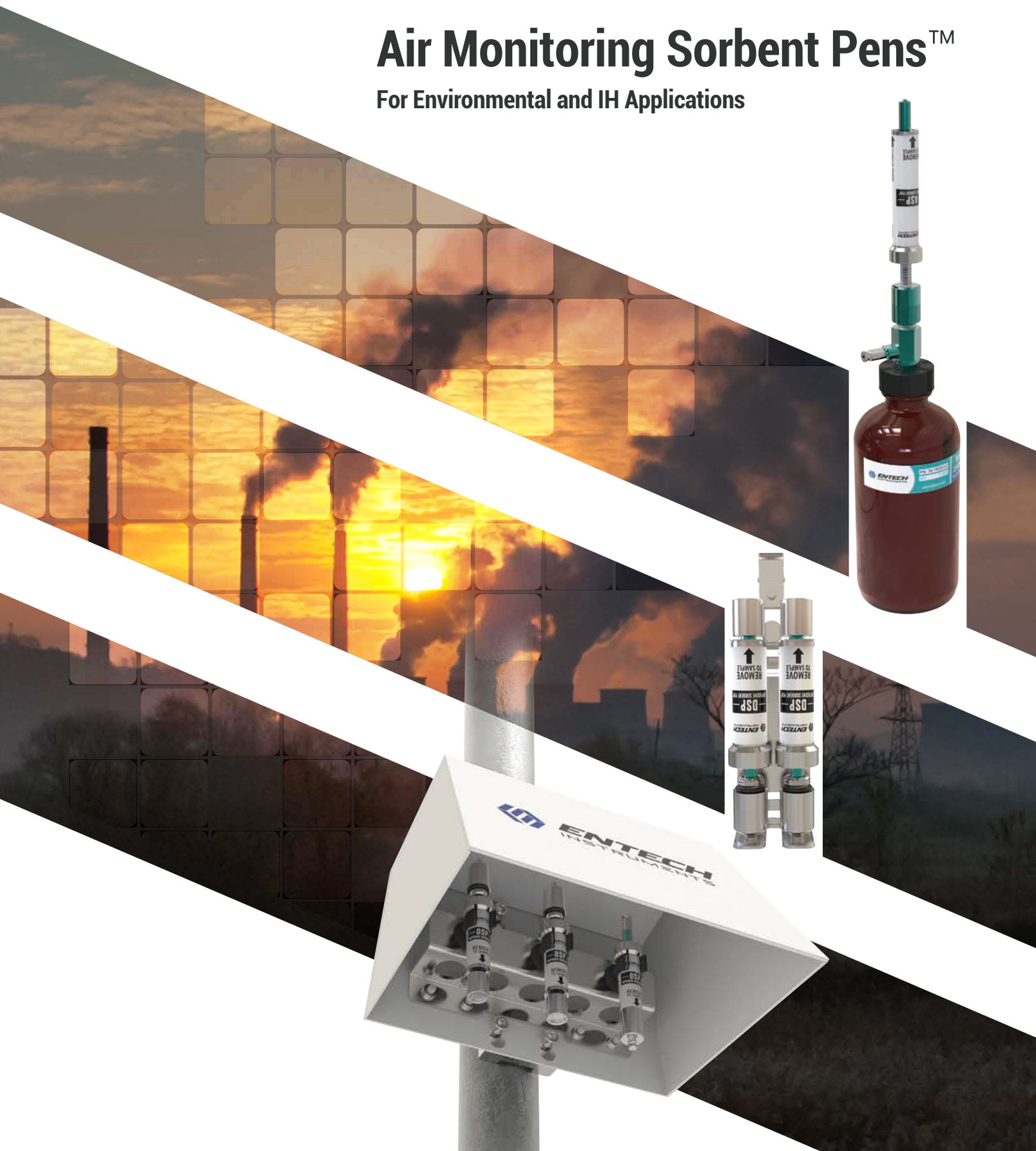
ENTECH INSTRUMENTS

Air Monitoring Sorbent Pens™

For Environmental and IH Applications



Sorbent Pens™ for Quantitative Air Monitoring

Sorbent Pens mark the latest innovation in quantitative air monitoring from Entech Instruments. These adsorbent based samplers can either be used to collect air via diffusion without the aid of a pump or vacuum device (Diffusive Sorbent Pens, or DSPs), or they can be actively sampled by drawing air through them (Active Sorbent Pens, or ASPs). Unlike the standard thermal desorption tubes that use the same geometry to do either diffusive or active sampling, the Sorbent Pens have been optimized to improve their performance for both of these "very different" sample collection approaches. This has been done to optimize the quantitative results, and to increase the durability and lifetime of each adsorbent based air monitoring device.

DSP - Diffusive Sorbent Pens

8 hours to 2 weeks

When To Use?

- Use when sampling for **8 hours to 2 weeks**
- When method calls for diffusive sampling

Benefits?

- Very easy use
- No pumps or vacuum source
- Uptake rate known for dozens of compounds
- Ideal for BTEX monitoring
- Both Environmental and Industrial Hygiene applications

See Page 2

ASP - Active Sorbent Pens

5 minutes to 8 hours

When To Use?

- Use for faster sample collection: **5 min to 8 hours**
- When method requires an active sampling

Benefits?

- Multiple adsorbent traps are available which substantially increases the range of recoverable compounds
- Accurate volume collection measurements made using Entech's Accu-Bottle vacuum sampler.

