

Diffusive Sampling *in an IAQ Context*

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Indoor Air Quality (IAQ) Investigations

- IAQ vs PEL Sampling
 - Lower Air Concentrations
ppb instead of ppm
- Analytical Requirement
 - Lower Detection Limits

Diffusive vs Active Sampling

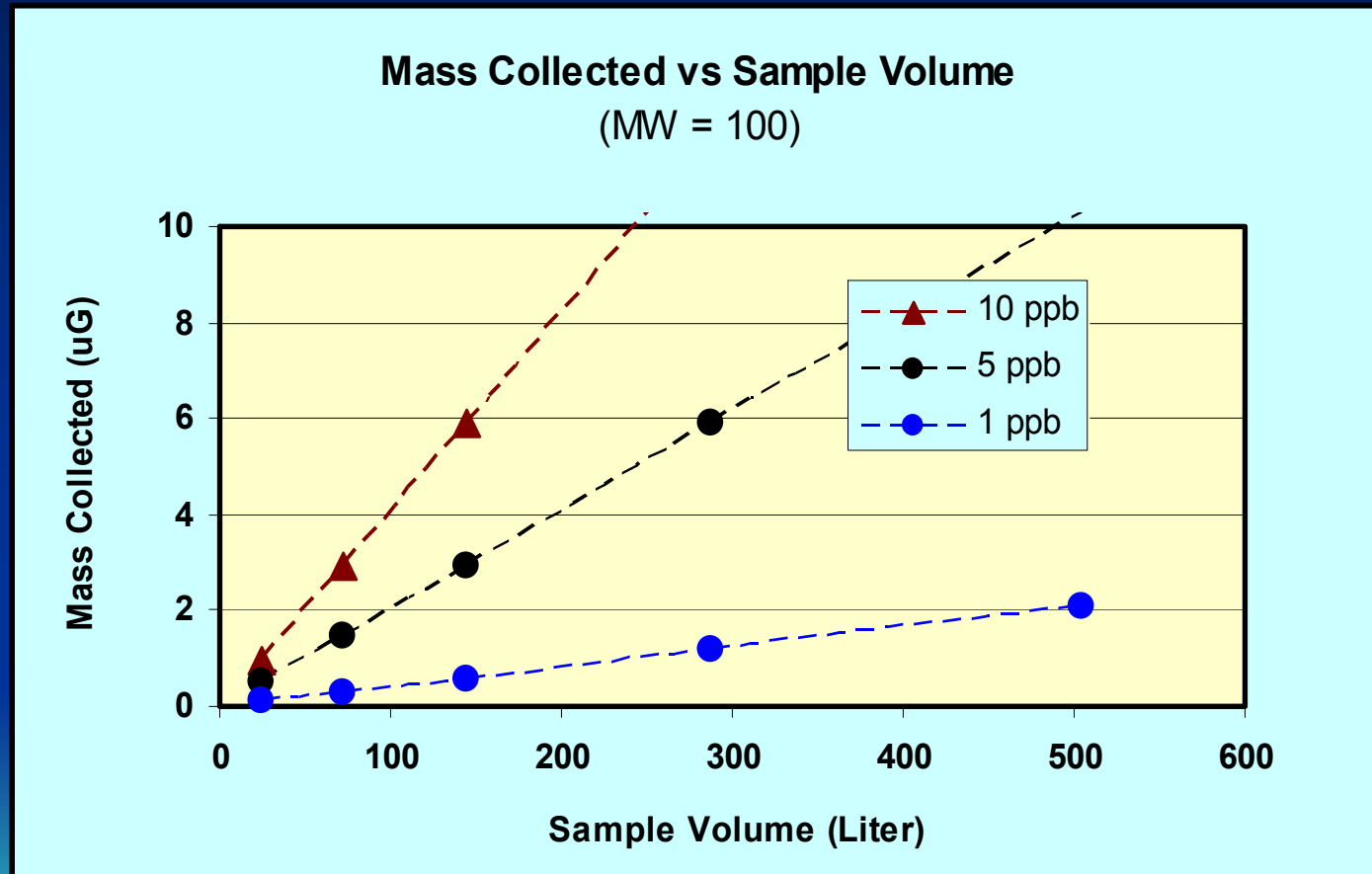
- Active Sampling Rates
 - typ. 100-500 mL/min
- Diffusive Sampling Rates
 - Typ. 10-100 mL/min

Active Sampling typically collects a larger volume of air, a larger mass of contaminant, and, consequently, has lower detection limits.

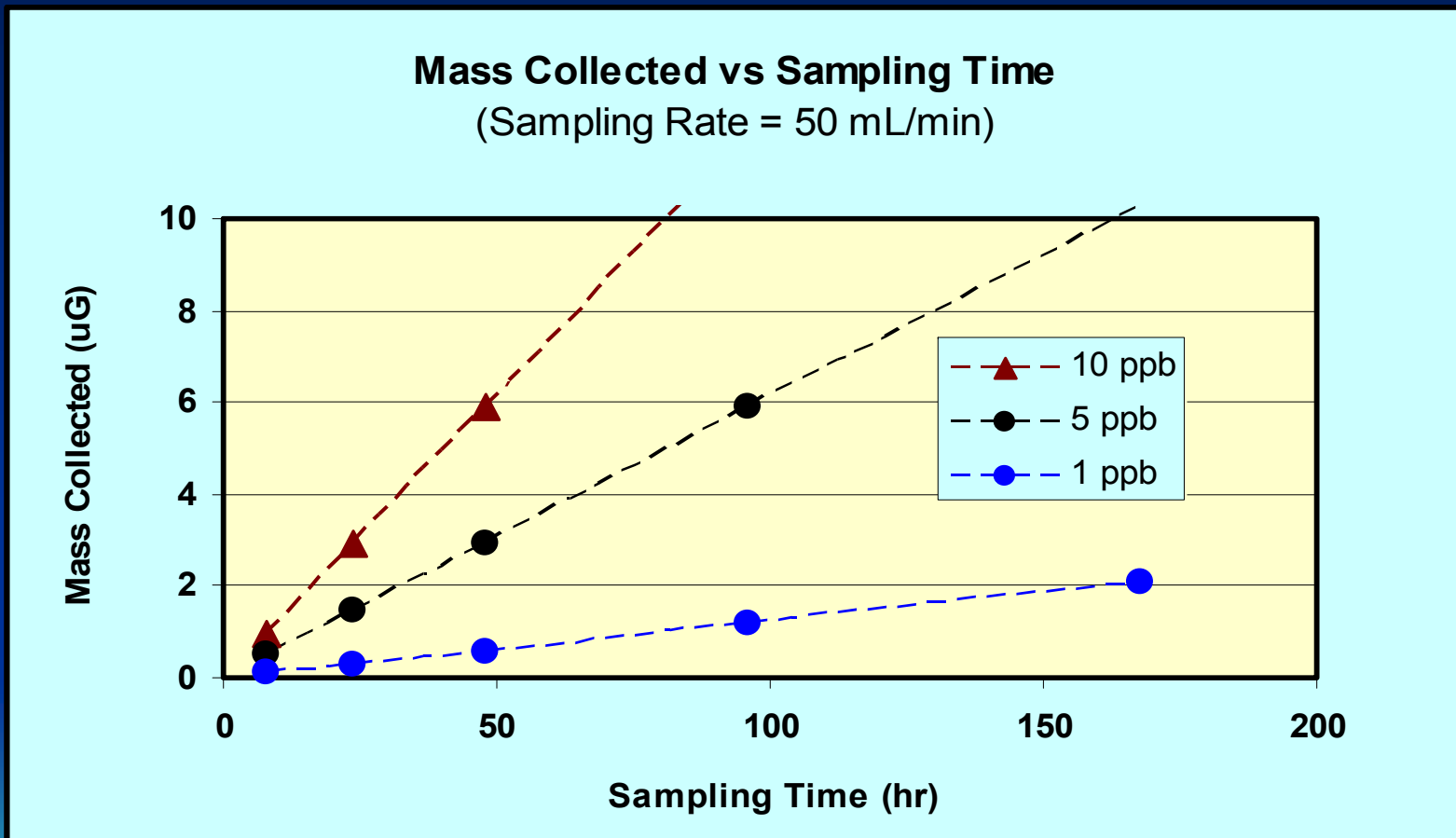
Whence Cometh Detection Limit?

