An Evaluation of Indoor Air Sampling Procedures: Short Duration vs. Long Duration Sampling

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April 2, 2009

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Road Map

- Purpose and Overview
- Background
- Laboratory Methods: EPA Methods TO-15 and TO-17/ASTM 6196
- Sampling Program and Procedures Indoor Air at Hill AFB
- Passive Diffusion Sampler Evaluation and Uptake Rate Indoor Air Study Dec 2008-Jan 2009
- Established Uptake Rate Applied to Data Set
- Conclusions

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Genesis

Mr. Henry Schuver of the U.S. EPA OSW stated at the September 2007 A&WMA vapor intrusion conference in Providence, RI that EPA may consider recommending longer-term sampling of indoor air to achieve more accurate time-weighted-average detections.

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Ambient / Indoor Air Active Flow Testing Options

EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air: Jan. 1997

EPA TO-17 -- Determination of VOCs in Ambient Air Using Active Sampling Onto Sorbent Tubes

http://www.epa.gov/ttn/amtic/files/ambient/airtox/to-17.pdf

EPA TO-15 -- Determination of VOCs In Air Collected In Specially-Prepared Canisters

http://www.epa.gov/ttn/amtic/files/ambient/airtox/to-15.pdf

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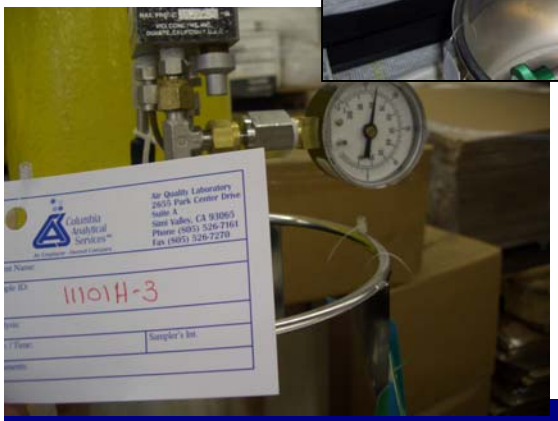
Recent Testing Near LAX-Active



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Method TO-15

Six-Liter Summa Canister

Height: One Foot plus (31 cm)

Diameter: ¾ Foot (22.9 cm)

Weight: Six Pounds (2.7 kg)

Method TO-15 samples were collected in Six-Liter Summa canisters

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Limitations of Canisters

- **Restricted analyte range - not suitable for polar compounds or VOCs with volatility >C10.**
- **Difficult and expensive to clean**
- **Bulky - require special storage facilities and transport**
- **Partitioning effects with liquid water (*i.e.*, condensation inside the canister) can cause quantitation difficulties**
- **Sensitivity limited by the volume of air that can be sampled in the canister and the sampling period**

Source: Markes International

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Indoor Air-Active and Passive

Off-Site Comparison Test: Tubes vs. Cans vs. PDS

- Three Sorbent Tubes, Three Canisters and Three PDS Tubes

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EPA Researcher`s Opinion

Dr. DiGiulio of the U.S. EPA states the use of sorbent tubes

"has several advantages including, rigorous QA/QC requirements, commercially available thermal desorption units and a large selection of sorbents, small size and weight of the sorbent and equipment, and the possibility of moisture management by dry purging and sample splitting prior to injection into the gas chromatograph."

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ASTM D6196-03

Standard Practice for Selection of Sorbents, Sampling, and Thermal Desorption Analysis Procedures for Volatile Organic Compounds in Air

This practice is intended to assist in the selection of sorbents and procedures for the sampling and analysis of ambient, indoor and workplace atmospheres for a variety of common volatile organic compounds (VOCs).

