

Basics in Air Monitoring

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sigma-aldrich.com/analytical



Content

Overview Air Monitoring

- Where and how it's done?

Sampling Techniques

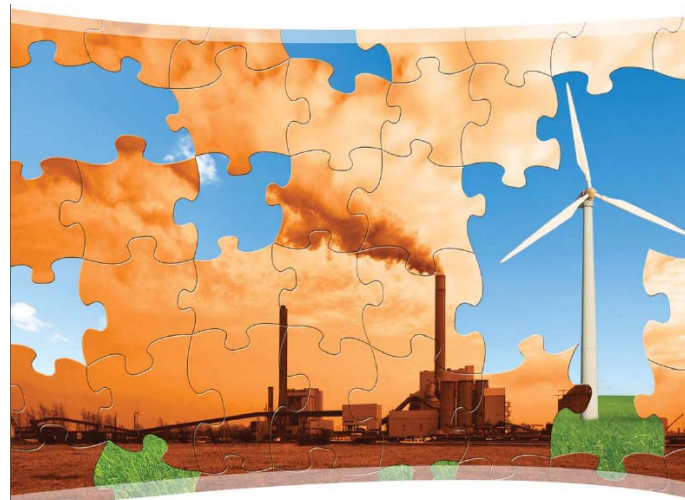
- Passive Sampling
- Active Sampling

Air Monitoring Devices

- Solvent desorption
- Thermal desorption

Accessories

- ATIS
- Pumps





Why we take Air Samples?

- ✓ To identify & measure air pollutants.
- ✓ To monitor personal exposures to chemicals.
- ✓ To assess the environmental impact of manufacturing processes.
- ✓ To comply with government regulations.
- ✓ To identify the source of the pollutants.
- ✓ To evaluate the effectiveness of engineering controls (i.e., ventilation)





What is Air Sampling ?

A means of collecting contaminants from air to identify and quantify the concentration of the contaminants.

- ✓ Typically we need to concentrate the contaminants with some sort of media. The exception is when we take “whole air samples” then the concentration step takes place in the lab.
- ✓ Concentration are calculated in either dimensionless terms:
ppm or ppb
or
- ✓ Concentrations are calculated in mass per volume terms:
 $\mu\text{g}/\text{m}^3$ or mg/m^3



Environmental



Industrial Hygiene

**Occupational
Workplace**



Ambient

**Industry
Farming
Hazardous
Waste Sites**



Source

**Industrial Stacks
Motor Vehicles
Vapor Intrusion**

Product Emissions

**Furniture
Flavor & Fragrances**

National Security

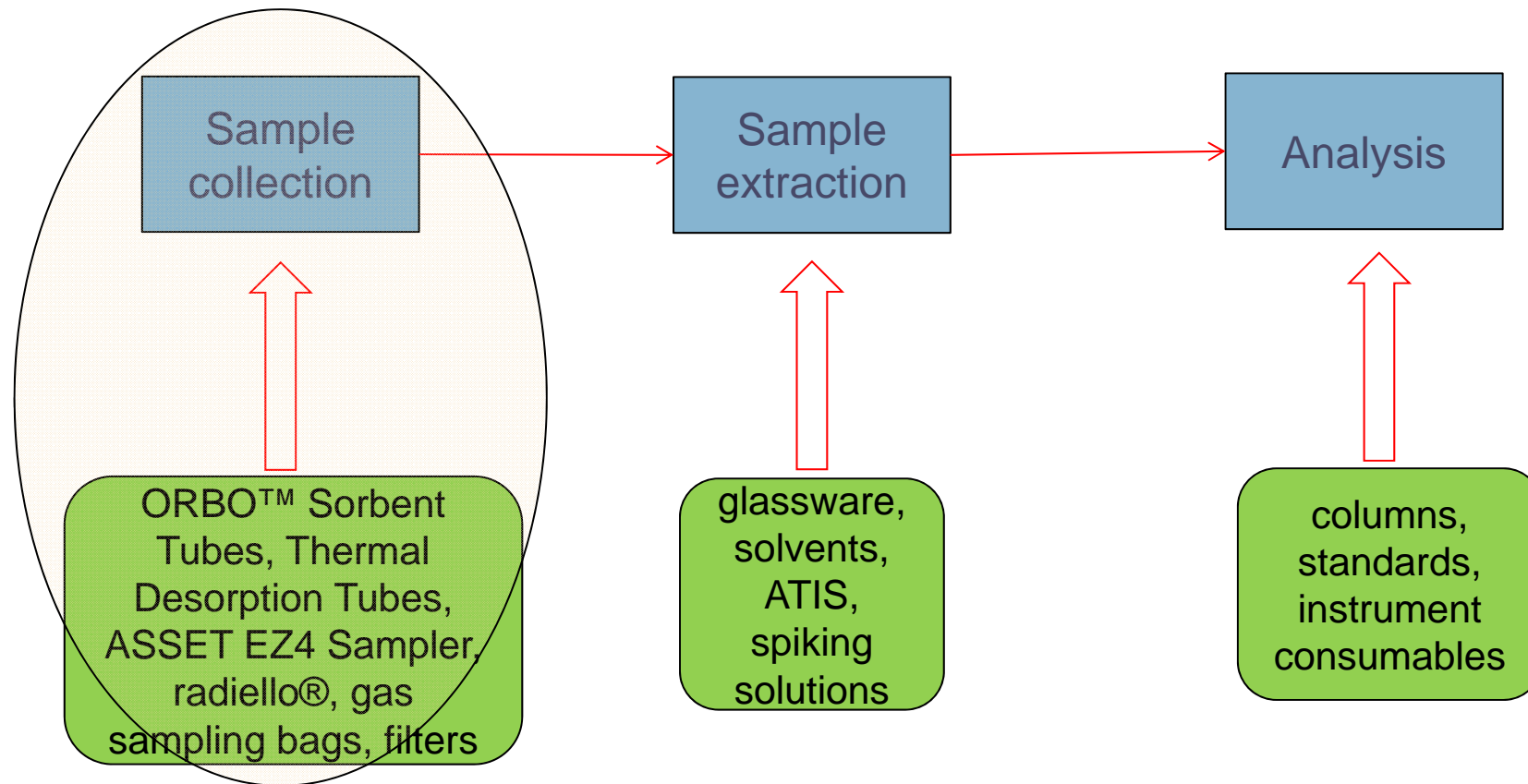
**Chemical Agents
Explosives
Airport Screening - TSA**

Healthcare

**Anesthetic Gases
Cancer Screening**



Air Sampling Workflow





Commonly Sampled Air Contaminants

Ambient Air

- Particulates
- BTEX/VOCs
- Pesticides, PAHs, PCBs
- Ozone
- Carbonyls
- Carbon Monoxide
- Nitrogen Dioxide
- Sulfur Dioxide
- Lead

Indoor Air / Industrial Hygiene

- BTEX/VOCs
- Carbonyls
- Hydrogen sulfide
- Isocyanates – TDI, MDI, HDI
- Acid vapors
- Metals – Lead, Cadmium, Hexavalent Chromium

There are over 400 sampled contaminants



What are we sampling (people or places)?

Personal Sampling

What concentration are people exposed to?

- Sampled taken in the breathing zone.



Area Sampling

What is the concentration in the air?