- At any given Air Conc'n (ng/L), increasing the Sample Volume (L) increases the mass collected by the Sampler, and lower the effective detection limit.
- At a given Sampling Rate (L/min), Sample Volume increases as Sampling Time (min) increases.
- Detection Limit **decreases** as Sampling Time ... (hence sample Volume) **increases**.

At a given air concentration, the Air Sample Volume (Liter) determines how much mass is collected.



At a given Sampling Rate, Mass Collected increases as Sampling Time increases.



Diffusive Samplers in an IAQ Context

- Cost-Effective and Convenient
- Can Achieve Low Detection Levels
 - If you are willing to wait a bit

Short-Term vs Long-Term DIFFUSIVE SAMPLING

	SHORT-TERM SAMPLING	LONG-TERM SAMPLING
SAMPLING TIME...	15 - 600 min	1day – 1 mo.
SAMPLE VOL.....	0.1 - 20 L.	40-1000 L.
HOLDING TIME.....	1 - 3 days	1 - 6 weeks
MEASUREMENT RANGE.....	1-1000 ppm	1-1000 ppb

Long-Term Sampling

Problems to Overcome...

- STABILITY of ANALYTES on the Sampler
 - Reverse Diffusion
 - Decomposition

LONG DURATION SAMPLING

Strategies...

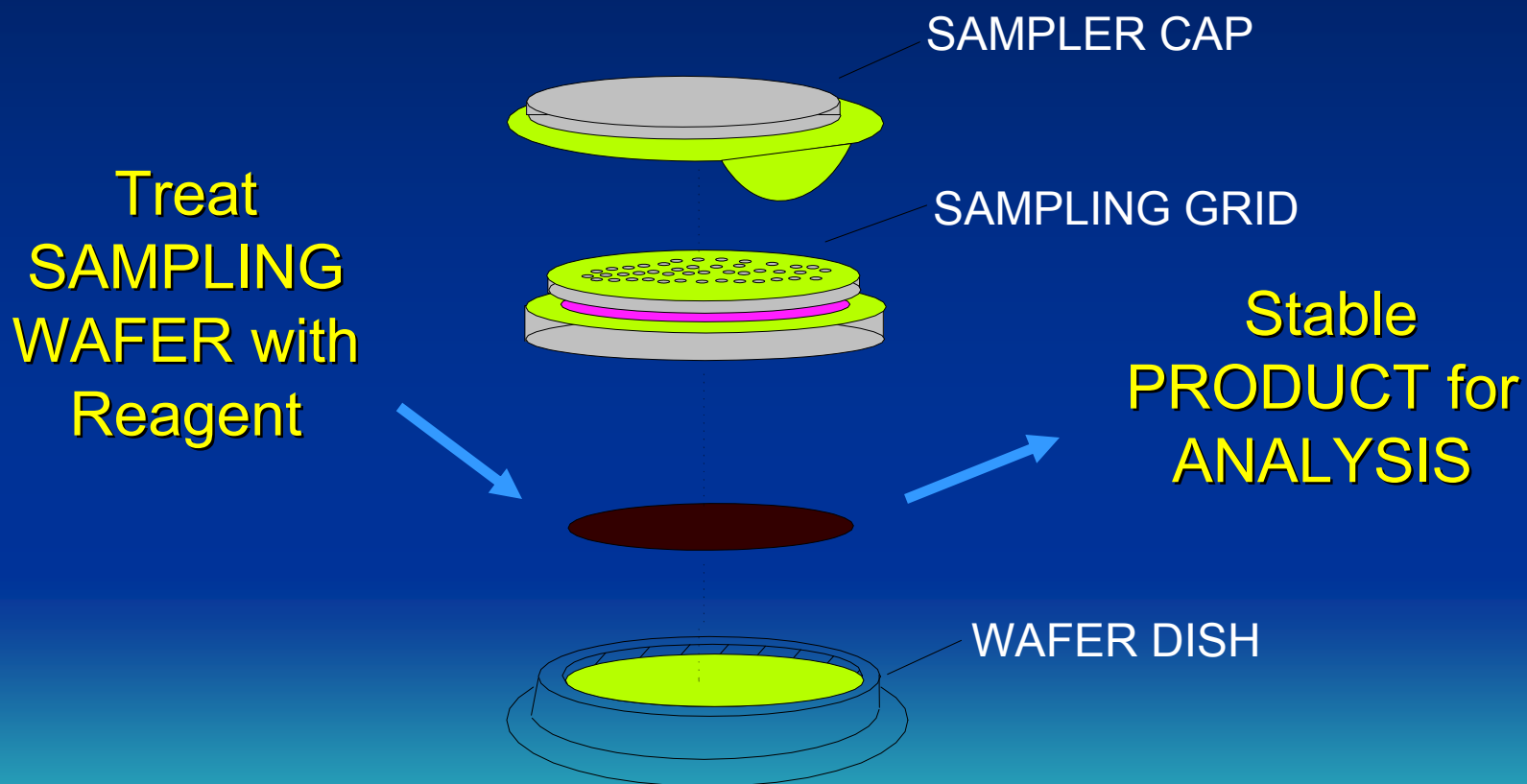
- Form STABLE DERIVATIVE with ANALYTE
 - a NON-VOLATILE form of the ANALYTE
- Reduce SAMPLING RATE
 - STAY within SAMPLE CAPACITY

LONG DURATION SAMPLING

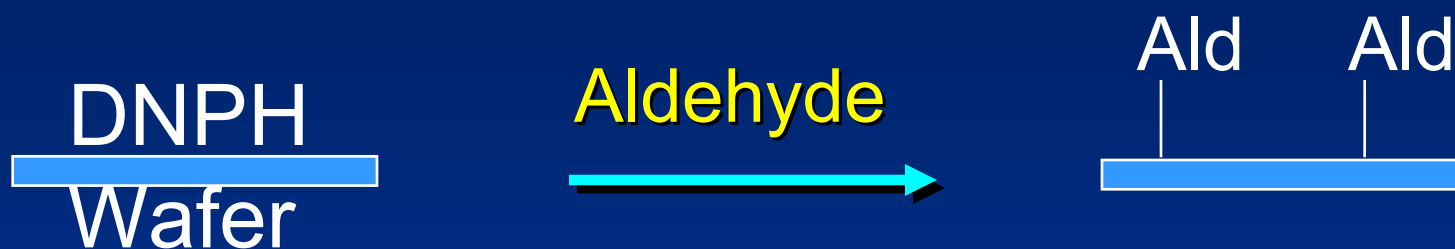
Strategies ...*for Reactive Analytes*
ALDEHYDES, AMINES, OZONE, NO₂