See Page 8

Sorbent Pens™ for Diffusive Sampling & Monitoring

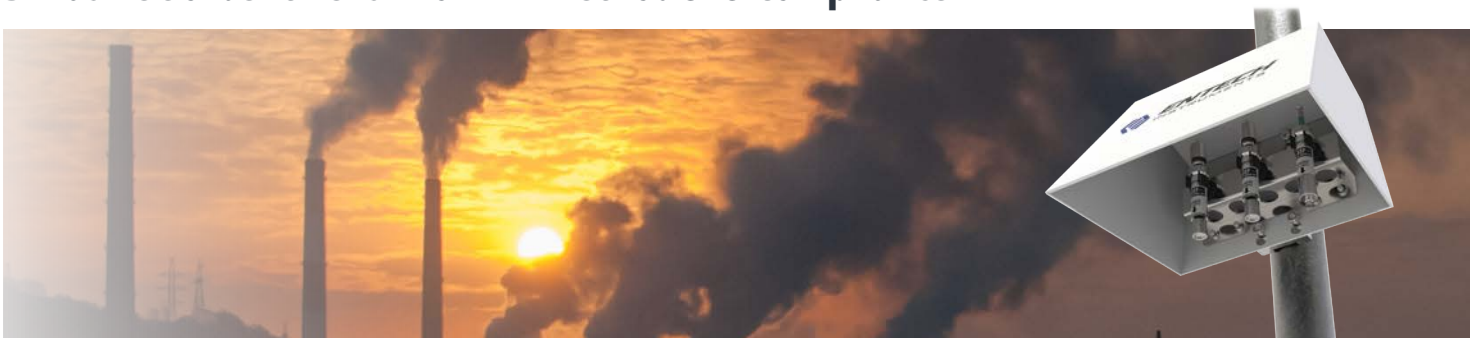
Entech Sorbent Pens™ represent in advancement passive 'diffusive' sampling, incorporating many subtle but critical engineering design elements that ensure quantitative recovery, reproducibility, and cost effective long term use. The result of decades of research into volatile chemical sampling and analysis has resulted in a sampler so accurate and reproducible that the data is almost unbelievable!

Passive or diffusive sampling is defined as the unassisted molecular diffusion of gaseous analytes through a diffusive region and onto an adsorbent. The DSP (Diffusive Sorbent Pen) does not require a pump and contains no moving parts. After sampling, the adsorbed analytes are desorbed directly into the GC or GCMS of choice.

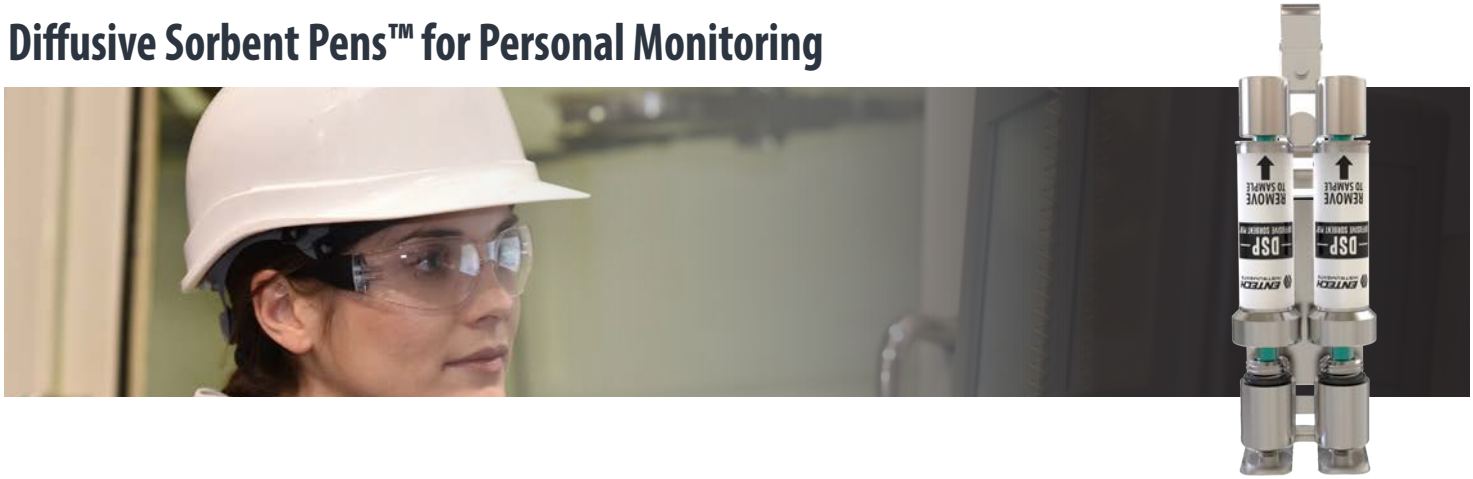
Benefits of passive/diffusive sampling:

- Compact, portable, unobtrusive, and inexpensive
- Offers indication of average pollution levels over time periods of 8 hours to several weeks
- Requires no supervision, is noiseless and can be used in hazardous environments
- Low cost allows for sampling at multiple locations (e.g., for highlighting pollution "hotspots"; or determining long term data trends in a specific geographical area)
- Amenable to personal monitoring (breathing zone), indoor air analysis, and outdoor ambient air analysis