See also:

ISO 16017-2: Indoor, ambient and workplace air — Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography —Part 2: Diffusive sampling

MDHS80: VOCs in Air: Laboratory methods using diffusive solid sorbent tubes, thermal desorption and gas chromatography

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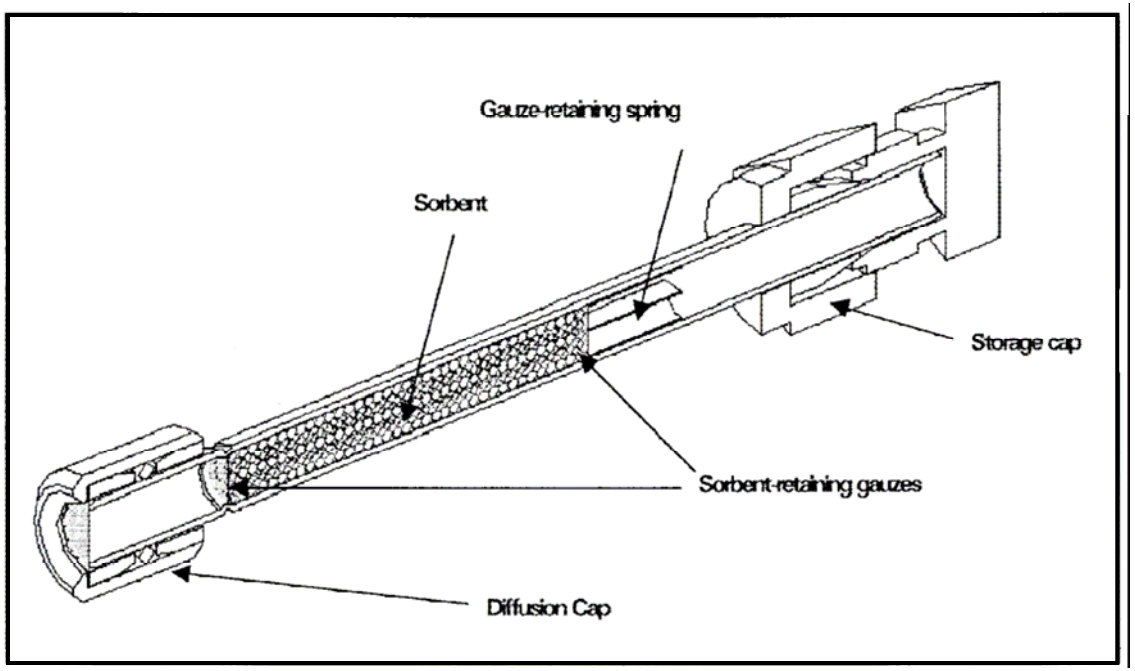
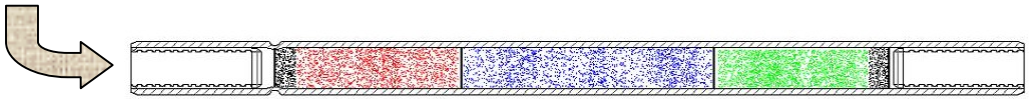
Advantages of Sorbent Tubes

- Convenient, small, portable and low cost
- Re-usable at least 100 times
- No reconditioning necessary after desorption - Tubes are completely clean after thermal desorption and can immediately be reused for the collection of more samples
- Suitable for a wide range of polar and nonpolar analytes
- Suitable for a wide volatility range (C3 to C30)
- Well validated for occupational hygiene as well as ambient outdoor and indoor applications - low ppt to high ppm
- Large air volumes may be collected and analyzed facilitating better detection limits
- Suitable for both pumped and diffusive sampling

Source: Markes International

TO-17 or Axial Diffusion Sampler Cross-Section





Multiple Adsorbent Beds

See ASTM D6196-03 for Sorbent Selection

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Sorbent Technology

TO-17/PDS Tube

Length: Four inches (10. cm)

Diameter: ¼ Inch (6.3 mm)

Weight: 1.8 ounces (45 g)

Tubes: TO-17 and PDS Types

TO-17

PDS

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Sorbent Tube Composition

MDHS80/PDS- Chromosorb 106 ~100 mg
Surface Area of 750 m^2/gram

Method TO-17
Tenax GR ~120 mg
Surface Area of 24 m^2/gram
Carboxen-569 ~180 mg
Surface Area of 485 m^2/gram

