Tedlar Bag Duplicates (PPBv)

Sample ID:	VP-5SD	VP-5SD
Container/Collection Method:	Vacuum Bottle	Tedlar/Air Pump
Analytical Method:	TO-15	TO-15
Laboratory:	Ace	Ace
Sample Duration:	Grab	Grab
Collection Time:	1023	1800
Date:	7-Dec-2006	7-Dec-2006
Tetrachloroethene	240	230
Trichloroethene	70	60
1,1-Dichloroethene	<1.0	<40
1,2-Dichlorobenzene	<0.5	<20
1,2-Dichloroethane	<1.0	<20
1,1,1-Trichloroethane	160	140
1,1,2-Trichloro-1,2,2-trifluoroethane	1.2	<20
1,1,2-Trichloroethane	<1.0	<10
1,1-Dichloroethane	8.2	<20
Carbon Tetrachloride	<1.0	15 J
Chlorobenzene	<0.5	<20
Chloroethane	<1.0	<20
Chloroform	<1.0	<20
cis-1,2-Dichloroethene	20	<20
trans-1,2-Dichloroethene	2.0	<20
Methylene chloride	<1.0	19 J
Vinyl Chloride	<1.0	<20
1,2-Dichloropropane	<1.0	<10
1,4-Dichlorobenzene	<0.5	<20
Dichlorodifluoromethane	<1.0	10 J
Trichlorofluoromethane	<1.0	<20
Benzene	<1.0	<20
Toluene	<1.0	<10
Ethylbenzene	<1.0	<20
m,p-Xylene	<1.0	<40
o-Xylene	<1.0	<20
Acetone	4.4	21
Methyl ethyl ketone	<4.0	<40
2-Butanone	<2.0	<40
2-Hexanone	<1.0	<100

Bottle-Vac and Tedlar Bag Duplicates

Sample ID:	VP-5ID	VP-5ID
Container/Collection Method:	Vacuum Bottle	Tedlar/Vacuum Box
Analytical Method:	TO-15	TO-15
Laboratory:	Ace	Ace
Sample Duration:	Grab	Grab
Collection Time:	1103	1047
Date:	7-Dec-2006	7-Dec-2006
Tetrachloroethene	510	460
Trichloroethene	90	79
1,1-Dichloroethene	1.1	<10
1,2-Dichlorobenzene	<0.5	<0.5
1,2-Dichloroethane	<1.0	<10
1,1,1-Trichloroethane	450	380
1,1,2-Trichloro-1,2,2-trifluoroethane	2.7	<10
1,1,2-Trichloroethane	<1.0	<10
1,1-Dichloroethane	69	59
Carbon Tetrachloride	<1.0	<10
Chlorobenzene	<0.5	<0.5
Chloroethane	<1.0	<10
Chloroform	<1.0	<10
cis-1,2-Dichloroethene	160	130
trans-1,2-Dichloroethene	11	10
Methylene chloride	<1.0	<10
Vinyl Chloride	4.5	<10
1,2-Dichloropropane	<1.0	<10
1,4-Dichlorobenzene	<0.5	<0.5
Dichlorodifluoromethane	<1.0	<10
Trichlorofluoromethane	<1.0	<10
Benzene	<1.0	<10
Toluene	<1.0	<10
Ethylbenzene	<1.0	<10
m,p-Xylene	<1.0	<10
o-Xylene	<1.0	<10
Acetone	130	43
Methyl ethyl ketone	25	<40
2-Butanone	<2.0	<2.0
2-Hexanone	4.6	<10

Bottle-Vac and Tedlar Bag Duplicates

Sample ID:	VP-6SD	VP-6SD
Container/Collection Method:	Vacuum Bottle	Tedlar/Vacuum Box
Analytical Method:	TO-15	TO-15
Laboratory:	Ace	Ace
Sample Duration:	Grab	Grab
Collection Time:	1200	1825
Date:	7-Dec-2006	7-Dec-2006
Tetrachloroethene	440	410
Trichloroethene	310	280
1,1-Dichloroethene	<10	<10
1,2-Dichlorobenzene	<0.5	<0.5
1,2-Dichloroethane	<10	<10
1,1,1-Trichloroethane	2,100	2,400
1,1,2-Trichloro-1,2,2-trifluoroethane	<10	<10
1,1,2-Trichloroethane	<10	<10
1,1-Dichloroethane	45	41
Carbon Tetrachloride	<10	<10
Chlorobenzene	<0.5	<0.5
Chloroethane	<10	<10
Chloroform	<10	<10
cis-1,2-Dichloroethene	94	85
trans-1,2-Dichloroethene	<10	<10
Methylene chloride	<10	<10
Vinyl Chloride	<10	<10
1,2-Dichloropropane	<10	<10
1,4-Dichlorobenzene	<0.5	<0.5
Dichlorodifluoromethane	<10	<10
Trichlorofluoromethane	<10	<10
Benzene	<10	<10
Toluene	<10	<10
Ethylbenzene	<10	<10
m,p-Xylene	<10	<10
o-Xylene	<10	<10
Acetone	87	<40
Methyl ethyl ketone	<80	<40
2-Butanone	<2.0	<2.0
2-Hexanone	<10	<10