- Fence line monitoring
- Evaluating engineering controls
- Smoke Stacks





How long to sample?

Grab Sampling

- ~1-minute

STEL Sampling (Short-term exposure limit)

- 15-minute exposure

TWA Sampling (Time weighted average)

- 8-hour exposure (typical personal sampling time)

Risk Assessment

- 24-hour

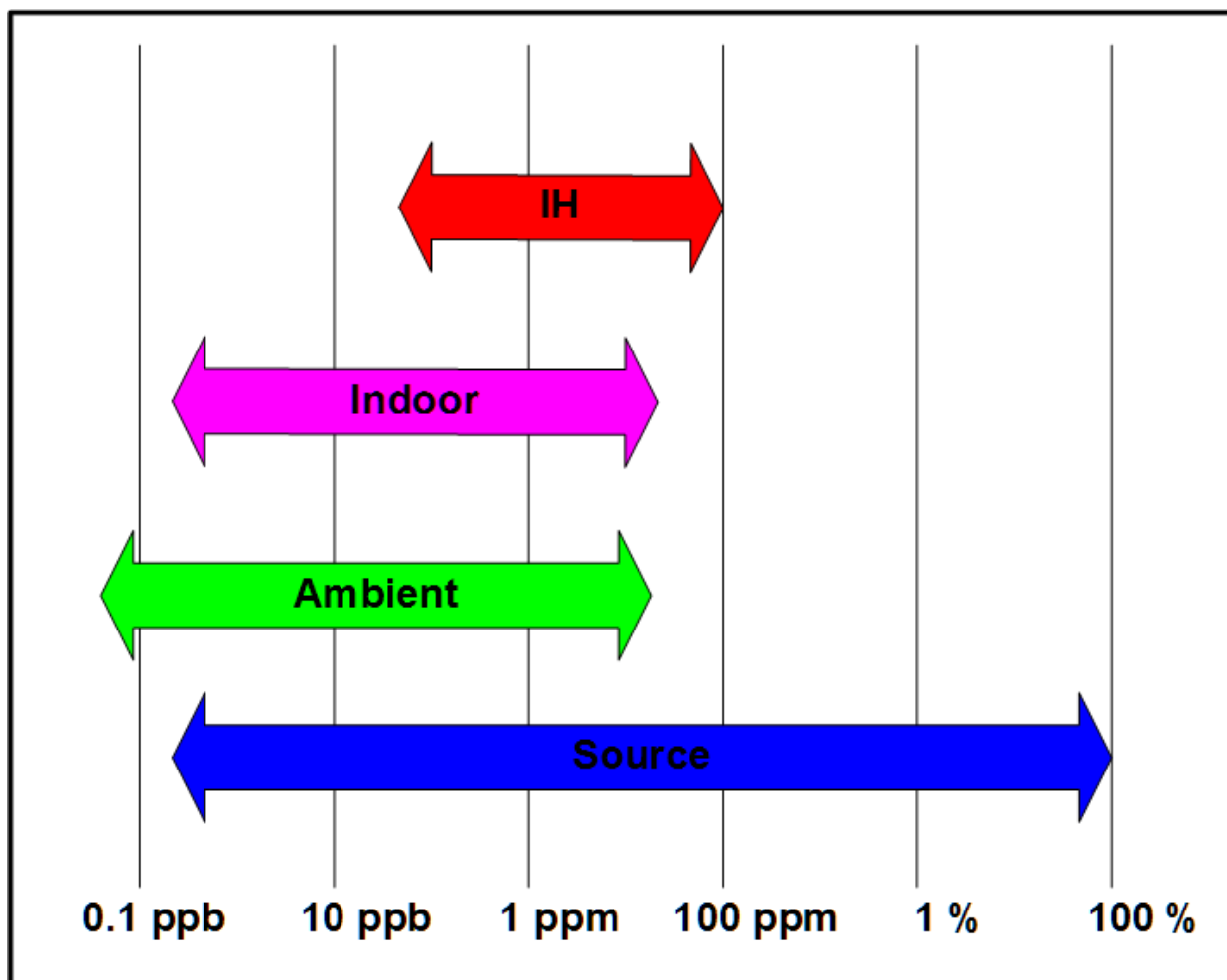
Real Time

- continuous sampling





Typical Concentrations of Various Sources





Air Sampling - The 3 Factors

When taking air samples - there are three factors in determining the concentration:

- **Sampling Rate**
 - Active Samplers – Requires a pump to control the flow rate
 - Passive Sampler – Design of the sampler dictates the flow rate “it’s fixed” by diffusion
- **Sampling Time**
 - How long of a sample do we need?
- **Sample Volume**
 - The **sample volume** is calculated by multiplying the flow rate x sampling time:

$$\text{Flow Rate} \times \text{Sampling Time} = \text{Sample Volume}$$

Note: sample volume is dependent on the temperature and pressure during sampling, so correction is normally required.



What Hazards (Analytes) are we Sampling

Gases and Vapor – typically need to be adsorbed using a adsorbent, such as Charcoal, Silica Gel, Porous Polymer, or Synthetic Carbons

Reactive analytes like aldehydes, and isocyanates need to be derivatized to stabilize them until they can be analyzed.

You can't see these...

Aerosols and Particles – typically are trapped using a filter media, or liquid media



You can see these...



What Analytes are we Sampling

Gases and Vapor – typically need to be adsorbed using a adsorbent, such as charcoal, silica gel, porous polymer, or synthetic carbons

Reactive analytes like carbonyls such as formaldehyde, and isocyanates need to be derivatized into stabilize analytes until they can be analyzed.

Aerosols and Particles – typically are trapped using a filter media, or Liquid Media



How to take the Air Samples

Passive Sampling

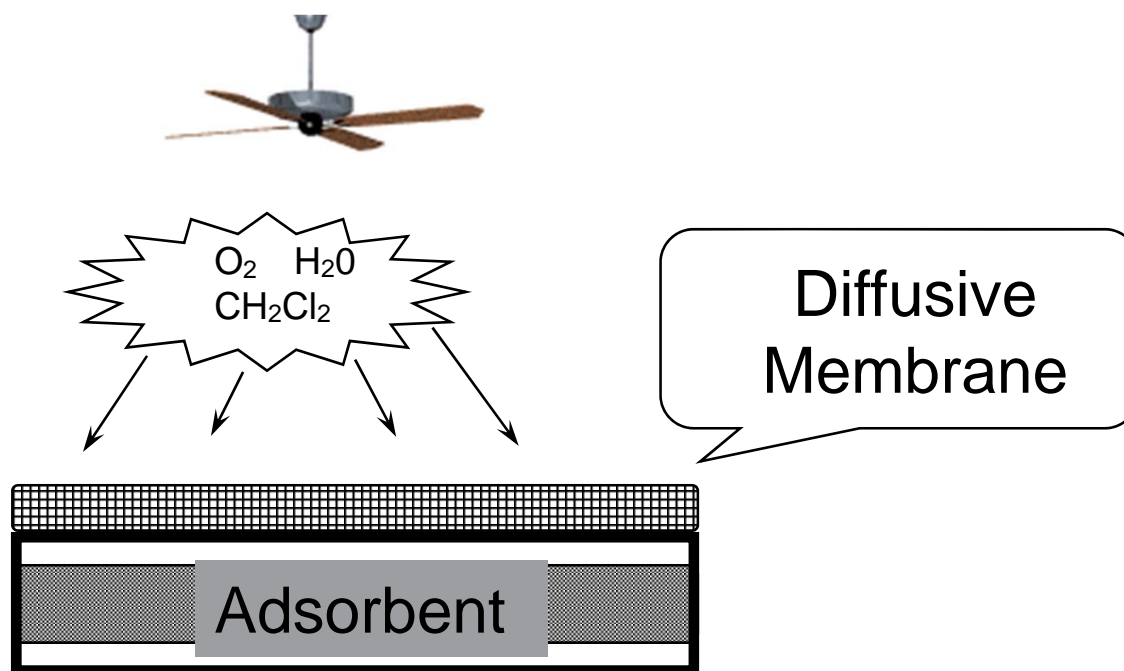
- *also called Diffusive Sampling*
- *Relies on the natural diffusion of analytes through the sampler*