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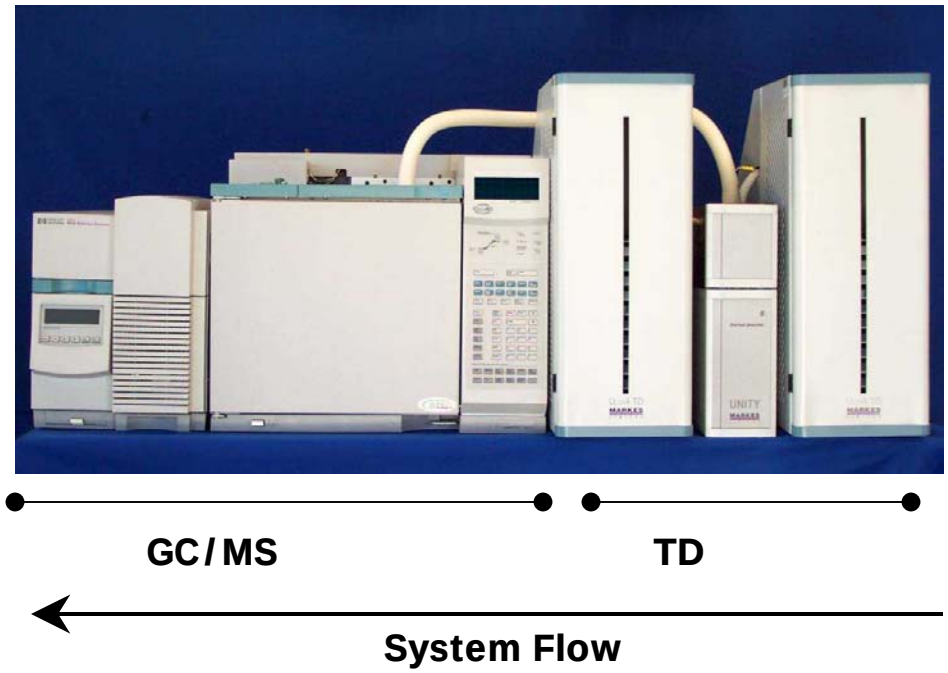
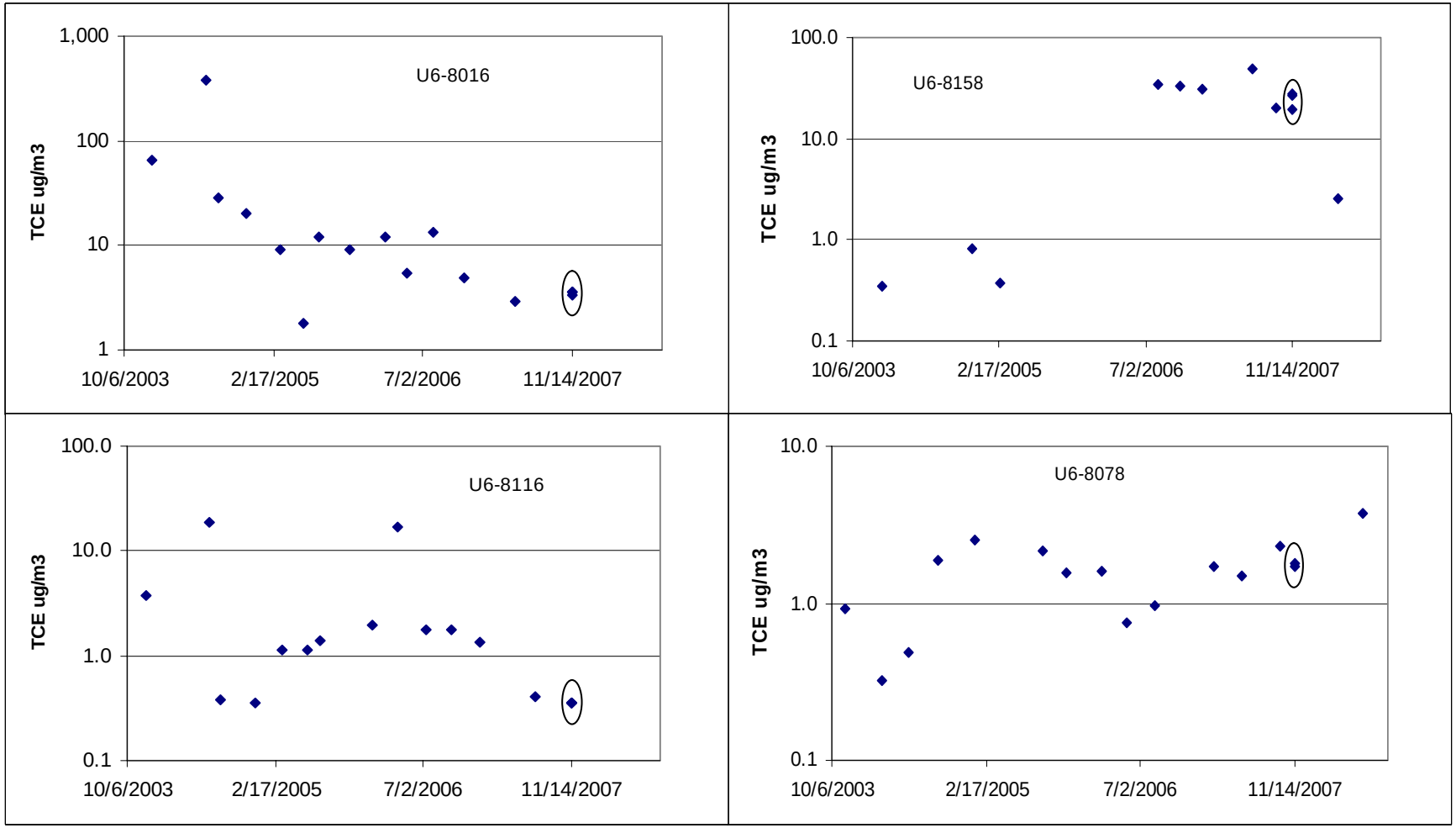
In The Lab: TO-17/MDHS 80