- FORM STABLE DERIVATIVE with ANALYTE
 - Non-Volatile Product for Analysis

Diffusive Sampler Features

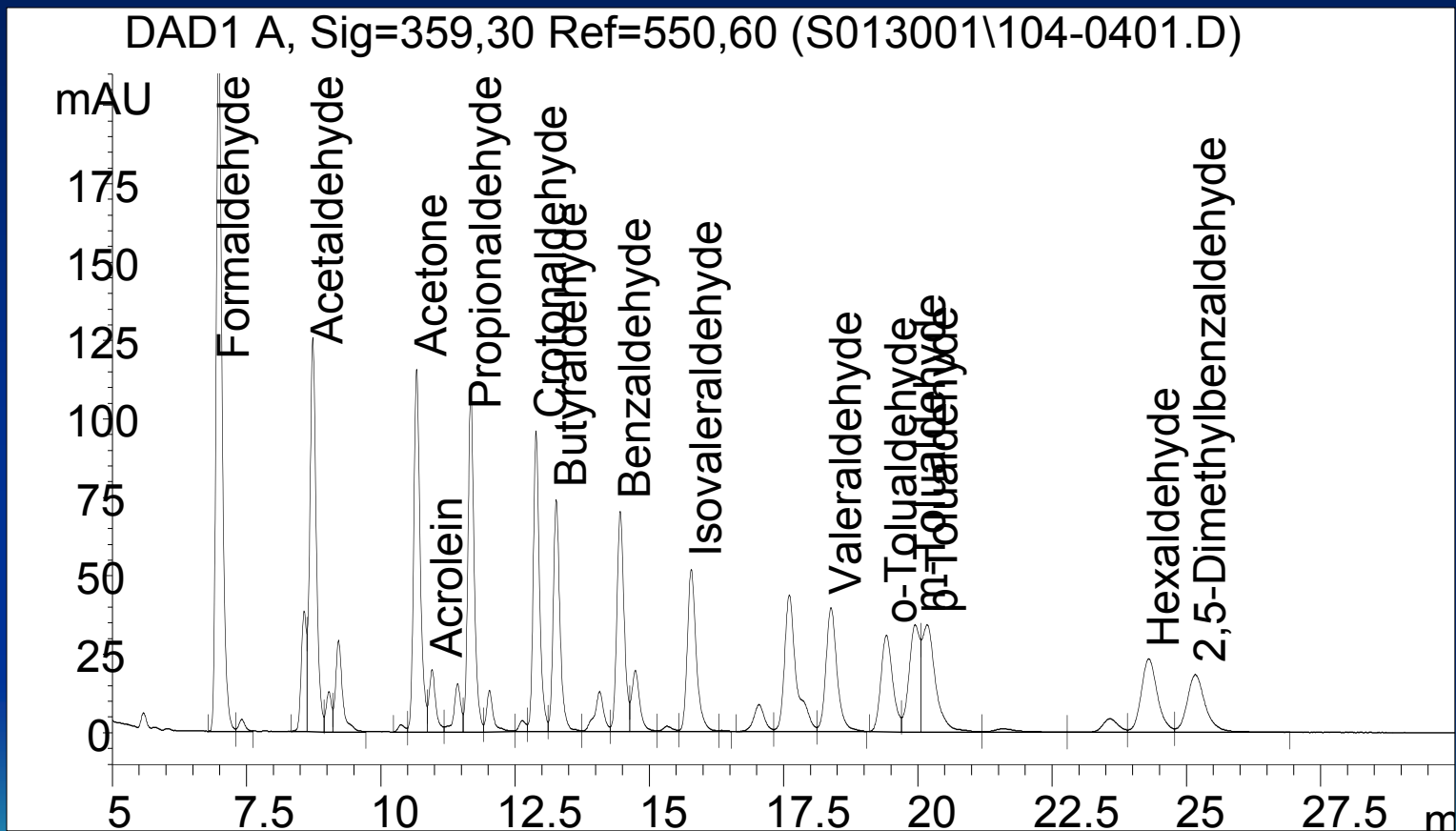


*Formation of
STABLE DERIVATIVES
on Sampler*



- Aldehyde-DNP Derivative
 - Stable Product
- HPLC Analysis

Aldehyde Scan



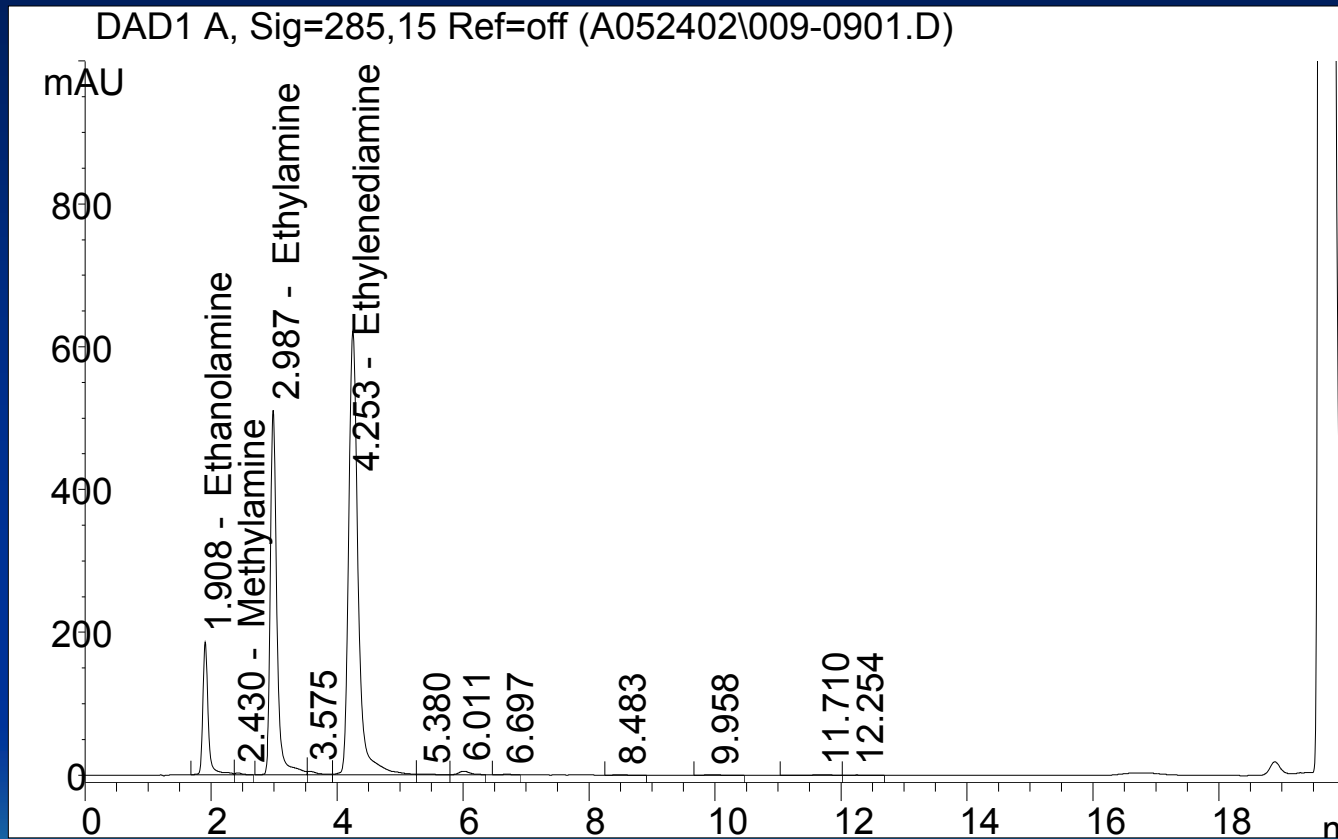
C-18 Column, 500 x 3.8 mm (3 μ M particles); Initial Mobile Phase: 30% Acetonitrile / 60% pH5 Acetate Buffer, 10% THF; gradient to 40% Buffer / 60% Acetonitrile in 11 min; 2nd gradient to 100% Acetonitrile in 20 minutes.

*Formation of
STABLE DERIVATIVES
on Sampler*



- **Amine-NIT Derivative**
 - Stable Product
- **HPLC Analysis**
 - similar to OSHA 64