Diffusive Sorbent Pens™ for EPA Method 325 Compliance



Diffusive Sorbent Pens™ for Personal Monitoring

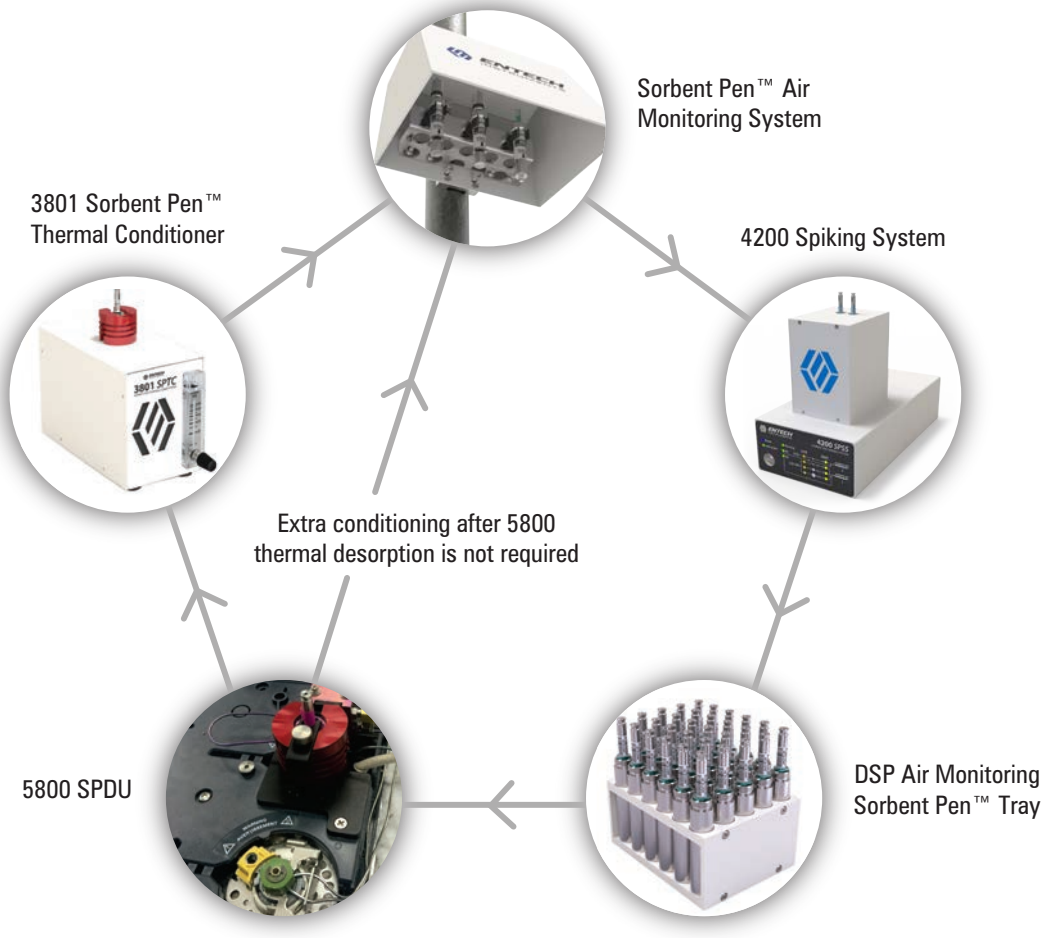


US EPA Method 325 - Passive Sampling on ¼" OD Tubes

The Sorbent Pen Does it Better!

- Meets requirements of U.S. EPA Method 325 finalized Fall 2015
- 8 hr - 2 week passive sampling provides highly reproducible results for BTEX and similar boiling range VOCs.
- More reproducible than radial samplers because sample is backflushed during thermal desorption rather than pushed through the entire adsorbent bed.
- Carbon Tetrachloride is quantitatively recovered, so Global background of 70 ppt can be used to validate proper sampling when performing GCMS or GC/FID/ECD

An Affordable End-to-End Solution



Sorbent Pen Air Monitoring System

Isolated Sorbent Pen for storage and transportation from lab to field and back. No crushing of tops and bottoms of tubes, common with nuts and ferrules on 3.5" TD tubes, so sampling rates remain the same.

During sampling bottom caps are placed on top of the Sorbent Pens for safe keeping.

Diffusers to prevent wind from affecting sampling rates

Field Blank (not sampling)