Samples analyzed with TD-GC/MS

- Thermal Desorption System
- GC/MS
- Lower detection limits possible with larger sampling volumes
- Not a "One-Shot Deal"



Time Histories in Study Areas



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Research Results 17/15/MDHS80

Compound>	TCE		
Units>	ug/m3		
Lab>	Beacon	CAS	Beacon
Method>	TO-17	TO-15	MDHS 80
Exposure>	24 hr	24 hr	2 weeks
Location			
8158	**20.4**	**28**	**12.1**
8158	**18.1**	**27**	**11.7**
8158	**10.9**	**19**	**10.8**
8016	**1.9**	**3.3**	**1.8**
8016	**2.0**	**3.6**	**1.7**
8016	**2.2**	**3.6**	**1.8**
8116	<0.3	<0.7	<0.5
8116	<0.3	<0.7	<0.5
8116	<0.3	<0.7	<0.5
8078	**1.2**	**1.8**	**1.0**
8078	**1.1**	**1.8**	**1.0**
8078	**0.9**	**1.7**	**1.1**

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Conclusions

1. The active sorbent tubes, Summa canisters and the long-term passive diffusion tubes (PDS) all measured the same trends relative to each residence.

2. The PDS results are consistently lower (on the average) than both the TO-15 & -17 concentrations and the effects of time-weighting of the samplers are more evident at increasing concentrations.

3. Regardless of the method used, each had strong agreement among the three reported concentrations within each home for each method.