Active Sampling

- *also called Pumped Sampling*
- *Relies on physically pulling the analytes through the sampler*
- Requires an air sampling pump
- Concentrating the analytes on some sort of media (adsorbents, or filters)

What is Passive Sampling?

The contaminated air enters the device by diffusing onto the adsorbent media inside the device. The analytes in the air are concentrated on to the media. The mass uptake of the monitor is controlled by the design of the device that surrounds the adsorbent media





Environmental

Passive Sampling

Radiello

- BTEX/VOC's (SD & TD)
- Aldehydes
- Ammonia
- Anesthetic Gases & Vapors
- Hydrochloric Acid (HCl)
- Hydrofluoric Acid (HF), Nitrogen Dioxide (NO₂), Sulfur Dioxide (SO₂)
- 1,3-Butadiene & Isoprene



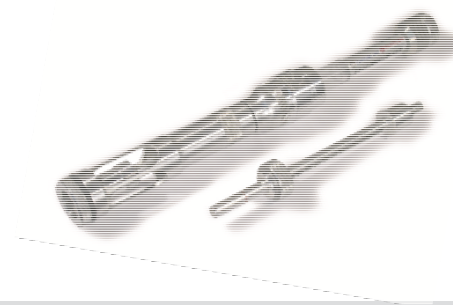
Thermal Desorption Tubes w/Diffusion Caps

- Any single bed Thermal Desorption tube
- Compound diffusion rates will need to be determined by the investigator



SPME

- Time-Weighted Average (TWA)

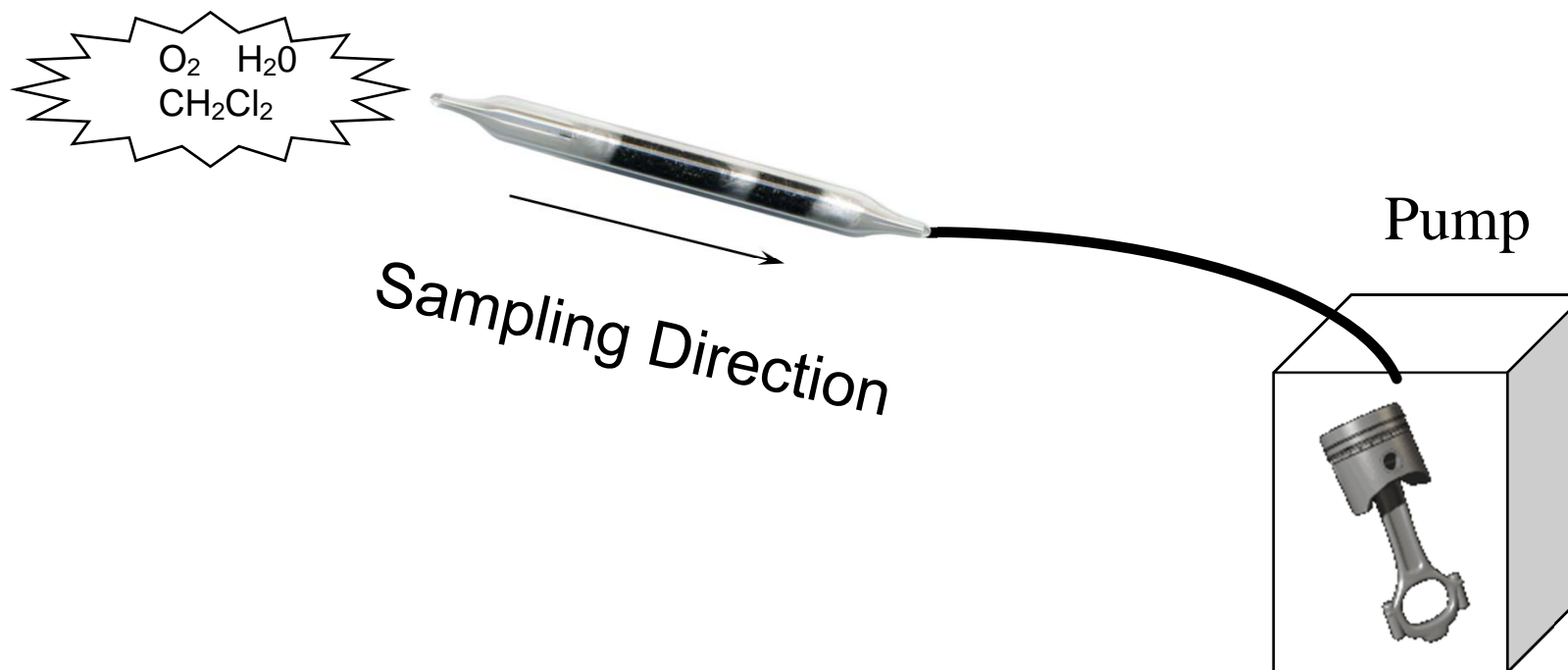




Active Sampling

Is performed by pulling air (vacuum) through the sampling media using an air sampling pump.

The chemicals in the air are concentrated on the adsorbent media.