Bottle-Vac and Tedlar Bag Duplicates

Sample ID:	VP-6ID	VP-6ID
Container/Collection Method:	Vacuum Bottle	Tedlar/Vacuum Box
Analytical Method:	TO-15	TO-15
Laboratory:	Ace	Ace
Sample Duration:	Grab	Grab
Collection Time:	1232	1219
Date:	7-Dec-2006	7-Dec-2006
Tetrachloroethene	2,700	2,700
Trichloroethene	2,300	2,400
1,1-Dichloroethene	<10	<10
1,2-Dichlorobenzene	<0.5	<0.5
1,2-Dichloroethane	<10	<10
1,1,1-Trichloroethane	5,800	6,600
1,1,2-Trichloro-1,2,2-trifluoroethane	<10	<10
1,1,2-Trichloroethane	<10	<10
1,1-Dichloroethane	160	160
Carbon Tetrachloride	<10	<10
Chlorobenzene	<0.5	<0.5
Chloroethane	11	<10
Chloroform	<10	<10
cis-1,2-Dichloroethene	900	1,000
trans-1,2-Dichloroethene	<10	<10
Methylene chloride	<10	<10
Vinyl Chloride	<10	<10
1,2-Dichloropropane	<10	<10
1,4-Dichlorobenzene	<0.5	<0.5
Dichlorodifluoromethane	<10	<10
Trichlorofluoromethane	<10	<10
Benzene	<10	<10
Toluene	<10	<10
Ethylbenzene	<10	<10
m,p-Xylene	<10	<10
o-Xylene	<10	<10
Acetone	<40	<40
Methyl ethyl ketone	<40	<40
2-Butanone	<2.0	<2.0
2-Hexanone	<10	<10

Bottle-Vac and Tedlar Bag Duplicates

Sample ID:	VP-10SD	VP-10SD
Container/Collection Method:	Vacuum Bottle	Tedlar/Vacuum Box
Analytical Method:	TO-15	TO-15
Laboratory:	Ace	Ace
Sample Duration:	Grab	Grab
Collection Time:	1346	1334
Date:	7-Dec-2006	7-Dec-2006
Tetrachloroethene	1,400	2,200
Trichloroethene	500	620
1,1-Dichloroethene	30	67
1,2-Dichlorobenzene	<0.5	<0.5
1,2-Dichloroethane	<10	13
1,1,1-Trichloroethane	15,000	29,000
1,1,2-Trichloro-1,2,2-trifluoroethane	50	80
1,1,2-Trichloroethane	<10	<10
1,1-Dichloroethane	3,000	5,800
Carbon Tetrachloride	<10	<10
Chlorobenzene	<0.5	<0.5
Chloroethane	3,500	6,800
Chloroform	12	32
cis-1,2-Dichloroethene	960	1,600
trans-1,2-Dichloroethene	73	150
Methylene chloride	50	110
Vinyl Chloride	61	180
1,2-Dichloropropane	11	63
1,4-Dichlorobenzene	<0.5	<0.5
Dichlorodifluoromethane	<10	<10
Trichlorofluoromethane	<10	<10
Benzene	<10	<10
Toluene	<10	12
Ethylbenzene	<10	<0.5
m,p-Xylene	<10	<10
o-Xylene	<10	<10
Acetone	<40	<40
Methyl ethyl ketone	<40	<40
2-Butanone	<2.0	<2.0
2-Hexanone	<10	<10