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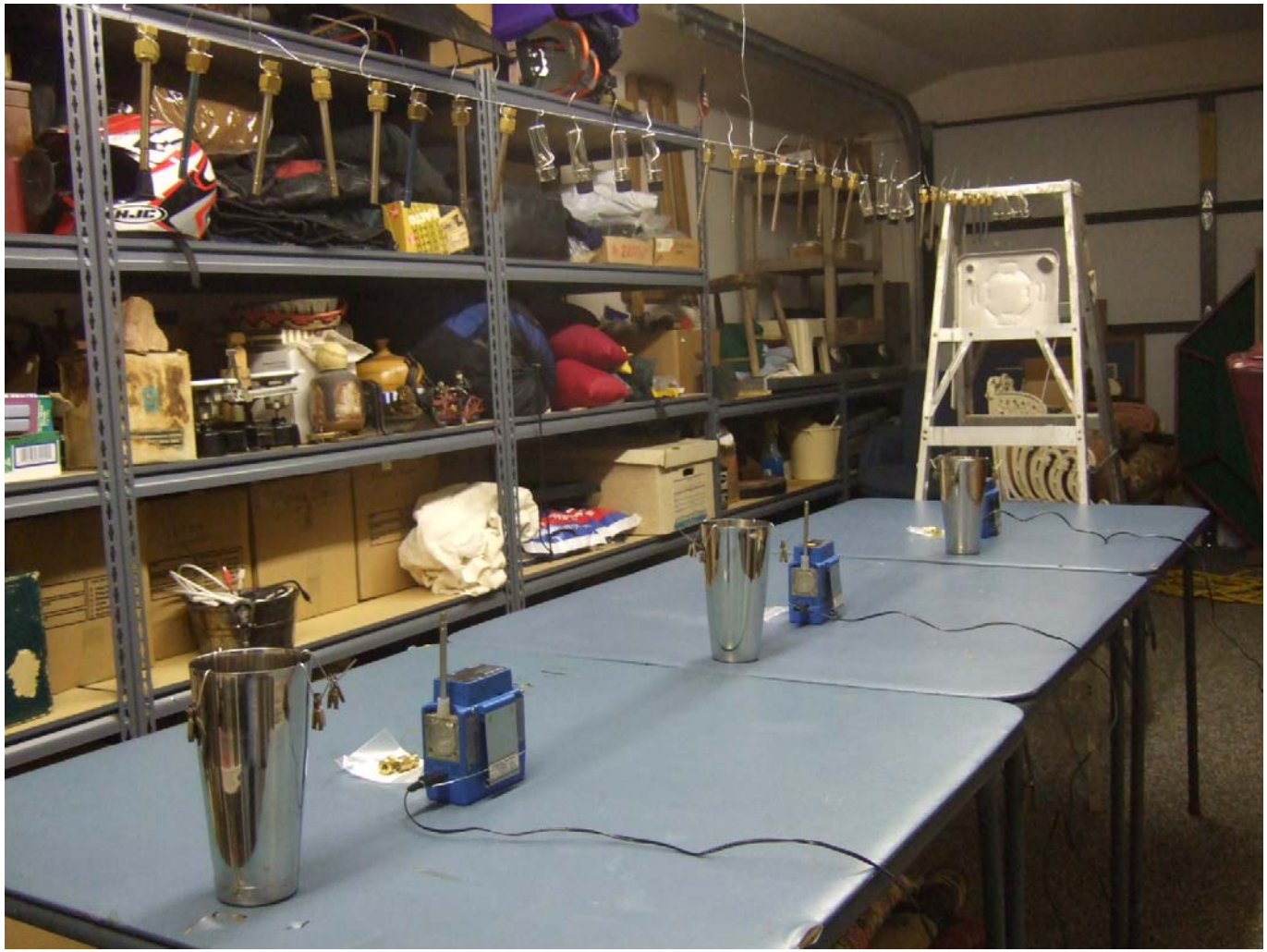
Changing Gears to Recent Indoor Air Study