Environmental

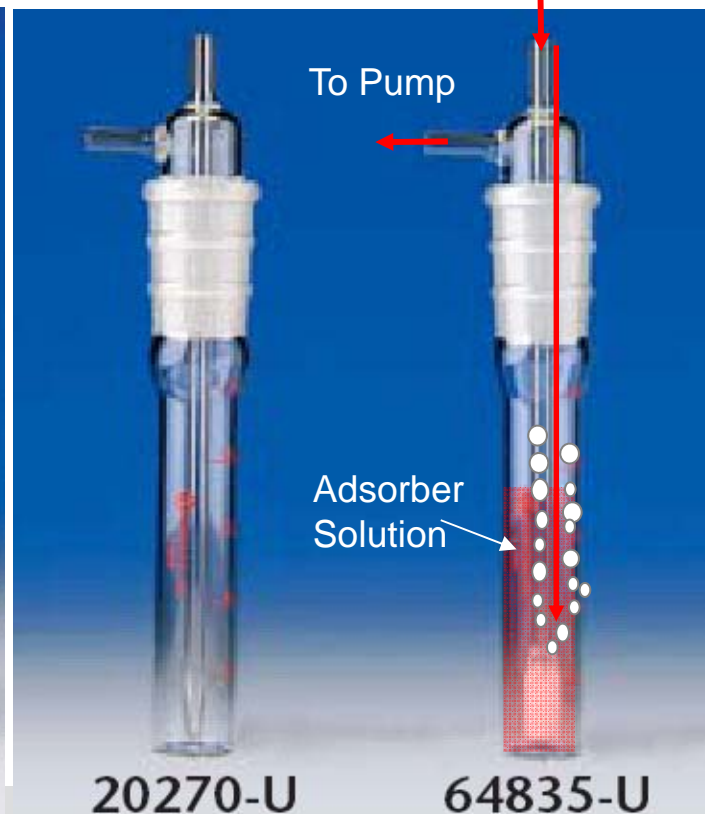
Solution Sampling: Impinger & Bubbler

Impinger → Small Hole in Glass Tip - Used to sample aerosols and particles

Bubbler → Fritted Glass – Used to sample gases and vapors

Impinger

Bubbler





Filters & Cassettes

Used for sampling particles (dust) and aerosols

Different filter materials are available

- PVC, Cellulose ester, PTFE, Glass Fiber



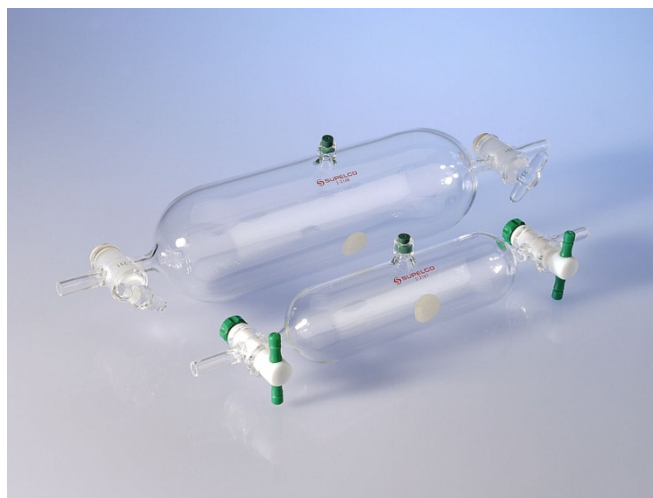


Whole Air Samplers

Whole air samplers do not concentrate the sample, the air is included with the sample.

If the sample needs to be concentrated - it is done in the lab

- Used to sample compounds that can not be trapped or concentrated
 - Methane, Carbon Monoxide



Whole Air Sampling Products

Gas Sampling Bags

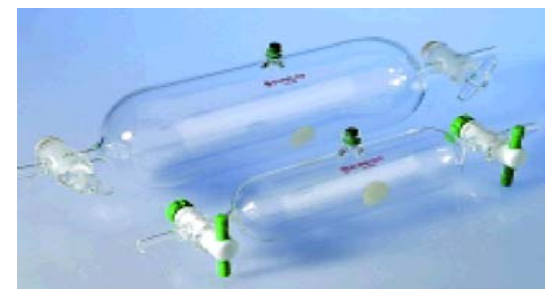
- Tedlar® Film
- Supel™ Inert Film – 2 valves; 5 sizes
- Supel™ Inert Foil – 2 valves; 4 sizes



Glass Sampling Bulbs

Used as alternatives to gas sampling bags

- 2 Stopcock types: Glass & PTFE
- 4 Sizes: 125 mL, 250 mL, 500 mL, 1 L



Bag Samplers (Negative Pressure Pump)

- 4 models available
- Battery charges are a separate purchase





Gas Sampling Bags



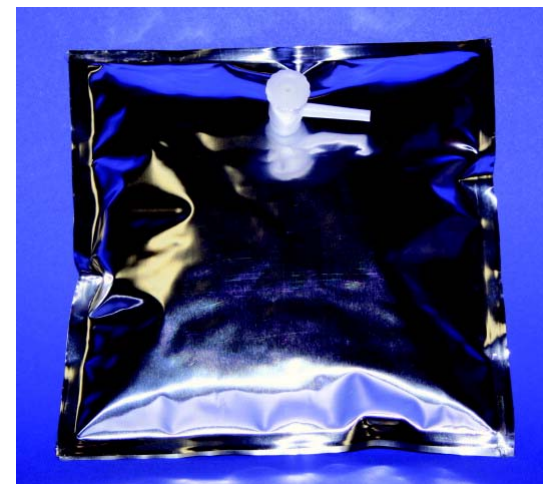
Supel-Inert Film
VOCs; Tedlar Alternative Film



Screw-Cap Valve



Push-Lock Valve



Supel-Inert Foil
Light & Permanent Gases

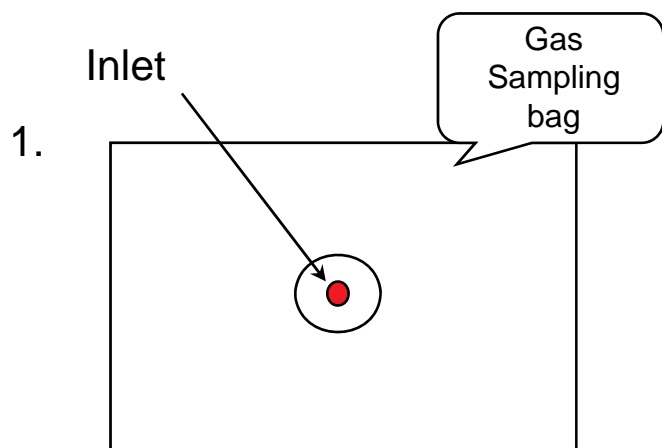
Example uses:

- VOCs – EPA TO-14A/15; TO-17
- Carbon Dioxide
- Carbon Monoxide
- Making Calibration Mixes

Note: Other products can be used in conjunction w/ gas sampling bags to analyze the captured air sample.



Air Sampling Bag Technique



VOC's along with the air are collected in the bag. Typically the bag is filled by the exhaust port of an air sampling pump.

Typical flow rates: 10-1000mL/min



A portion of the gas sample is injected into a Gas Chromatography system using Gas-Tight Syringe (Typically 1-500uL) or other sample prep method – ORBO, TDU, etc

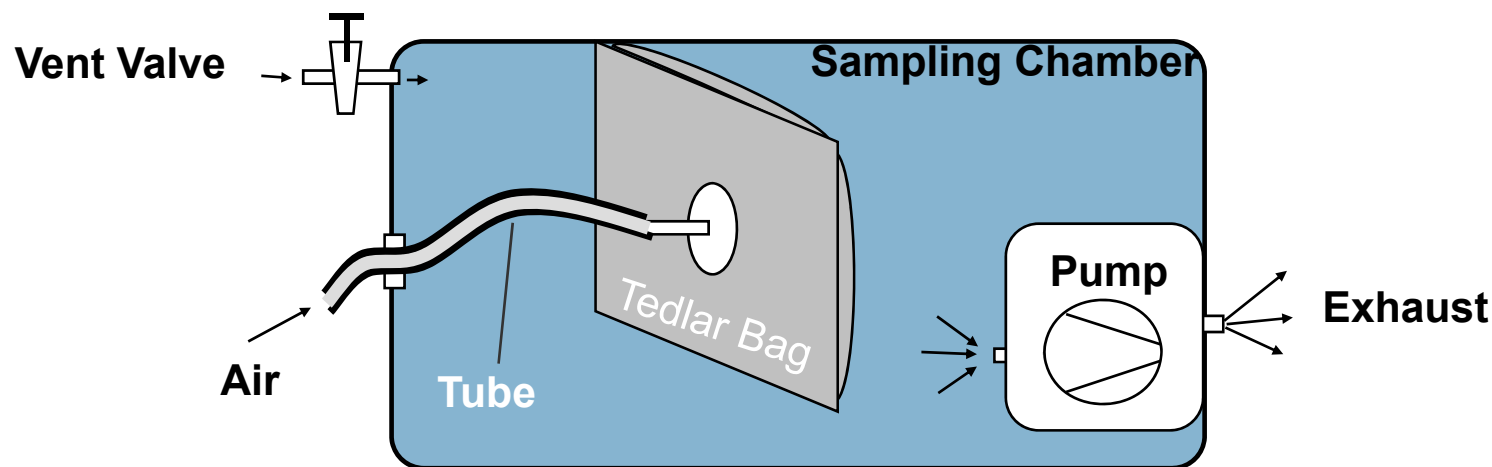


Bag Sampler (sometimes called a Lung Sampler)

The internal pump creates a vacuum inside the box, this creates a negative pressure that causes air to rush into the bag to equalize the pressure in the box.