Amine Scan



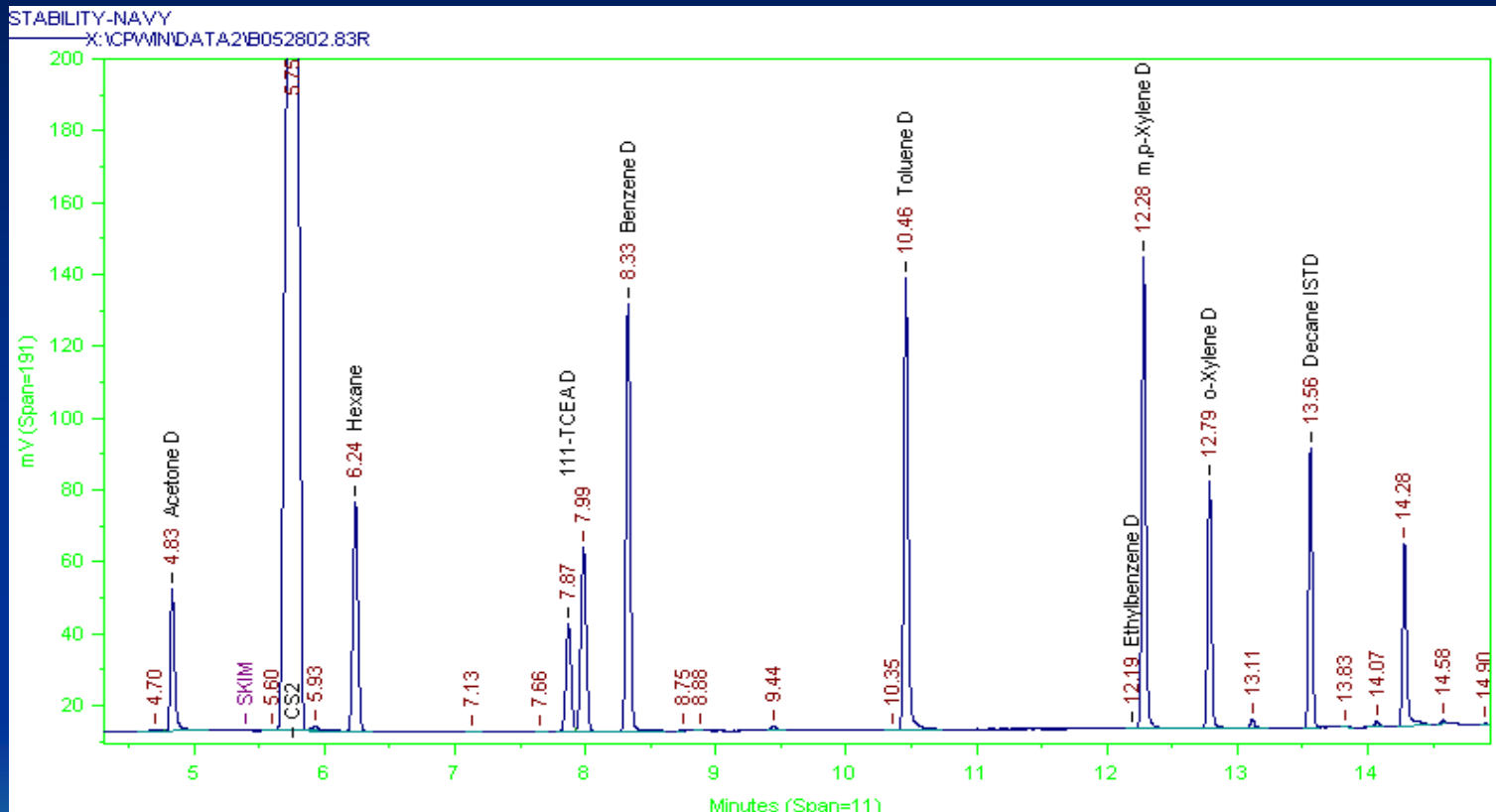
C-18 Column, 500 x 3.8 mm (3 μ M particles); Initial Mobile Phase: 50% Acetonitrile / 50% pH5 Acetate Buffer, gradient from 50% Acetonitrile / 50% Buffer to 100% Acetonitrile in 17 minutes.

LONG DURATION SAMPLING

Strategies...*for less-reactive*
VOLATILE ORGANIC COMPOUNDS

- May Need to Reduce SAMPLING RATE
 - STAY within Sample Capacity

VOC Scan



Restek RT Volatiles (Silicone 1.5 μ m Film) 30m x 0.32mm, Restek RT-1 (Methyl Silicone 1.5 μ m film) 30 x 0.32mm; Init Temp = 50°, 3 min hold, 15°C per minute to 250°C, Split 10:1

Optimizing SAMPLE CAPACITY *Issues...*

Not Enough ANALYTE....

ANALYTE < Detection Limit

SAMPLE Can't Be Analyzed

Too Much ANALYTE....

ANALYTE Overloads Media ...
leading to Reverse Diffusion

RESULTS Under-Estimated

ANALYTE just right !!