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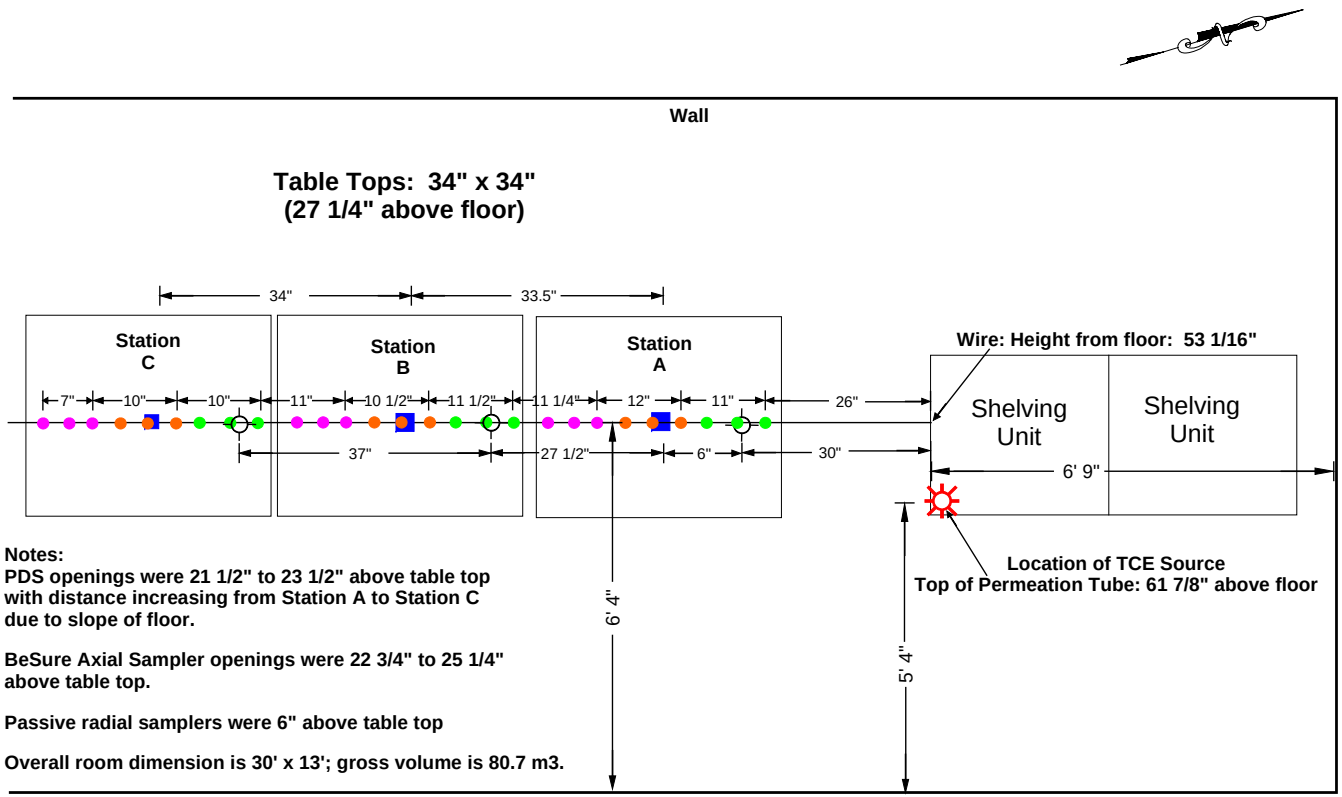
Indoor Air Study-Passive Diffusion Device Evaluation



Notes:
PDS openings were 21 1/2" to 23 1/2" above table top with distance increasing from Station A to Station C due to slope of floor.

BeSure Axial Sampler openings were 22 3/4" to 25 1/4" above table top.

Passive radial samplers were 6" above table top

Overall room dimension is 30' x 13'; gross volume is 80.7 m3.

Legend

- PDS TGr/Carboxen
- PDS Chromosorb 106
- BeSure Axial Sampler
- 4 Passive Radial Samplers
- TO-17 Sample Location

Not to Scale

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323 Williams Street, Bel Air, MD 21014, 800-878-5510
Beacon R&D Project, December 2008

Figure 1
Beacon R&D Project
Study Area Layout

Test Site
Maryland

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Controlled Release of TCE and Tracking Summary

Short and Long Term Sampling Comparison

- **Daily Active Measurements for a 14-day period in Triplicate**
- **Four Types of Passive Devices Deployed at the Beginning of Study**
- **Passive Devices Pulled at 3, 7, 10 and 14 days in Triplicate**
- **Statistical Analysis of Passive Device Performance**