325 Sorbent Pen Comparison to Canister Sampling and Triplicate Pen Results at Elevated Levels

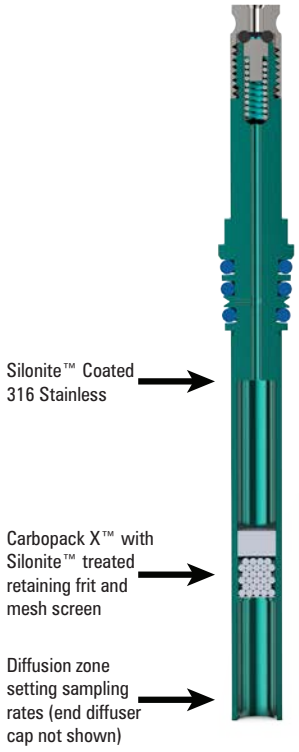
	Benzene	Toluene	Ethybenzene	m,p-Xylene	o-Xylene
Rate of Collection:	0.67+-0.06	0.52+-0.14	0.46+-0.07	0.46+-0.09	0.46+-0.12
Total Volume, 163 Hrs	6553	5086	4499	4499	4499
			Concentrations (PPBv)		
Ambient Air Tube#1	0.101	0.185	0.044	0.111	0.040
Ambient Air Tube#2	0.089	0.173	0.036	0.098	0.040
%RSD Amb Air Tubes	9.09%	4.66%	13.31%	7.96%	0.00%
Ambient Air Canisters (Ave)	0.076	0.340	0.043	0.109	0.045
Parking Lot Tube #1	0.63	2.98	0.31	1.08	0.36
Parking Lot Tube #2	0.62	2.89	0.30	1.06	0.35
Parking Lot Tube #3	0.63	2.91	0.29	1.06	0.36
%RSDs ParkLot Tubes	0.49%	1.68%	2.75%	0.89%	1.32%

BTEX Data for 1 week duplicate diffusive samples compared to 6L canister samples, and triplicate 1 week diffusive tubes at elevated levels . The reproducibility was better than anticipated for a diffusive technique, and the ability to inject the sample directly onto the GC column probably contributed to the consistency in the results.

Diffusive Monitoring of BTEX

Collection Times 8 Hours to 2 Weeks

- The sampling end of the Diffusive Sorbent Pen™ exactly meets EPA 325 requirements for diameter and distance to adsorbent
- A diffuser is used at the end of each tube to prevent convective transfer during windy days
- No LN2 needed. Typical split of 20:1 produces low part per trillion detection limits
- A 0.5um x 5m pre-column and an Entech CL-BTEX-30 main column allow compounds heavier than BTEX to be backflushed off of the pre-column for much shorter run times
- Internal Standard can be added to each tube before analysis



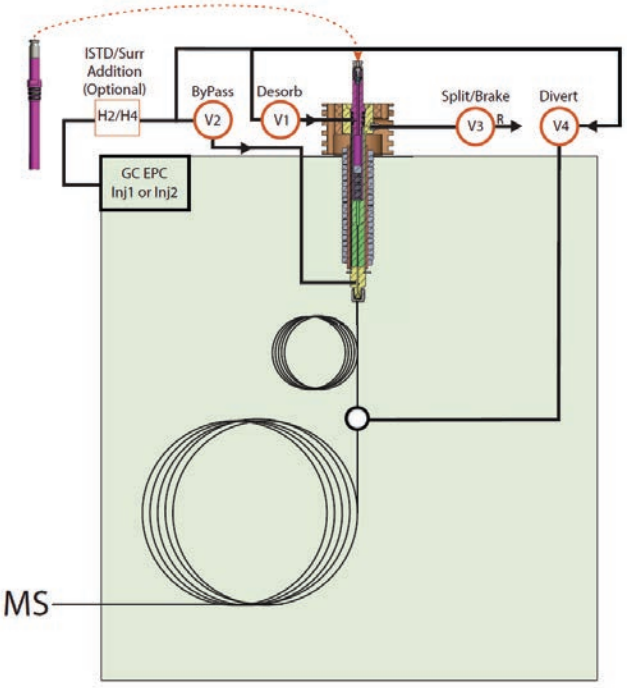
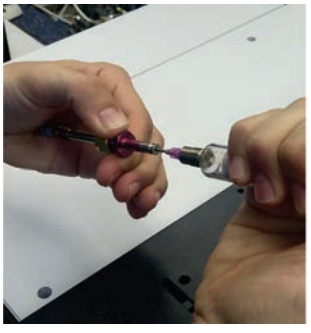


Figure 1 (above) - Diffusive Sorbent Pen developed for BTEX monitoring over 8 hours to 2 weeks. The Carbopack adsorbent is positioned to create reliable sample collection rates. The 5800 SPDU allows rapid injection into the GC, and controls the diversion of the carrier gas to back flush off heavy compounds before they reach the second more highly retentive column. Expensive and complicated secondary preconcentration systems, electronic cooling, transfer lines, and rotary valves are avoided.



Perfect Peak Shape without LN2 Focusing.
Back-flushing Eliminates Ghost Peaks and Reduces Run Times