ANALYTE >> Detection Limit

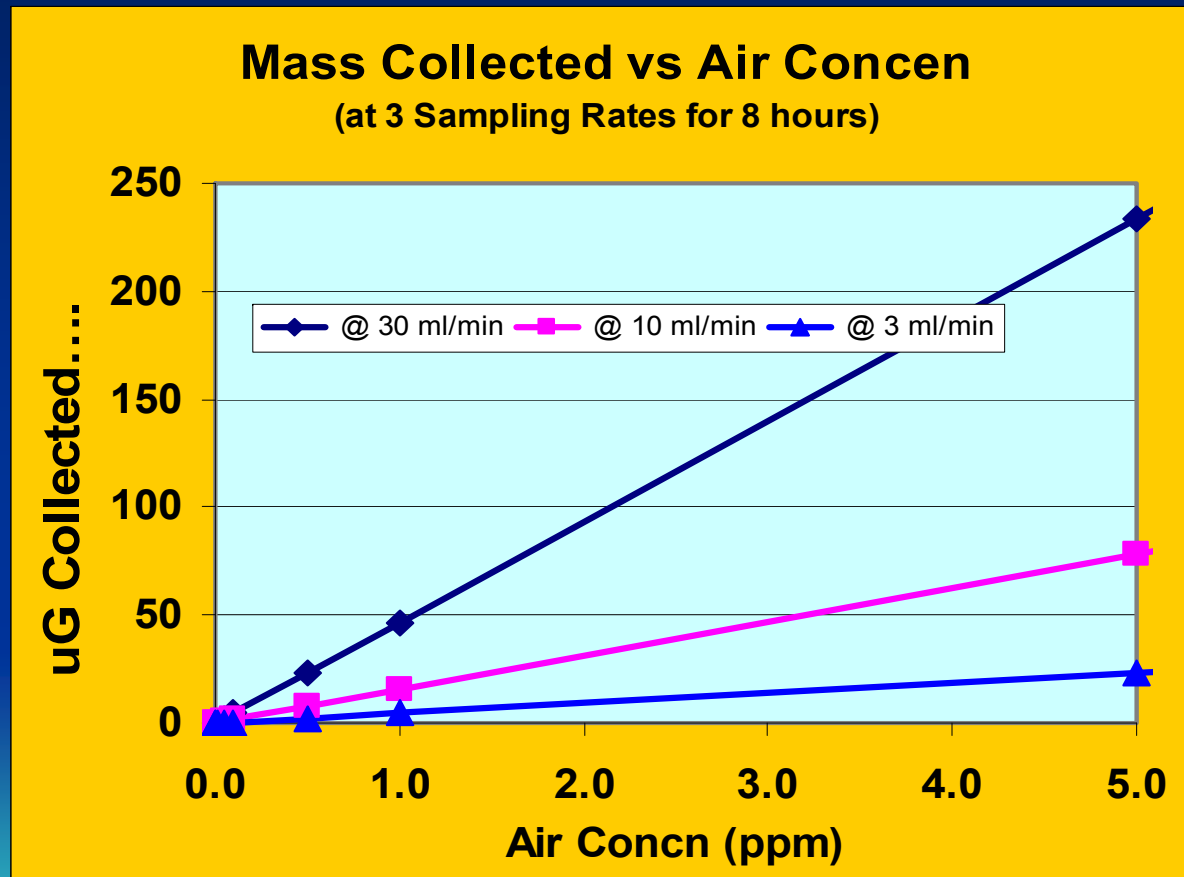
ACCURATE Sample Analysis

OPTIMIZE



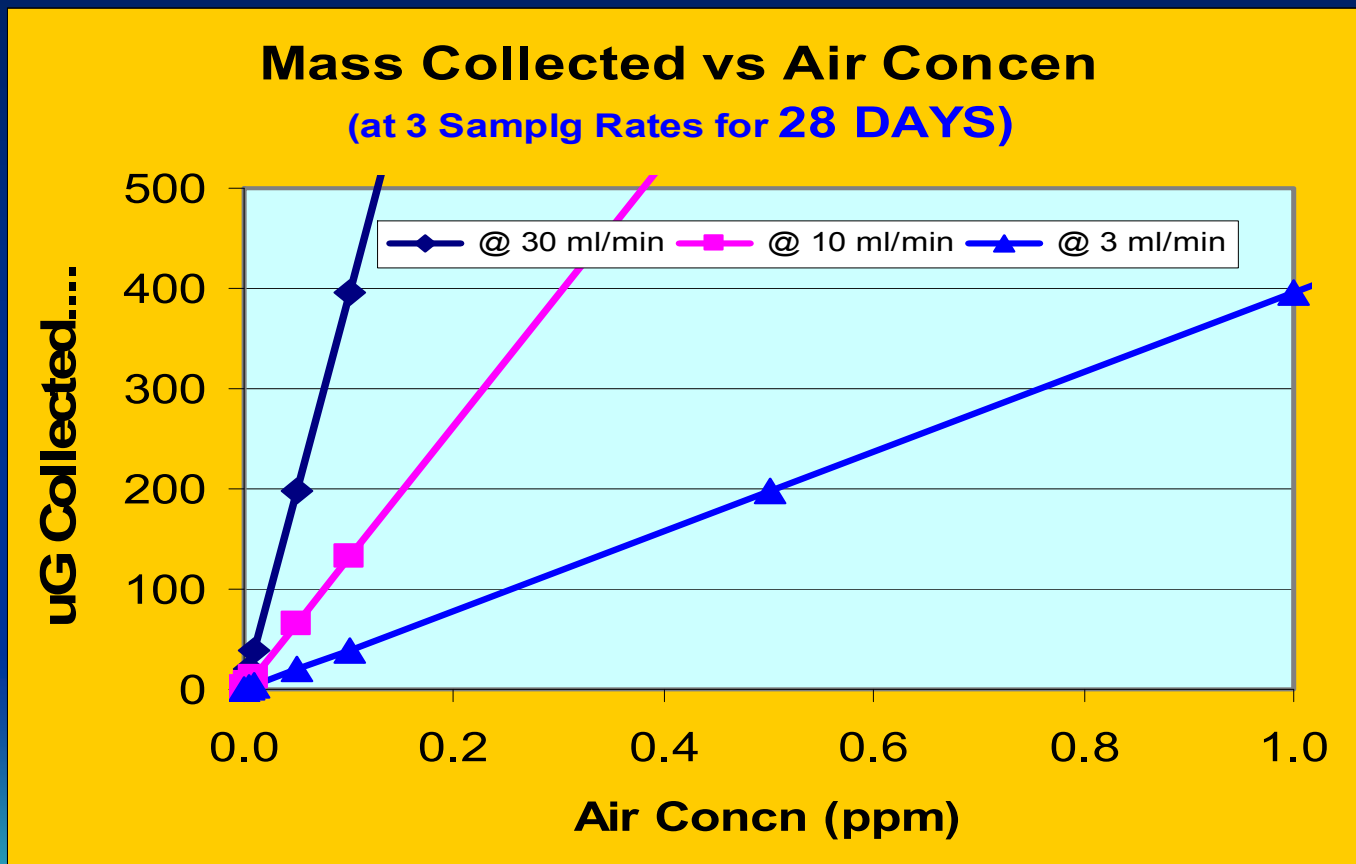
Short-Term Sampling

It's **Hard** to EXCEED CAPACITY
Diffusive Sample Volumes only \square 1-15 L.



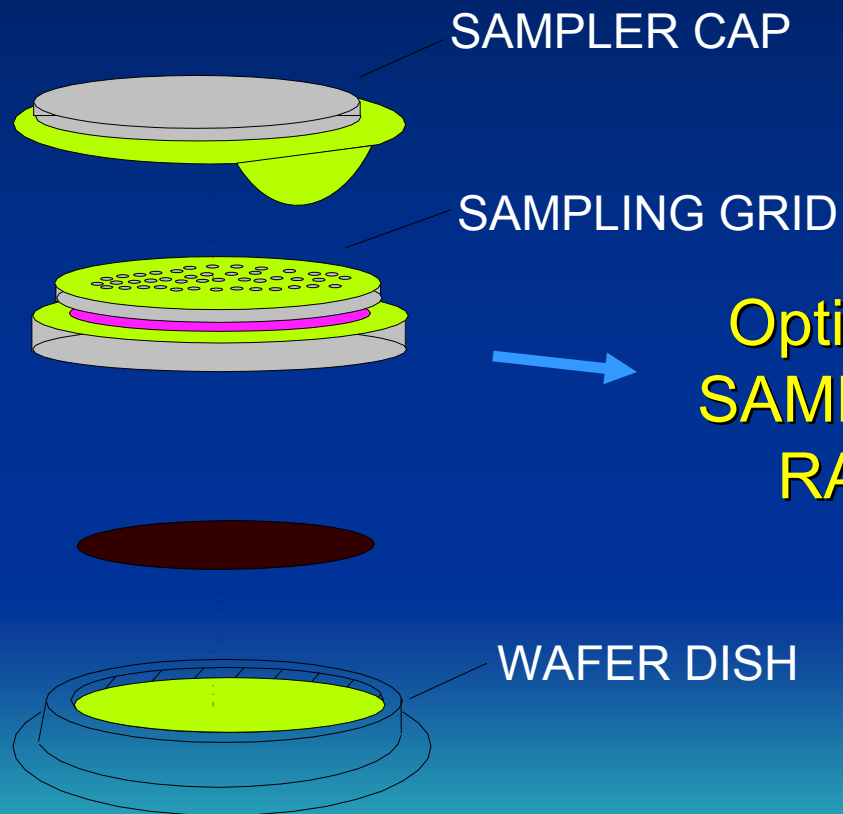
Long-Term Sampling

It's Easy to EXCEED CAPACITY
Plenty of Sample ... Volumes > 100 L.



Sampling Rate Adjustment

Adjust
SAMPLING
RATE of
SAMPLING
GRID



Optimized
SAMPLING
RATE

Varying the Sample Capacity Ratio

AT Sampler Model.....	AT546	AT566	AT521
No. of Sampling Ports (holes).....	19	76	560
Sampling Rate (ml/min)...	2.5	10	75
Charcoal Mass(mg).....	150	150	300
Ratio Mass/SR	60	15	4

Evaluation Protocol

Reverse Diffusion & Sample Storage

VOCs

Carbon Media

Hi Sampling Rate (541)

Lo Sampling Rate (546)

- *1,1,1-Trichloroethane (TCEA)*
- *Hexane*
- *Benzene*
- *Toluene*
- *Xylenes*

Aldehydes

DNPH-coated media

Sampler (571)

- *Acetaldehyde*
- *Formaldehyde*

Amines

NIT-coated media

Sampler (585)

- Ethylenediamine*
- *Ethanolamine*

Evaluation Protocol

Reverse Diffusion & Sample Storage

Vapor Exposure in Chamber

Spike at 2 Concentrations

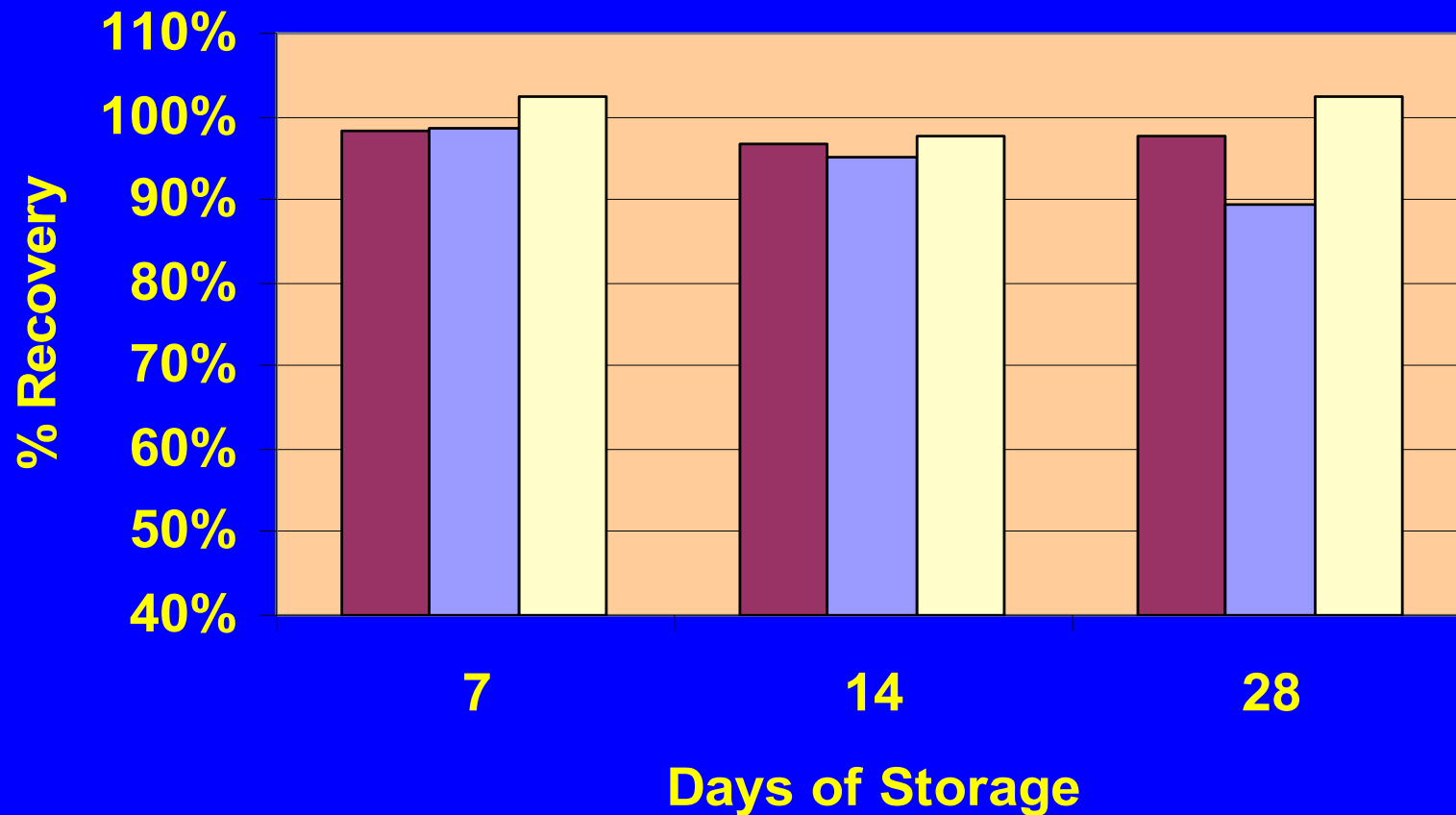
Storage - Closed & Open Samplers
- Freezer Controls