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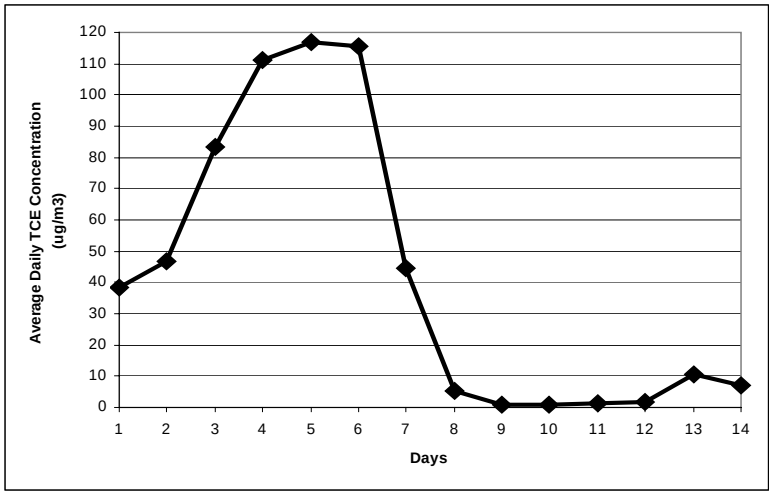
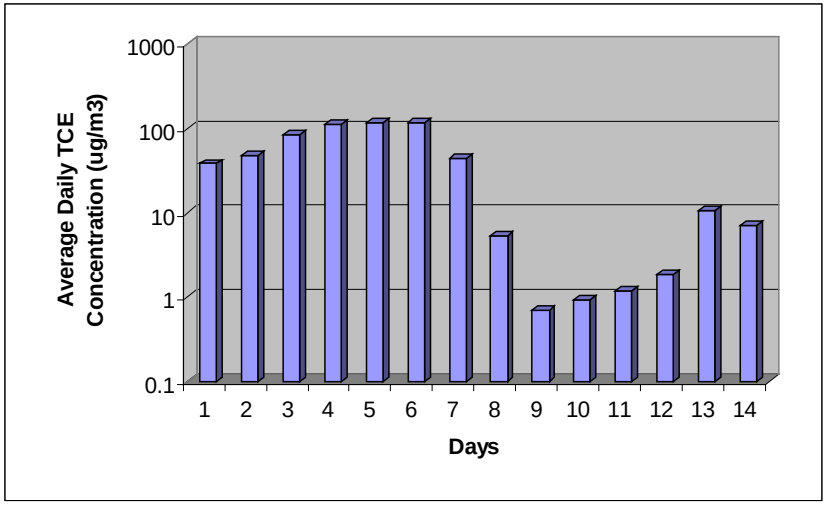
Passive Diffusion Devices and TO-17 Active Arrangement

Daily TCE Concentration Variability





Calculation of Uptake Rates

Equation

Uptake Rate = Mass from Passive Device ÷ Average Concentration times Time

Units

cm3/min = [ng ÷ (ug/m3 * min)] * 1,000

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Uptake Rate Calculations

Uptake Rates for TCE on BeSure Axial Sampler										
	0.148993	cm3/min								
C =	56.25	79.57	56.39	41.77	ug/m3	Observed average concentration from TO-17 samples				
	0.05625	0.07957	0.05639	0.04177	mg/m3					
C =	1000M/(U x t)									
C =	54.56	87.17	51.96	42.32	ug/m3	Conc based on calculated average Uptake rate				0.148993
M =	(C x U x t)/1000									
			Days							
	3	7	10	14						
	4367	10093	14439	20107		Exposure time (min)				
U=	0.144518	0.16323	0.137286	0.15094		Calculated Uptake Rate: cm3/min			Average	0.148993
M=	35.5	131.09	111.78	126.77		Average mass found on passive tubes in study				ng
StdDev=	0.011009									
Mean=	0.148993									
COV=	0.073887									

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Coefficient of Variation Summary

Type	Average Uptake Rate cm3/min	Standard Deviation cm3/min	Coefficient of Variation
PC	0.237	0.008	0.036
PT	0.148	0.044	0.300
BA	0.149	0.011	0.074
PR	2.024	0.543	0.268