Advantages of using a Bag Sampler:

- Sample is not exposed to the pump parts
 - Prevents contaminating the pump
 - Compounds do not get stuck in the pump





Environmental

Adsorbent Tubes (Active Samplers)

Solvent Desorption Tubes

- ORBO Tubes (Supelco's Trade name)
- Over 75 configurations available
 - Charcoal
 - Carbons
 - Silica Gel
 - Porous Polymers
 - Coated Adsorbents

Thermal Desorption Tubes

- TD Tubes (Carbotrap-XXX Trade name)
- Single Bed Tubes
- Multi-Bed Tubes



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Types of Solvent Desorption Products

Adsorption

Common Adsorbents:

- Charcoal
- Silica Gel
- FLORISIL®
- Amberlite® XAD® - 2, 4, 7, 8
- Carbotrap™, Carbopack™
- Carbosieve™ SIII, Carboxen™
- Filter media – Glass Fiber Filter, Mixed cellulose ester (MCE), Quartz, PTFE

- Commonly analyzed by GC-FID or GC-MS

Derivatization

- Agents coated on an adsorbent such as:
 - Silica gel
 - Amberlite XAD
 - FLORISIL
 - Filter media
- Used for sampling reactive compounds:
 - Formaldehyde
 - Isocyanates
 - Ozone

Common Agents:

2,4-Dinitrophenylhydrazine (DNPH) on Silica Gel

2-(Hydroxymethyl)piperdine (HMP) on Supelpak™20

- Commonly analyzed by HPLC-UV or HPLC-MS



Environmental

ORBO - Solvent Desorption Tubes

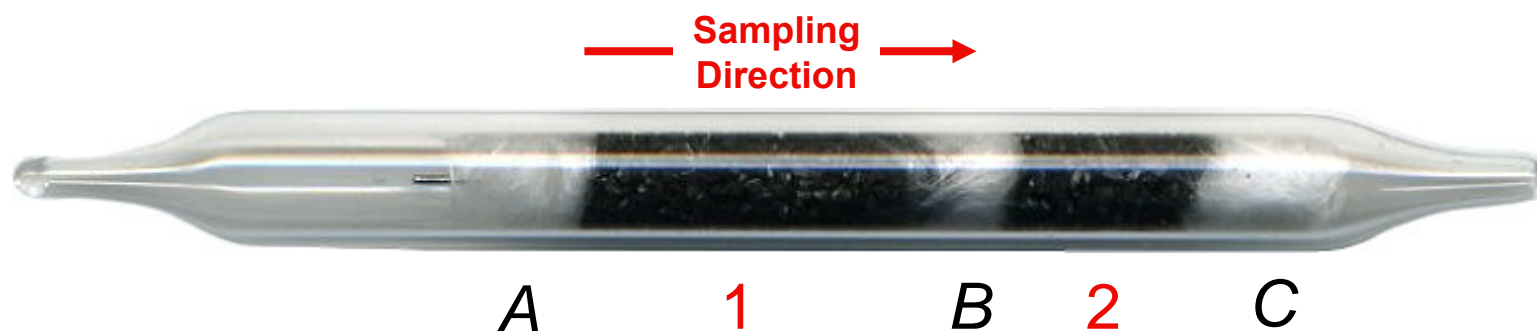
The design and recipe of the tubes are normally from OSHA & NIOSH methods

Typically packed with two beds of the same adsorbent

- Ratio 2:1. The smaller bed is used to test for breakthrough.

Flamed sealed to keep the adsorbent clean

- Before use, the user breaks the glass tips off using a special tool



1 – Primary Bed 2 – Back-up Bed

A,B,C – Plugs (Glass Wool or PUF)

Single use product – the tube is broken to remove the adsorbents for analysis.



ORBO - Solvent Desorption Tubes

Sampling

- Tips of tubes are broke off
- Tube is connected to a sampling pump and the flow rate is adjusted.
- After sampling –caps are placed on the tubes until they are analyzed.

Work up

- The adsorbents are removed from the tube
 - Each adsorbent bed is placed in a separated vial
 - Typically the glass wool plugs are discarded
- Solvent is added to the vials (carbon disulfide is popular)
- Vials are sonicated for ~ 30 minutes
- An aliquot is removed and injected into a chromatographic system for analysis

Note:

Break-through has occurred - If analyte is detected in the back-up bed





Environmental

Ultra-clean Polyurethane Foam (PUF) Samplers for Pesticides, PAHs, PCBs and Dioxins in Air

Polyurethane Foam



Large PUF Methods (ORBO-2000/2500)

ASTM D6209 PAHs Pesticides/PCBs
EPA IP-7 PAHs
EPA TO-4A Pesticides/PCBs/Dioxins
EPA TO-9A Dioxins
EPA TO-13 PAHs

Small PUF Methods (ORBO-1000/1500)

ASTM D4861 Pesticides/PCBs
ASTM D4947 Chlordane/Heptachlor
EPA IP-8 Pesticides/PCBs
EPA TO-10A Pesticides/PCBs



Coated Adsorbents

Why?

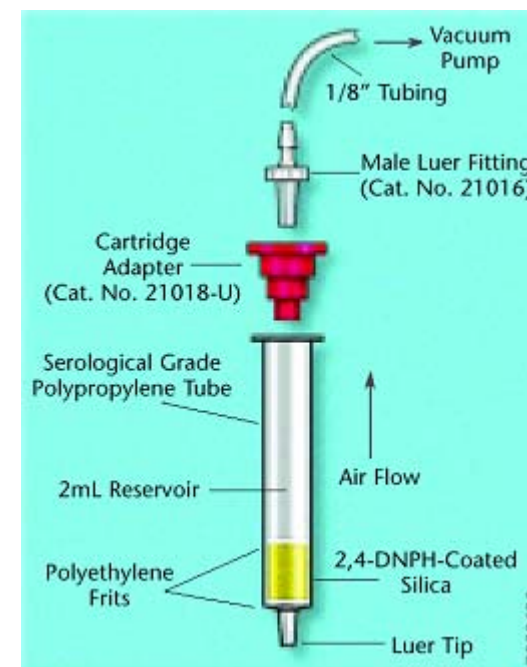
- Converts (i.e., derivatizes) reactive analytes into a less volatile derivatives, making them more stable
- Typically the derivatives also increases the detectors response – resulting in better sensitivity
- Our most popular coated sampler
 - LpDNPH Cartridges for Aldehydes and Ketones



Rezorian



How to connect?