Analyze Samples Weekly

STABILITY of TOLUENE

(0.2ppm for 28 days = 0.05 mg on Sampler 546)

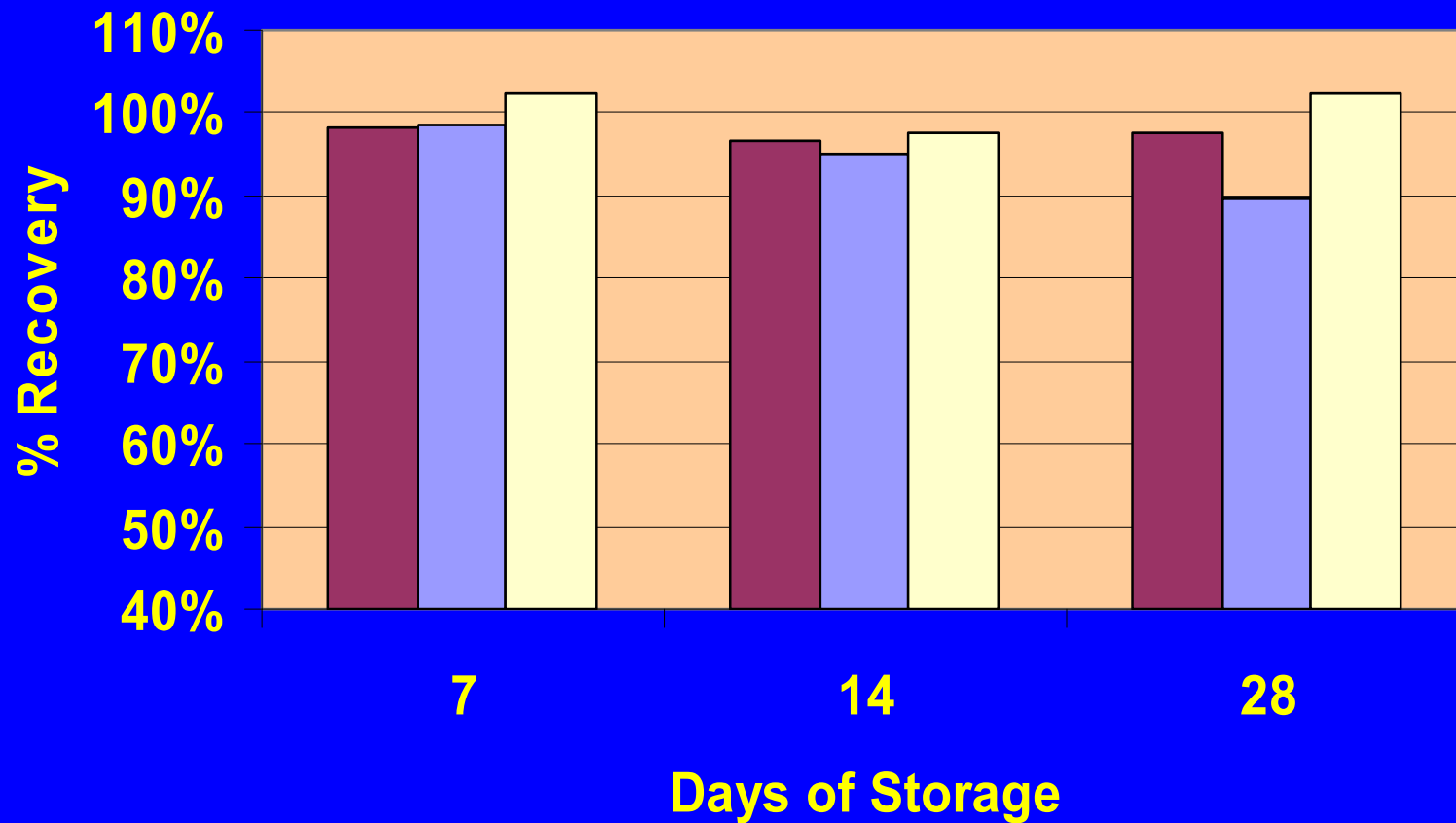
CAP ON CAP OFF Container



STABILITY of TOLUENE

(0.05ppm for 28 days = 0.05 mg on Sampler 541)

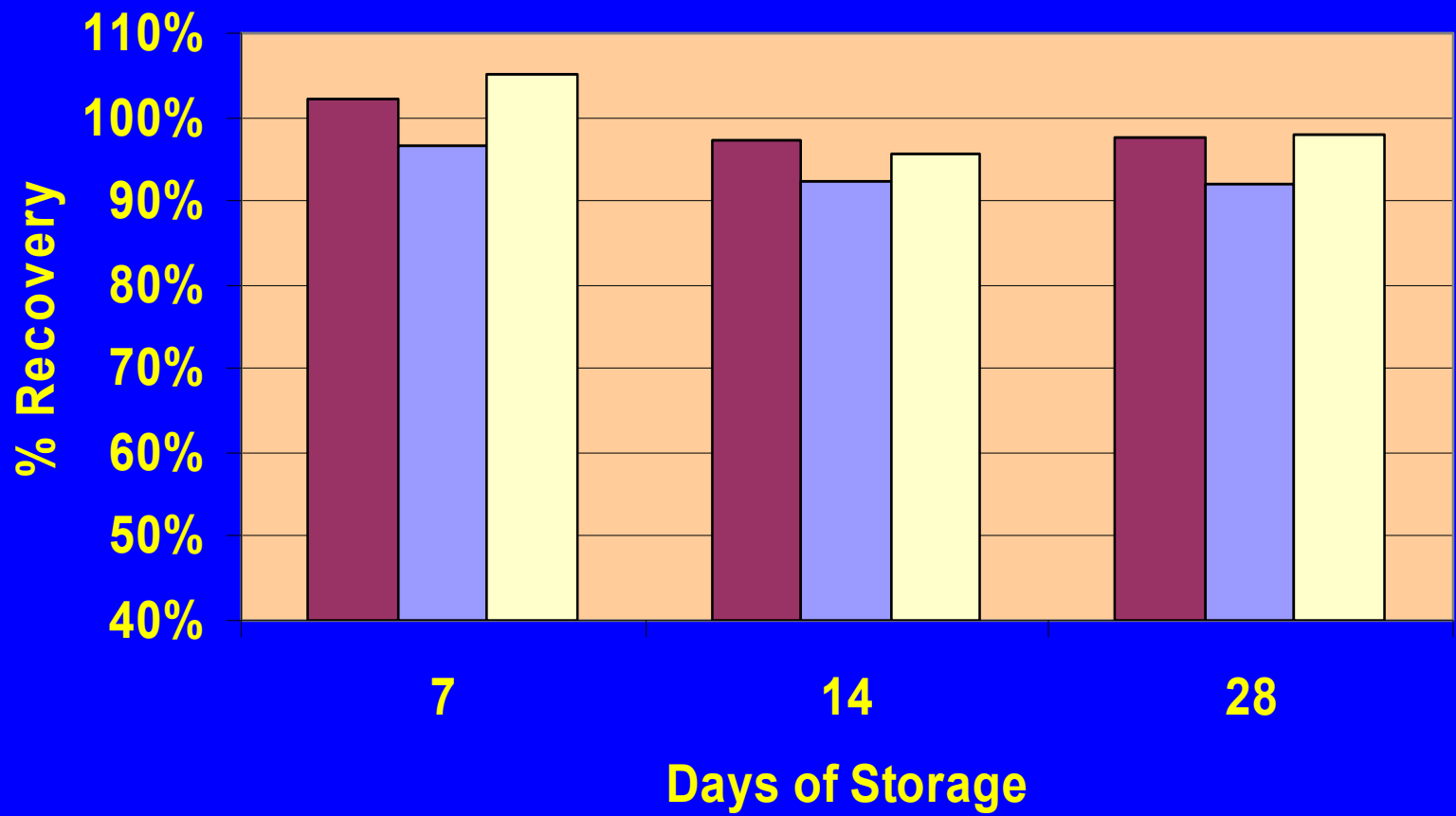
CAP ON CAP OFF Container



STABILITY of XYLENES

(0.2ppm for 28 days = 0.05 mg on Sampler 546)