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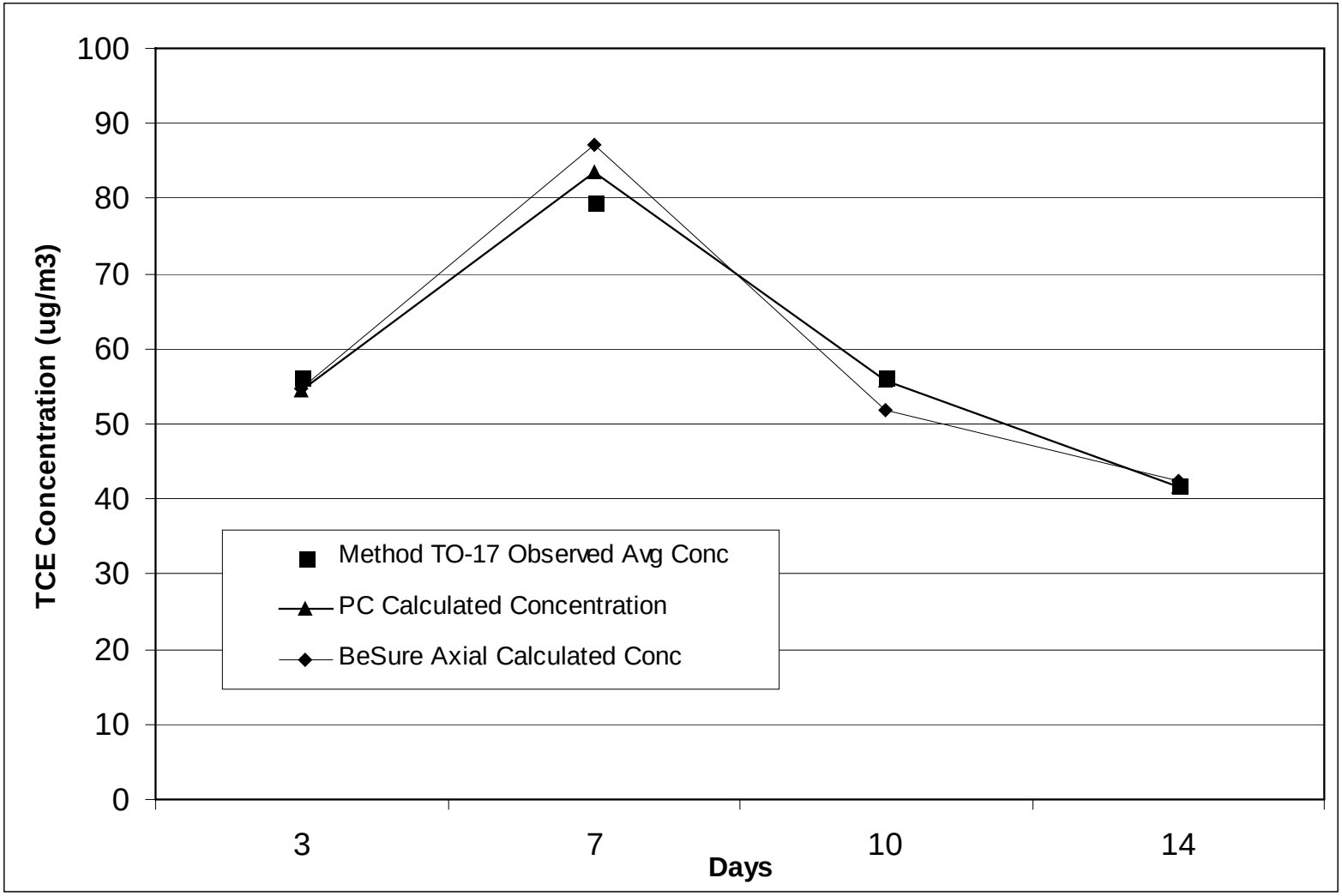
Prediction Using Established Uptake Rates



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Conclusions

- A controlled release of TCE in an indoor air environment allowed for over two orders of magnitude daily concentration variability over the course of the two-week monitoring event.
- The daily concentration measurements by EPA Method TO-17 and the passive diffusion samplers were done in triplicate and had excellent reproducibility.
- The coefficient of variation of the uptake rate was lowest for the single sorbent tube (PC) and highest for multiple sorbent tube (PT). The radial sorbent configuration (PR) had the highest uptake rate. The BeSure Axial Sampler (BA) uptake rate was nearly identical to PT (same sorbent make-up), however, the BA coefficient of variation was four times lower at 0.074.

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Conclusions-Continued

- The TCE uptake rate for the PC configuration is approximately half of that reported in a previous laboratory study (MDHS80) for shorter duration sampling and may be more representative of real world conditions.
- The performance of all the passive diffusion devices was analyzed in this study for large fluctuations of TCE concentrations. The average concentration for all of the exposure periods could be reliably predicted using the established uptake rates and with no pump/active air flow/vacuum for the PC and BA devices. The PT and PR devices' coefficients of variability were above 0.10 and did not produce reliable concentration estimates.
- The passive diffusion indoor air study demonstrated two devices were able to provide reliable 3, 7, 10 and 14 day average concentrations for their respective exposure periods.