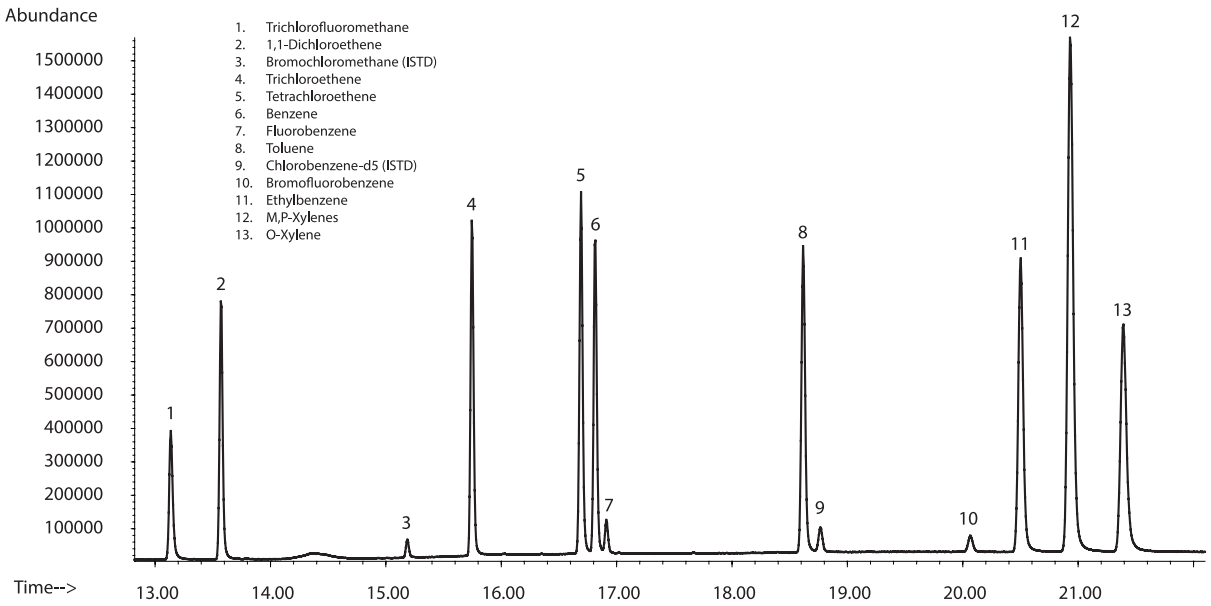


Figure 2 - BTEX Standard Corresponding to 6 PPBv for Benzene as sampled for 1 week.

Triplicate Sampling of 325 Sorbent Pen
Virtually perfect overlap of BTEX Compounds