Thermal Desorption What is it?

A sample preparation technique used with gas chromatography

The sample is collected onto one or more adsorbents packed inside a glass or, stainless steel tube.

- The packed tube is heated (**Thermal**) and the compounds are released into the carrier gas (**Desorption**) where they are swept onto the GC column and analyzed by the gas chromatograph.





What is Thermal Desorption?

Thermal Desorption Tube can be used to collect volatile organic analytes, which can be analyzed by gas chromatography

Can not be used to sample:

- Analytes that require derivatization before analysis
- Analytes sensitive to thermal degradation
- Analytes larger than $>n-C_{40}$



Thermal Desorption Tubes

Requires a thermal desorption instrument for analysis

Tubes are available in Glass and Stainless Steel

- Glass is more inert, can visually see the integrity of the packing
- Stainless Steel - more durable- will not break

Reusable ~100 times

Single and Multi-beds tubes available

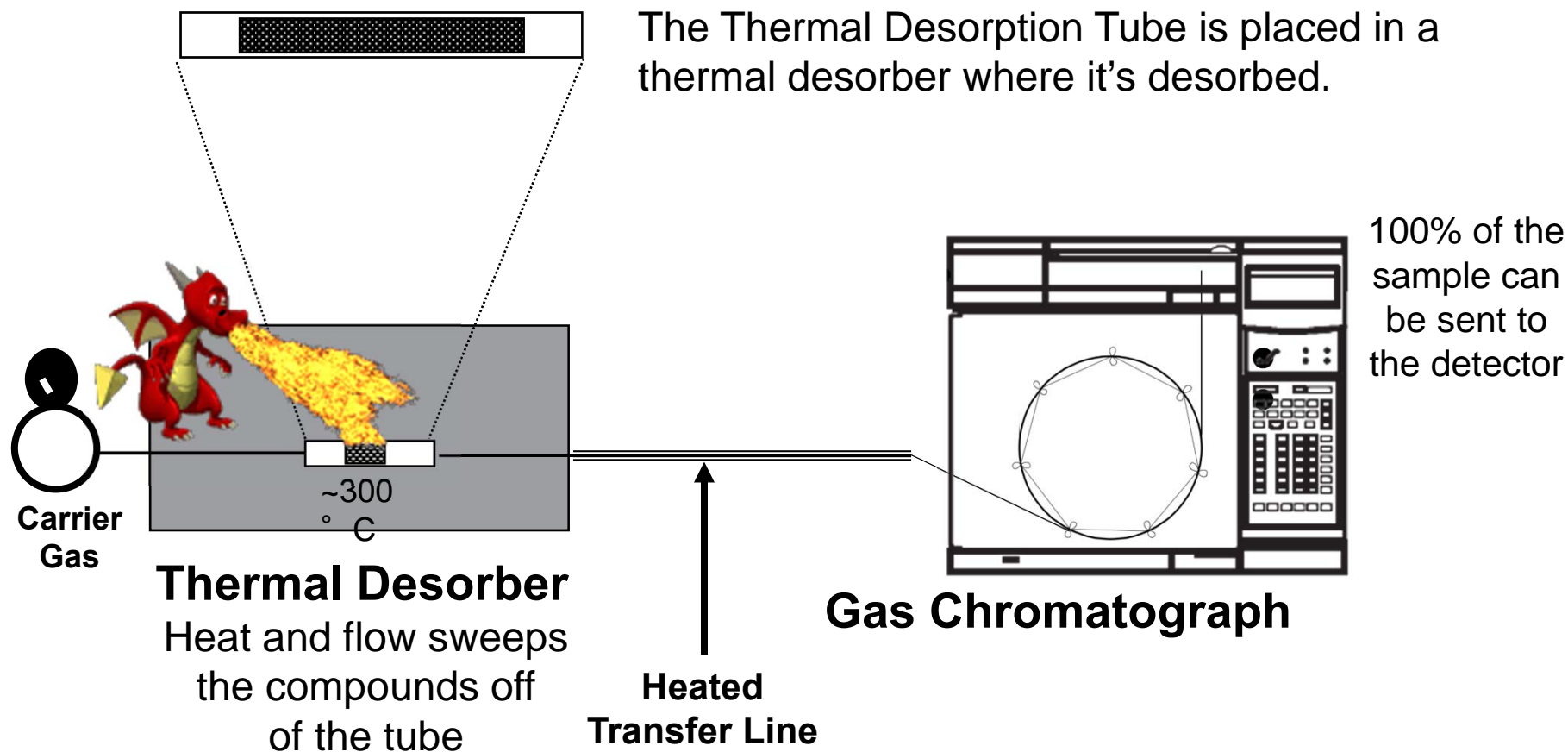


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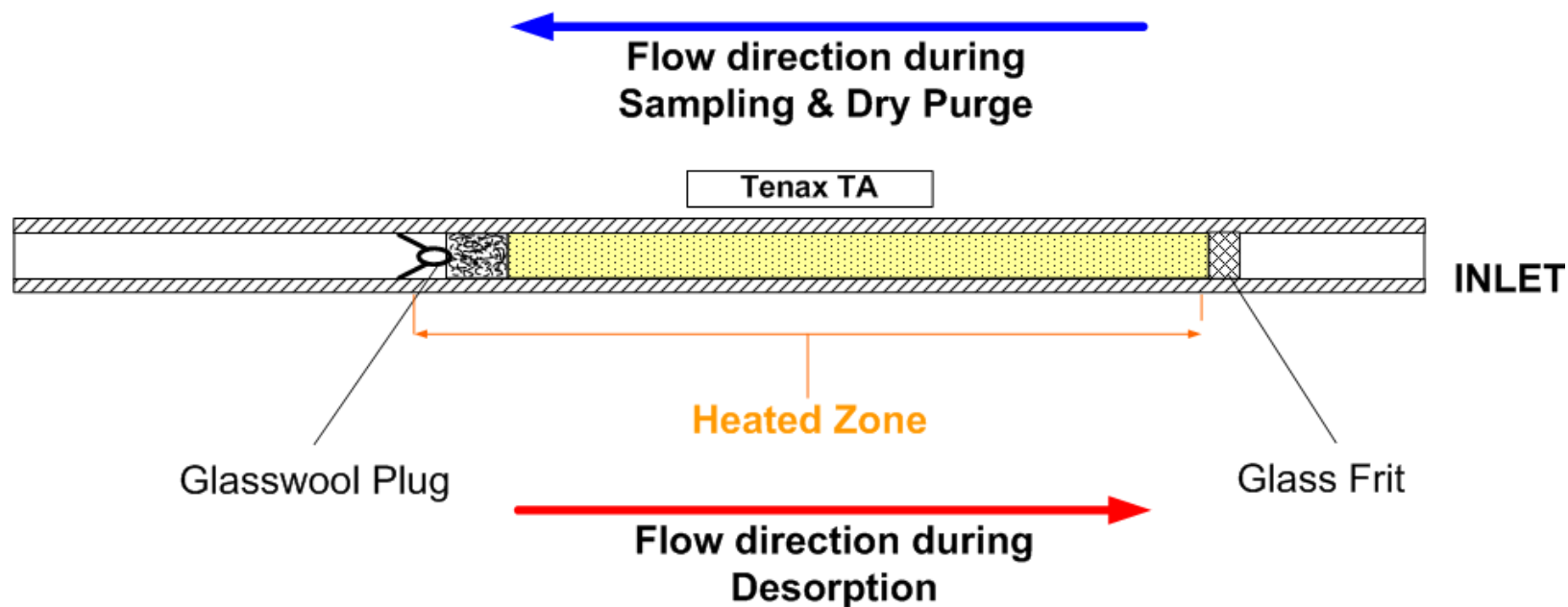
Thermal Desorption – How it Works ?