Bottle-Vac and Tedlar Bag Duplicates

Sample ID:	VP-10ID	VP-10ID
Container/Collection Method:	Vacuum Bottle	Tedlar/Vacuum Box
Analytical Method:	TO-15	TO-15
Laboratory:	Ace	Ace
Sample Duration:	Grab	Grab
Collection Time:	1427	1359
Date:	7-Dec-2006	7-Dec-2006
Tetrachloroethene	2,100	2,100
Trichloroethene	560	590
1,1-Dichloroethene	50	50
1,2-Dichlorobenzene	<0.5	<0.5
1,2-Dichloroethane	<10	<10
1,1,1-Trichloroethane	23,000	25,000
1,1,2-Trichloro-1,2,2-trifluoroethane	64	62
1,1,2-Trichloroethane	<10	<10
1,1-Dichloroethane	4,600	4,900
Carbon Tetrachloride	<10	<10
Chlorobenzene	<0.5	<0.5
Chloroethane	4,400	4,700
Chloroform	20	20
cis-1,2-Dichloroethene	1,300	1,200
trans-1,2-Dichloroethene	120	110
Methylene chloride	81	79
Vinyl Chloride	120	120
1,2-Dichloropropane	27	27
1,4-Dichlorobenzene	<0.5	<0.5
Dichlorodifluoromethane	<10	<10
Trichlorofluoromethane	<10	<10
Benzene	<10	<10
Toluene	<10	<10
Ethylbenzene	<10	<10
m,p-Xylene	<10	<10
o-Xylene	<10	<10
Acetone	<40	<40
Methyl ethyl ketone	<40	<40
2-Butanone	<2.0	<2.0
2-Hexanone	<10	<10

Bottle-Vac and Tedlar Bag Duplicates

Sample ID:	VP-10DD	VP-10DD
Container/Collection Method:	Vacuum Bottle	Tedlar/Vacuum Box
Analytical Method:	TO-15	TO-15
Laboratory:	Ace	Ace
Sample Duration:	Grab	Grab
Collection Time:	1526	1507
Date:	7-Dec-2006	7-Dec-2006
Tetrachloroethene	1,800	2,300
Trichloroethene	480	530
1,1-Dichloroethene	64	33
1,2-Dichlorobenzene	<0.5	<0.5
1,2-Dichloroethane	14	<10
1,1,1-Trichloroethane	34,000	45,000
1,1,2-Trichloro-1,2,2-trifluoroethane	77	53
1,1,2-Trichloroethane	<10	<10
1,1-Dichloroethane	5,400	7,400
Carbon Tetrachloride	<10	<10
Chlorobenzene	<0.5	<0.5
Chloroethane	4,600	7,200
Chloroform	34	12
cis-1,2-Dichloroethene	1,100	1,300
trans-1,2-Dichloroethene	150	75
Methylene chloride	110	49
Vinyl Chloride	180	64
1,2-Dichloropropane	63	11
1,4-Dichlorobenzene	<0.5	<0.5
Dichlorodifluoromethane	<10	<10
Trichlorofluoromethane	<10	<10
Benzene	<10	<10
Toluene	68	<10
Ethylbenzene	<10	<10
m,p-Xylene	12	<10
o-Xylene	<10	<10
Acetone	<40	<40
Methyl ethyl ketone	<40	<40
2-Butanone	<2.0	<2.0
2-Hexanone	<10	<10

Duplicate Samples Sent to Two Laboratories

Sample ID:	VP-5ID	DUP1
Container:	Vacuum Bottle	Vacuum Bottle
Laboratory:	Ace	Lab B
Date:	7-Dec-2006	7-Dec-2006
1,1,1-Trichloroethane	450	390
1,1,2-Trichloro-1,2,2-trifluoroethane	2.7	2.6
1,1,2-Trichloroethane	<1.0	<2.0
1,1-Dichloroethane	69	51
1,1-Dichloroethene	1.1	<8.0
1,2-Dichlorobenzene	<1.0	<4.0
1,2-Dichloroethane	<0.5	<4.0
1,2-Dichloropropane	<1.0	<4.0
1,4-Dichlorobenzene	<1.0	<2.0
2-Butanone	4.6	8.1
2-Hexanone	<2.0	<2.0
Acetone	130	37
Benzene	<1.0	<2.0
Carbon Disulfide	<1.0	<4.0
Carbon Tetrachloride	<1.0	<4.0
Chlorobenzene	<0.5	<4.0
Chloroethane	<1.0	<4.0
Chloroform	<1.0	<4.0
cis-1,2-Dichloroethene	160	170
Cyclohexane	<1.0	<4.0
Dichlorodifluoromethane	<1.0	17
Ethylbenzene	<1.0	<4.0
Styrene	<0.5	<4.0
Tetrachloroethene	510	490
Tetrahydrofuran	<0.5	<8.0
Toluene	<1.0	<2.0
trans-1,2-Dichloroethene	11	10
Trichloroethene	90	67
Trichlorofluoromethane	<1.0	<4.0
Vinyl Chloride	4.5	4.1
m,p-Xylene	<1.0	<8.0
o-Xylene	<1.0	<4.0

Conclusion

Data Supports Use of Bottle-Vac Samplers

Low cost canister

For Sub PPB and >Applications

Longer holding times

Easy field sampling

Markets: Indoor Air Quality, Industrial Hygiene (STEL, TWA, Area Monitoring), Soil Gas, Stack Gas, Landfill Gas, Remote Headspace, Flux Chamber Sampling.