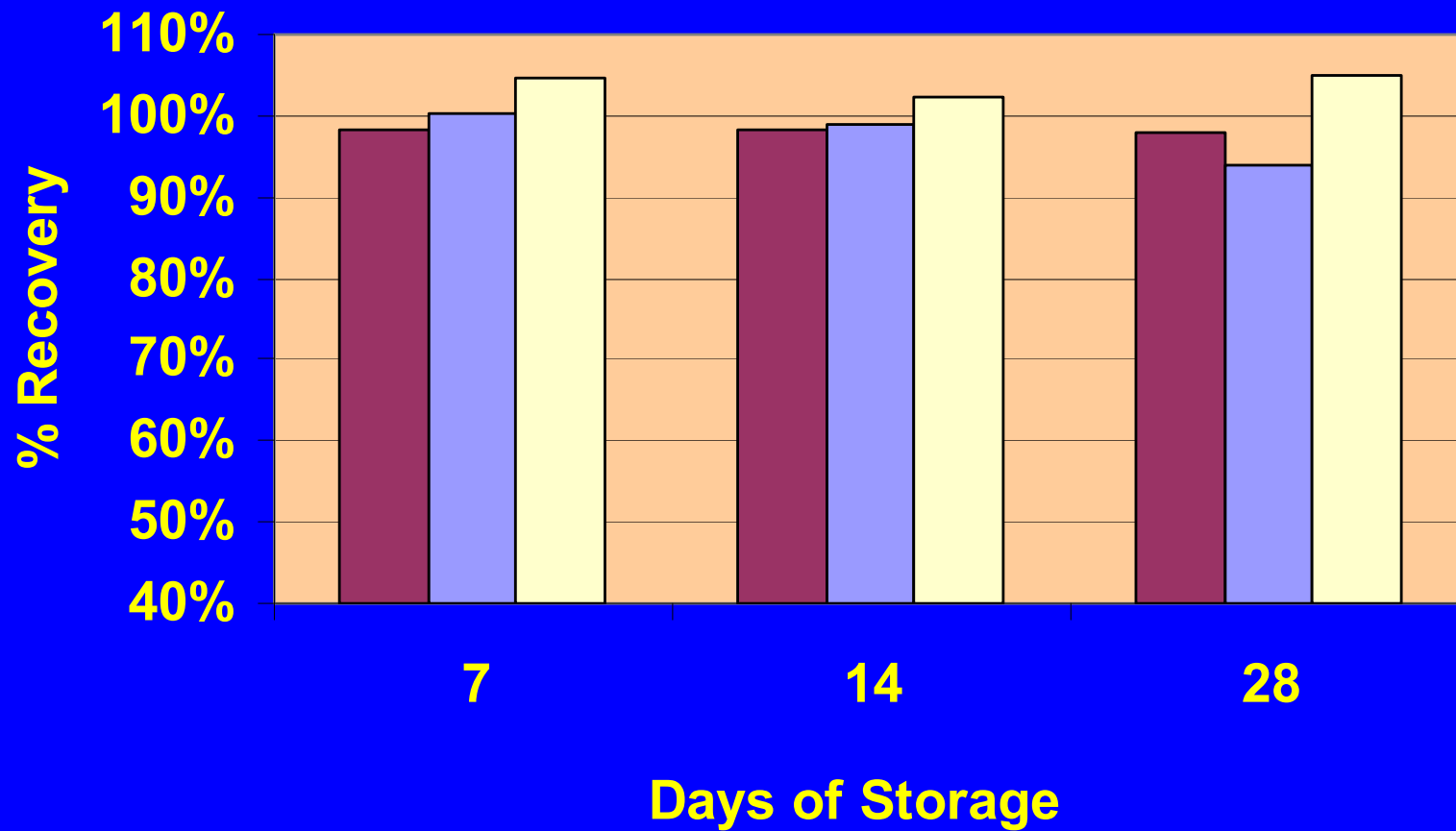
■ CAP ON ■ CAP OFF ■ Container



STABILITY of XYLENES

(0.05ppm for 28 days = 0.060 mg on Sampler 541)

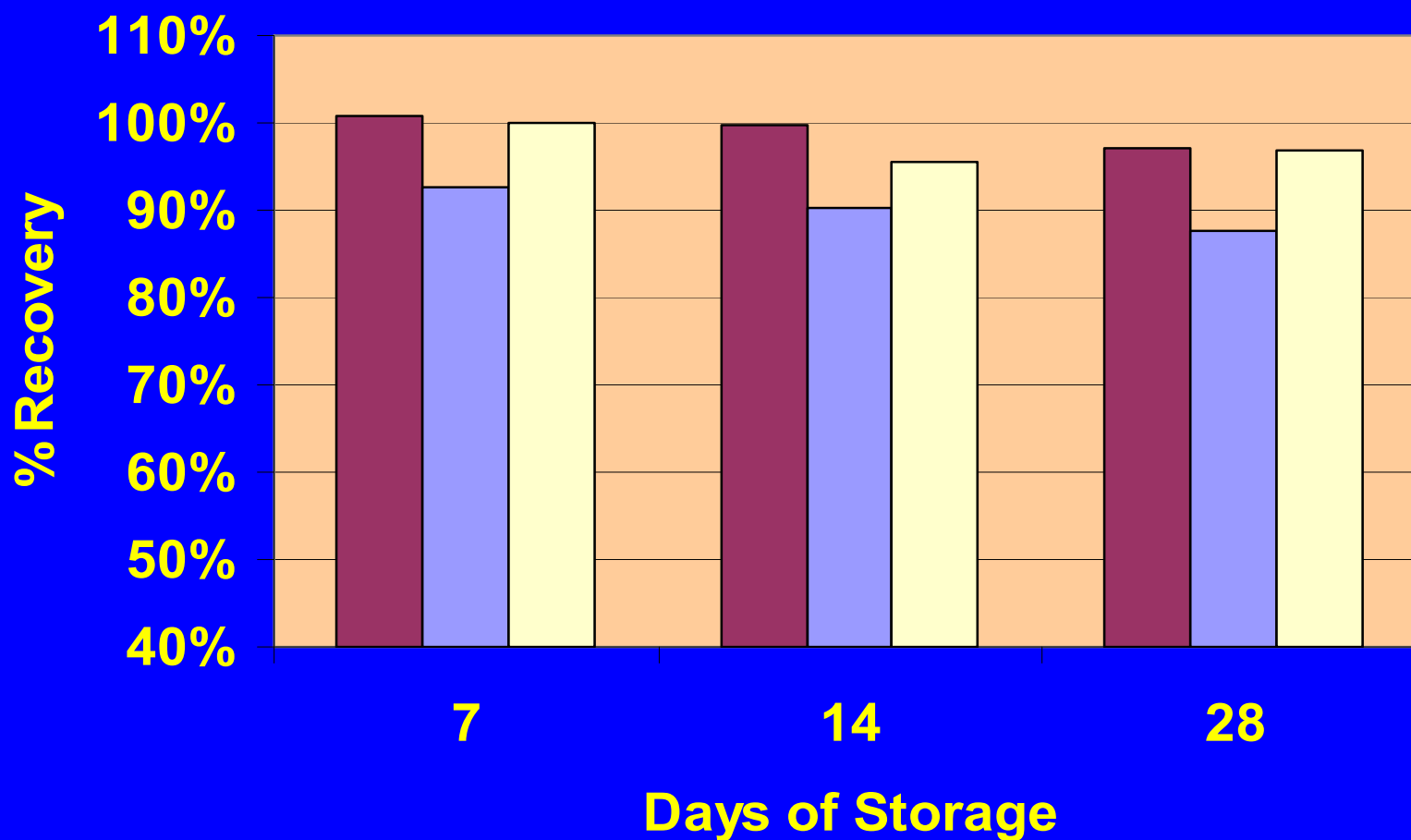
CAP ON CAP OFF Container



STABILITY of BENZENE

(0.2ppm for 28 days = 0.05 mg on Sampler 546)