Single-Bed - Thermal Desorption Tube

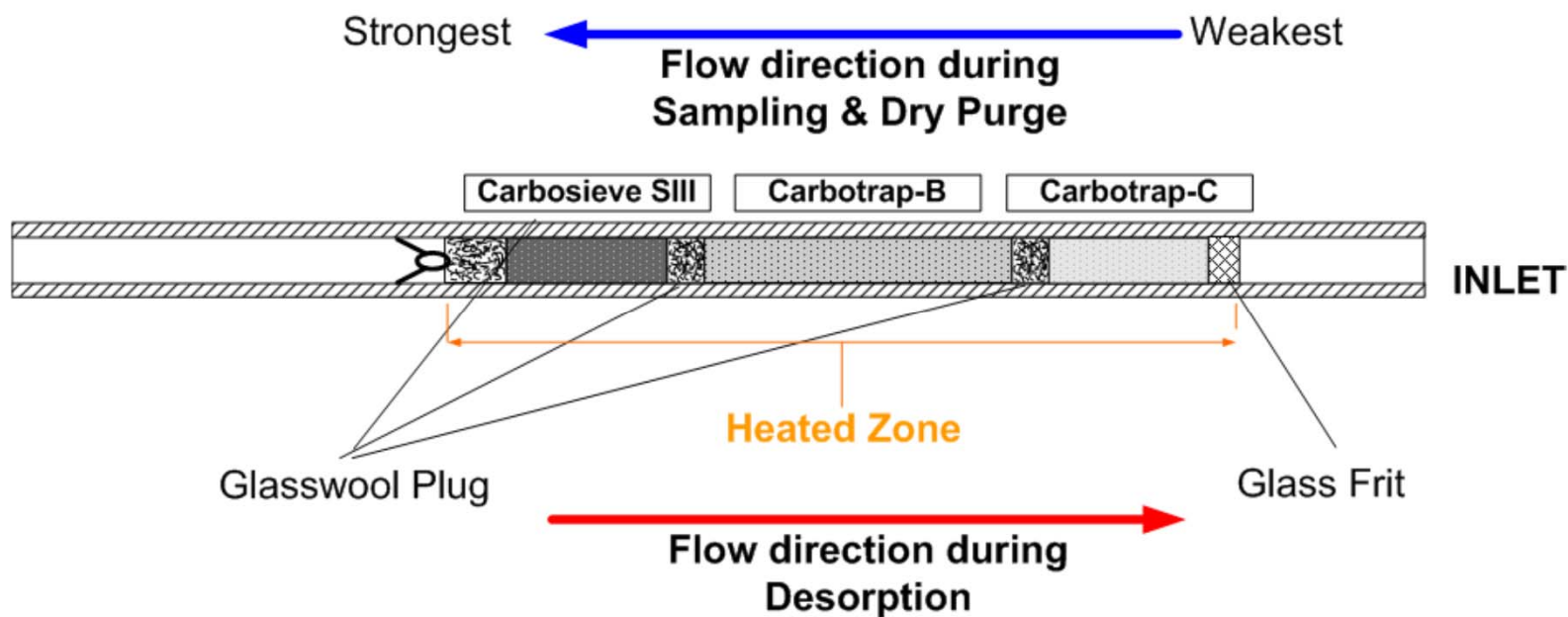
Typical 1-Bed Tube (Tenax TA)





Multi-Bed - Thermal Desorption Tube

Typical 3-Bed Tube (Carbotrap 300)





Advantages / Disadvantages of Thermal Desorption

Advantages

- Wide range of compounds can be analyzed at one time
- Detection limits increased 1000 times - compared to solvent desorption
- No desorbing solvent required
- Tubes are reusable

Disadvantages

- Only one analysis per sample (typical)
- Initial investment of a thermal desorber
- Tubes are not interchangeable between all instrument brands



Typical Adsorbents used for Thermal Desorption

- Tenax TA (2,6-diphenyl-p-phenylene oxide)
- Graphitized Carbon Blacks (GCB)
 - Non porous
 - Names: **Carbopack**, **Carbotrap**
 - Various types available
- Carbon Molecular Sieves (CMS)
 - Porous
 - Names: **Carboxen**, **Carbosieve**
 - Various types available
- Glass beads
 - Used to retain large molecular weight volatiles

Key Expertise of Supelco !!



A Tool for Selecting an Adsorbent(s) for Thermal Desorption Applications

Carbon adsorbent sampler kits





Environmental

Thermal Desorption Tube Offering by Manufacturer

Tube Dimension

3.5"x1/4" (89 x 6.3mm)

PerkinElmer (ATD-400, TurboMatrix)

Shimadzu (TD-20)

DANI (Master TD)

Markes (Unity)

Other Dimensions

Gerstel (TDS2 & TDS A)

CDS/Dynatherm (850 & 890, ACEM-900)

Teledyne Tekmar (AEROTrap 6000)

PerkinElmer

ATD-400



TurboMatrix

SHIMADZU



MARKES
international

GERSTEL



Gerstel TDS-A

TELEDYNE INSTRUMENTS
Tekmar

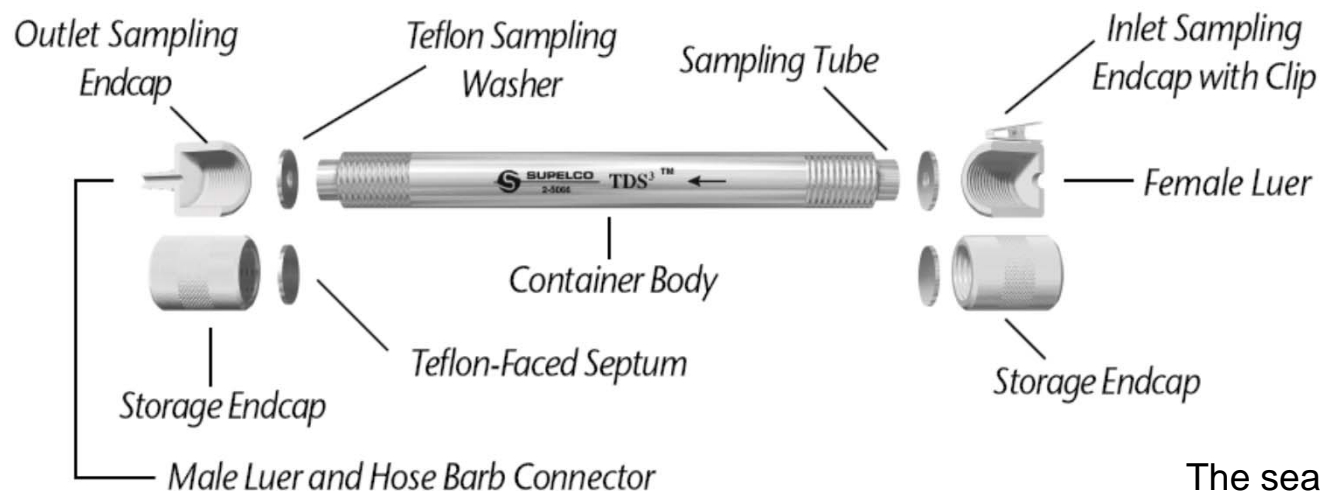


TDS³ Container

What does this mean?