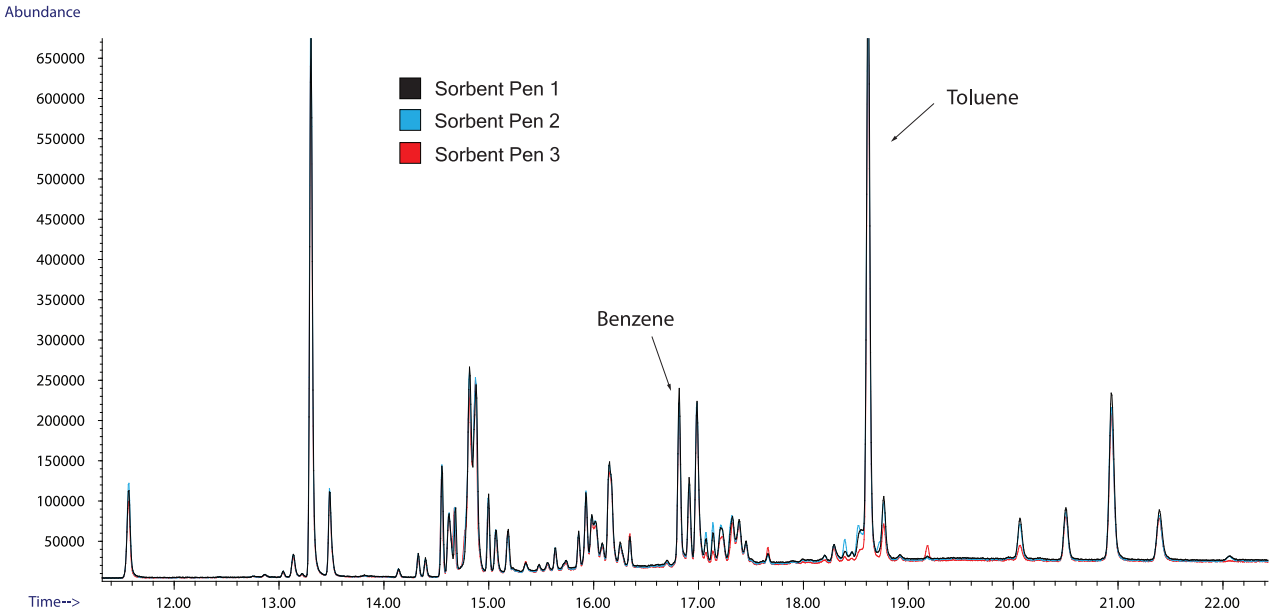


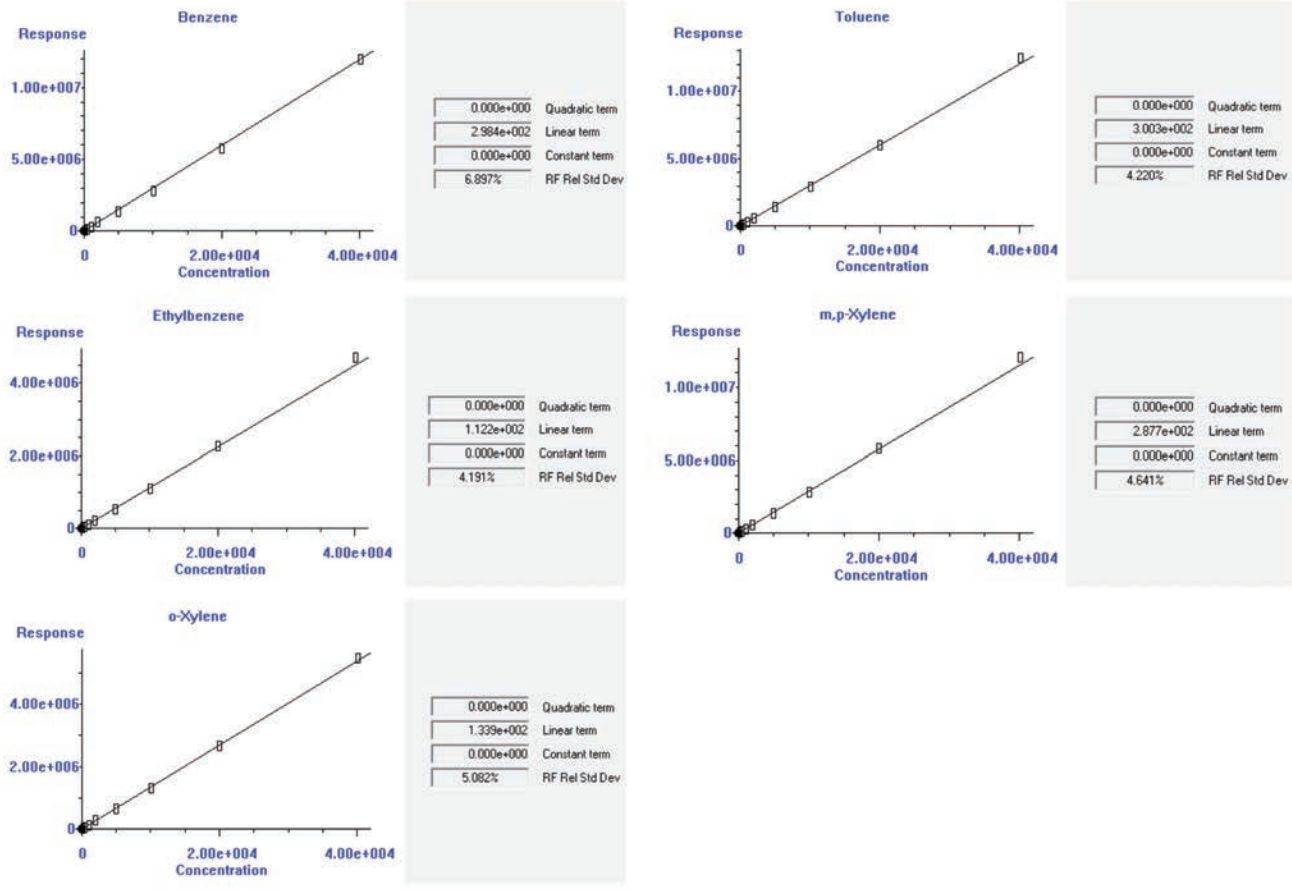
Figure 3 - Triplicate tubes placed in parking lot near parked vehicles to increase BTEX Concentrations. Sampling was performed over a 1 week period. Overlap of BTEX is virtually perfect.

4200 Sorbent Pen Spiking System

For Sorbent Pen Air Monitoring Solutions

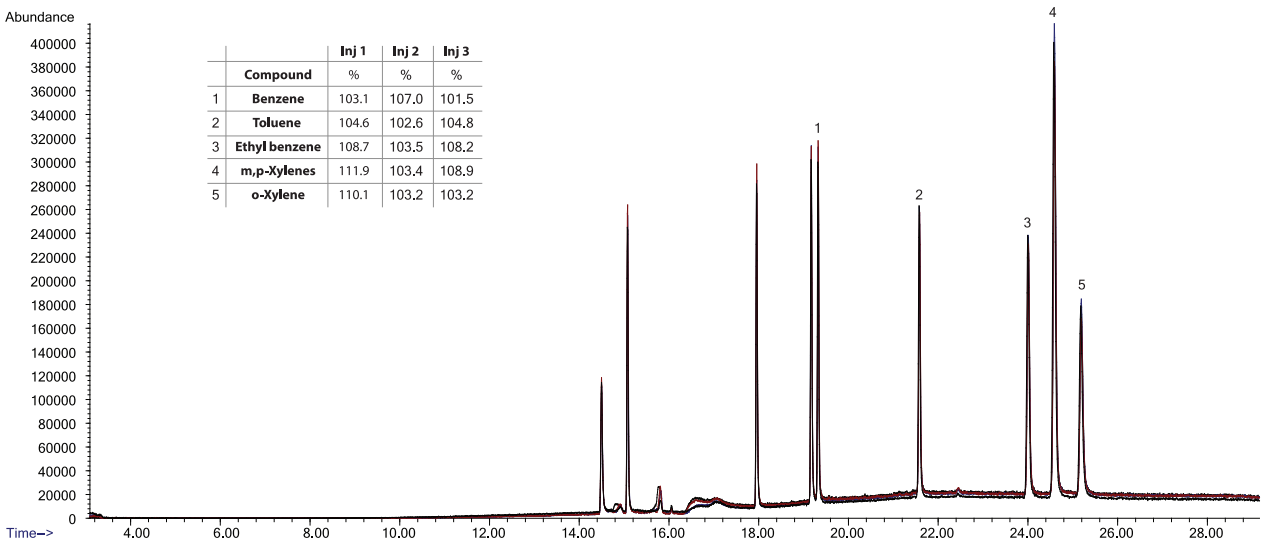
- Fully automated way to create accurate spiking of standards onto Sorbent Pens
- Separate Calibration Standard and Internal Standard spiking ports to prevent any possibility of cross contamination
- Can spike 1 to 200cc of calibration standard or 5cc of internal standard automatically using calibrated reservoirs
- Self purges using UHP Nitrogen
- Compatible with all Sorbent Pens, but primarily intended for DSP and AAM Air Monitoring Pens
- Not compatible with 3.5"TD Tubes
- Single model handles all voltages (90-250VAC)