Thermal **D**esorption **S**torage & **S**ampling **S**ystem

Serves two purposes --- Storage and Sampling with one device





Environmental

Application of TDS³ Containers





Environmental

Air Monitoring Accessories

ATIS



Air Sampling Pumps





Model 1067 Dual Channel Ambient Air Sampler (fenceline sampler – for area sampling)

- Flow Range 5-500mL/min per Channel
- 1/4" and 6mm OD Tubes
- Battery for 12-hour Operation
- Self-contained in a durable case
- Build-in Timer → automatic shut off





Escort® Elf – Personal Air Sampler Specifications

- Flow 0.5-3 L/min
- (with Twinport Sampler < 0.5 L/min)
- Accuracy $\pm 2.5\%$ (1-3 L/min)
- Certified Explosion-Proof

Power supply:

- 4,8V Battery
- min. 8h operation at 2.5 L/min

For tube sampling the Twin Port accessory is required

- e.g. for flows <0.5L/min





Environmental

Twin Port Sampler with 2 tube ports

2 Ports separately controlled by needle valves

- Sample 2 tubes in parallel
 - 2 different tubes
 - 2 different flows



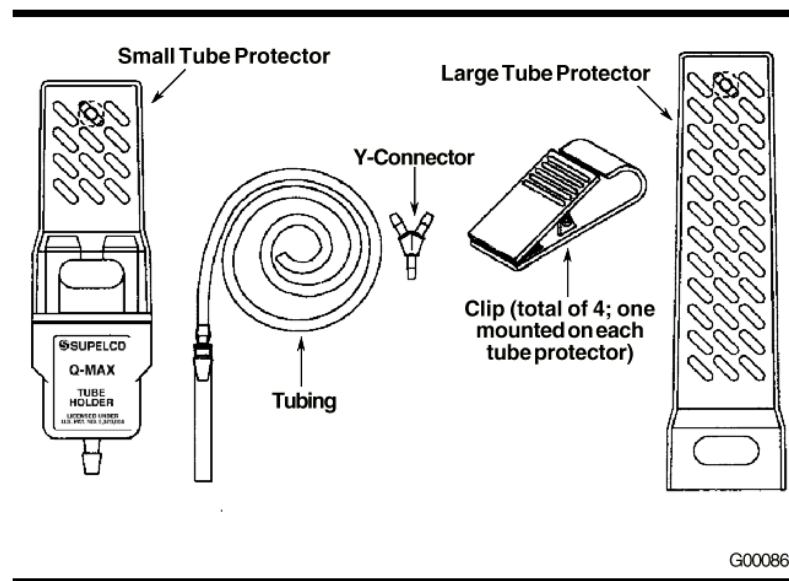
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Q-MAX Tube Holder

Tube Sampling



P000060





Environmental

Supelco Air Monitoring Literature

Passive

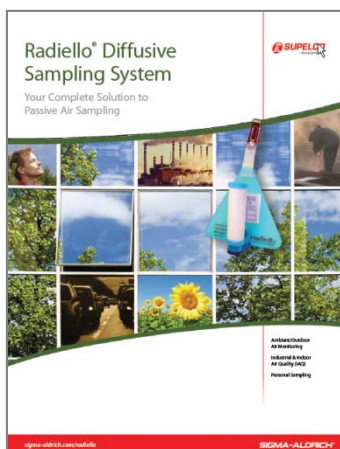
- Radiello

Active

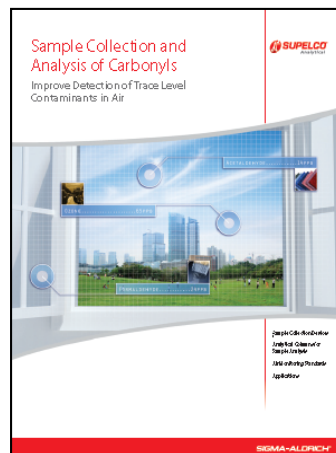
- Tubes
 - ORBO solvent desorption
 - LpDNPH cartridges
 - Thermal desorption
- Filters
- Impingers
- Gas Sampling Bags



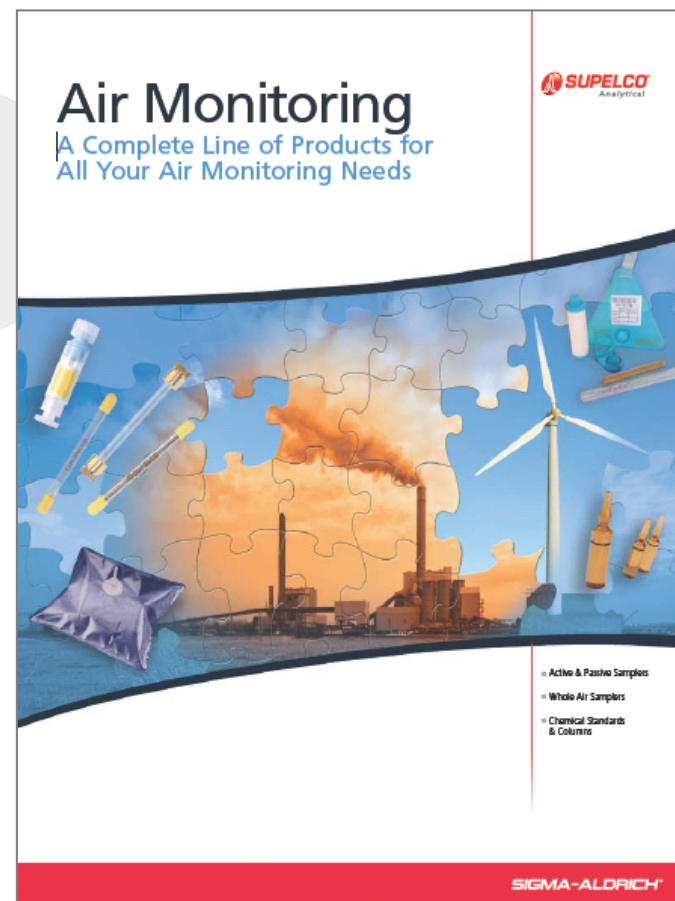
(IXW)



(IXV)



(OMZ)



(KQV)



Environmental

Sigma-Aldrich Web sites

Air Monitoring

sigma-aldrich.com/air_monitoring

Application specific

- Vapour Intrusion Monitoring
- Chinese Drywall Contamination
- Petrochemical
- Agricultural Contaminants
- Anesthetic Gases in Healthcare
- Paints & Coatings



Vapor Intrusion



Petrochemical Industry



Chinese Drywall Contamination



Anesthetic Gases in Healthcare



Agricultural Contaminants



Paints & Coatings



Environmental

**Dziękuję za
uwagę!**