4200 Calibration Curves – 0.2PPBv to 40PPBv



- Calibrations were performed over a 200x range. The 4200 performed all spikes automatically
- All compounds had %RSDs within 4-7%
- US EPA Method 325 allows for up to a 30% Relative Standard Deviation, so the Sorbent Pen easily meets this criteria.
- Concentrations were based on the sampling rate for Benzene, and how much would have loaded during the 2 week sampling period specified in Method 325

Perfect Peak Shape without LN2 Focusing.
Triplicate 4200 5cc BTEX Spike Compared to a Manually Spiked Sorbent Pen



		Inj 1	Inj 2	Inj 3
	Compound	%	%	%
1	Benzene	103.1	107.0	101.5
2	Toluene	104.6	102.6	104.8
3	Ethyl benzene	108.7	103.5	108.2
4	m,p-Xylenes	111.9	103.4	108.9
5	o-Xylene	110.1	103.2	103.2

- Manual injection was performed using a glass, gas-tight syringe. The 4200 spiked Sorbent Pens were generally 3-10% higher, especially for the heavier compounds, which could be the difference between affinity to the glass syringe and the reduced affinity to the Silonite™ coated reference volumes in the 4200
- Retention times were identical for both the manually spiked and the 4200 spiked Sorbent Pens

DESCRIPTION	PART #	UNIT
DSP 325 Bundle		
Diffusive Air Monitoring Bundle DSP-B01, 120VAC - GC Mounting Kit Ordered Separately (BTEX and Other Compounds, Meets EPA Method 325 Requirements)	SP-DSP-B01	EA
Sorbent Pen Thermal Desorption Unit (120VAC/60Hz) - Order GC install kit separately	5800-SPDU	EA
5800 Liner for Headspace Sorbent Pen - Silonite™ Coated	5800-LNR-DSP	EA
Sorbent Pen Spiking System (1 - 200cc from regulated cylinder)	4200-SPSS	EA
6L Silonite™ Canister with Valve Guard	29-10621	2
BTEX Plus Cylinder, 800L, 2.7PPM Benzene, 350 CGA Fitting	40-SP-325-27	EA
Fluorobenzene Cylinder, 800L, 50PPM, 350 CGA Fitting	40-SP-FB-500	EA
High Purity Regulators	40-02004	2
Sorbent Pen™ Thermal Conditioner (120VAC/60Hz)	3801-SPTC	EA
Diffusive Sorbent Pen - CarboPack X	SP-DSP-CPX	10
30 Position Tray - Diffusive Sorbent Pens. Manual or 7800 Autosampler	SP-DSPTray30	EA
BTEX GC Column, 30m	CL-BTEX-30	EA
PDMS Pre-Column, 5m x 0.32mmID, 1um	56-10510	EA
Diffuser Caps (Prevents Convective Sampling in windy conditions) (10 pack)	SP-DSP-DFCAP	EA
3-Position Diffusive Pen Monitoring Station	SP-DSP-AMS3	EA

New DSP Badge Samplers

More Reliable and Sensitive than Solvent Extraction Badges

- Diffusive sampler that collects a wide range of compounds
- Several adsorbents available depending on compounds to be collected
- The DSP Badge has several advantages
  - Higher sensitivity due to much greater percentage of sample reaching the detector during analysis (thermal desorption rather than solvent extraction)
  - 20-60 times lower sampling rates, so far less likely to "starve" during sampling (common problem with other badges) Easier analysis. Just spike with 4200 and desorb

New DSP Badge Samplers

Dual Sampler also Available

- Allows DSP Badges with different adsorbents to be used together to increase range of chemicals to be monitored
- Perfect when duplicates are needed
- Uses diffusers on the Pen inlets to prevent convective transfer, so diffusion is the only transport mechanism onto the adsorbent
- Just like badges, chemicals will have different diffusion rates, but the Diffusive Sorbent Pens have adopted the same inlet geometry used by 3.5" diffusion TD Tubes, so sampling rates for a large number of compounds are already known.

DSP Badge Personal Monitors

Approximate Molecular Wt Range Based on Sorbent Type

- Carboxen 1000 (**PN: SP-DSP-C1000**)
  - C3-C6
- Carbopack X (**PN: SP-DSP-CPX**)
  - C4-C8
- Carbopack Y (**PN: SP-DSP-CPY**)
  - C9-C14
- Carbopack C (**PN: SP-DSP-CPC**)
  - C14-C22
- Tenax TA (**35/60 Mesh, PN: SP-DSP-T3560**)
  - C10-C20

Note: For diffusive sampling, each compound must irreversibly "stick" to the adsorbent in order for quantitative collection to occur. This is why the lowest acceptable carbon number is "higher" than with active sampling. Also, carbon number ranges above are approximate and must be verified for each compound.

325 Sorbent Pen / 5800 SPDU
Advantages over Classical 3.5" TD Tubes

- Improved design allows much lower blank levels
- Tube ends will not crush, as classical compression fittings are avoided
- This keeps sampling rates the same from tube to tube
- Direct desorption into GC improves recovery and reproducibility
- Pre-Column backflush eliminates the buildup of high molecular weight compounds
  - Simple replacement of liner and pre-column creates an entirely new flow path, essentially creating a "new" system
  - Very simple to operate, understand, and maintain
  - The secondary traps and transfer lines in externally desorbed TD tube systems allows deposition of 4-7 ring PAH compounds that will eventually reduce recovery of light compounds, while increasing column bleed and bakeout times.
    Difficult to replace flow path
- The 5800 SPDU and the 7200 can both connect into the same GCMS simultaneously with no replumbing to switch from Sorbent Pens to Canisters.

Sampling Rates of Several Compounds into SP-DSP-CPX

Compound	Carbopack™ X[a]
1, 1-Dichloroethene	0.57 ±0.14
3-Chloropropene	0.51 ±0.3
1, 1-Dichloroethane	0.57 ±0.1
1, 2-Dichloroethane	0.57 ±0.08
1,1,1-Trichloroethane	0.51 ±0.1
Benzene	0.67 ±0.06
Carbon tetrachloride	0.51 ±0.06
1, 2-Dichloropropane	0.52 ±0.1
Trichchloroethene	0.5 ±0.05
1, 1, 2-Trichloroethane	0.49 ±0.13
Toluene	0.52 ±0.14
Tetrachloroethene	0.48 ±0.05
Chlorobenzene	0.51 ±0.06
Ethylbenzene	0.46 ±0.07
m, p-Xylene	0.46 ±0.09
Styrene	0.5 ±0.14
o-Xylene	0.46 ±0.12
p-Dichlorobenzene	0.45 ±0.05

ASPs - Active Sampling with Sorbent Pens

Active sampling dramatically speeds up the sampling process, because rather than sampling at about 0.5cc/min via diffusion, the sampling rates can be increased to several cc's per minute. This is accomplished by providing both a vacuum source to draw the air through the sampler, and a way to measure the total volume of air sampled. Although adding a vacuum device that also measures the collected volume adds complication and cost to the sampling event, there are many advantages to performing active sampling:

1. Samples are collected over a shorter period of time. This is advantageous when the period of investigation for toxicology reasons must be below 8 hours

2. A much wider range of compounds can be recovered, buy using a multi-bed trap.

Multi-bed traps are packed with weak adsorbents at the trap's entrance, and then use stronger adsorbents further into the trap. This creates an adsorbent strength gradient that allows heavier VOCs to be recovered without using extremely high temperatures, while still recovering the lighter compounds that would have otherwise broken through if only using a weaker adsorbent. A typical number of adsorbents in a multi-bed trap is 3, above which there are diminishing returns relative to the difficulty in pack these traps reproducibly.

One of the more important disadvantages in active air sampling onto adsorbents can be eliminated by simply collecting air at a slower rate. When sampling at rates that are more than about 20-30 times the diffusion rate, a phenomenon called "channeling" starts to create a lot of inconsistencies in sample penetration into the tubes, and therefore consistency from tube to tube, and even carryover from one sampling event to the next. Like almost all materials, adsorbents expand when they are heated and then contract upon cooling. When adsorbents contract, they leave gaps that are low impedence flow paths that allow chemicals in air to penetrate much further into the tube then if these gaps are not present. Since these gaps are inconsistent from tube to tube, the extent of penetration will also be inconsistent. When the sampling rates are slowed down, the extent of penetration into the tube will decrease, and recoveries between tubes will become more similar, despite a different pattern of channels within each adsorbent tubes.

The Active Sorbent Pen has been designed to not only minimize the creation of channels, but they have a very small entrance hole that allows sampling rates to be reduced to very low rates without the potential for reverse adsorption off the front of the tube. Optimal sampling rates from 0.2 to 20 cc/min are used to achieve rapid sampling onto multi-bed traps to recover a very wide range of compounds, from C3 to over C25. Like all Sorbent Pens, the ASPs are desorbed with 2 cm of the GC column to not only trap these compounds, but then deliver them quantitatively onto the GC column. The simple replacement of the 5800 SPDU liner provides a completely new flow path to the GC column, eliminating the potential for degradation of analytical performance over time.

Collecting ASP Samples using the "Accu-Bottle Sampler"

Another source of errors when actively sampling air onto adsorbent tubes comes from incorrectly measuring the volume that passes through the tube. Generally, time and flow rate is used to collect a known volume, but flow rates using sampling pumps are not always constant, and pumps that measure and record flow rates are very expensive and can still suffer from flow measurement errors. Entech has developed a simple means of controlling flow and directly measuring trapping volumes that is far more accurate, reliable, and best of all cost effective. Using the Accu-Bottle sampler, a bottle of known volume is evacuated either in the lab or in the field, and then sampling is either performed until the bottle reaches atmospheric pressure, or until a desired pressure increase has occurred. The Accu-Bottle sampler uses precision flow elements to sample at either 10, 20, or 30cc/min, based on volumes and sampling times desired. Again, to avoid channeling and reduced recoveries, the best data will be obtained when sampling at 10-20cc/min, although 30cc/min is acceptable in some cases. A simple pump can be used to recharge the Accu-Bottle sampler in the field, or samplers can be evacuated in the lab, and will remain under vacuum for weeks awaiting use in the field. With the Accu-Bottle samplers, tube to tube consistency is dramatically improved, allowing active sampling to be a reliable means for quantitative air measurements over a very wide molecular weight range.

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Sorbent Pens™ *– A revolutionary extraction technology that is quantitative by design.*

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