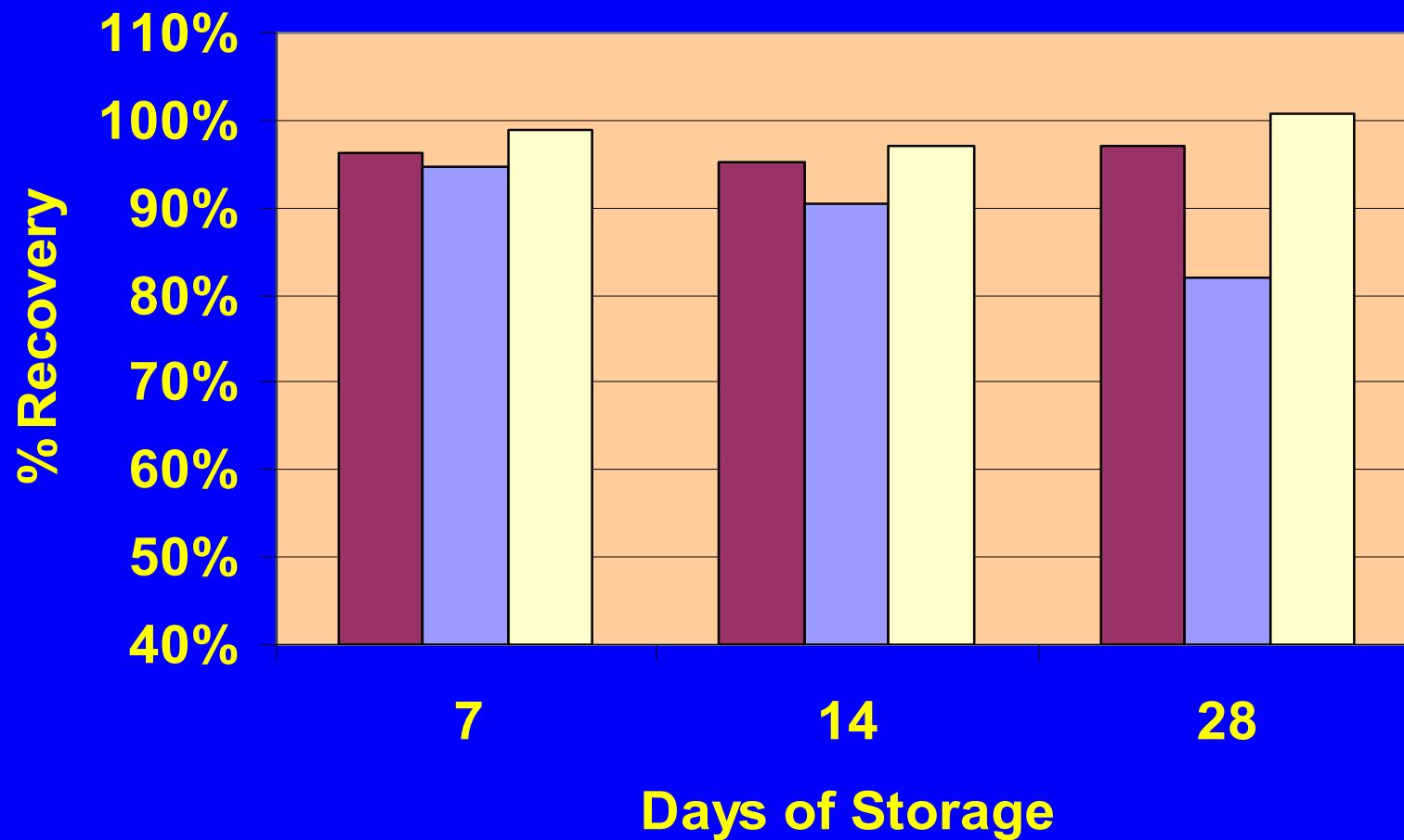
■ CAP ON ■ CAP OFF ■ Container



STABILITY of BENZENE

(0.06ppm for 28 days = 0.05 mg on Sampler 541)

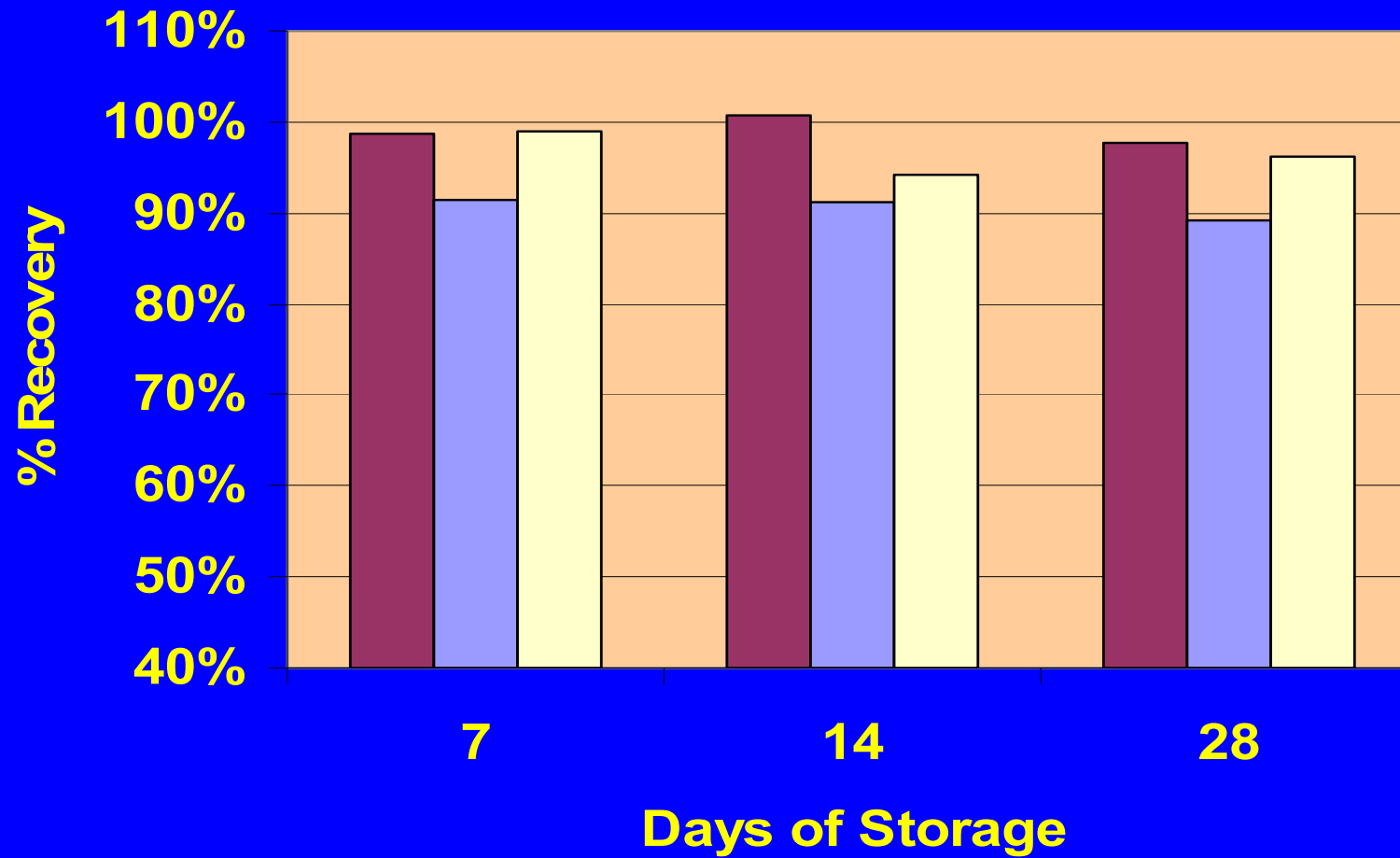
CAP ON CAP OFF Container



STABILITY of HEXANE

(0.1ppm for 28 days = 0.03 mg on Sampler 546)

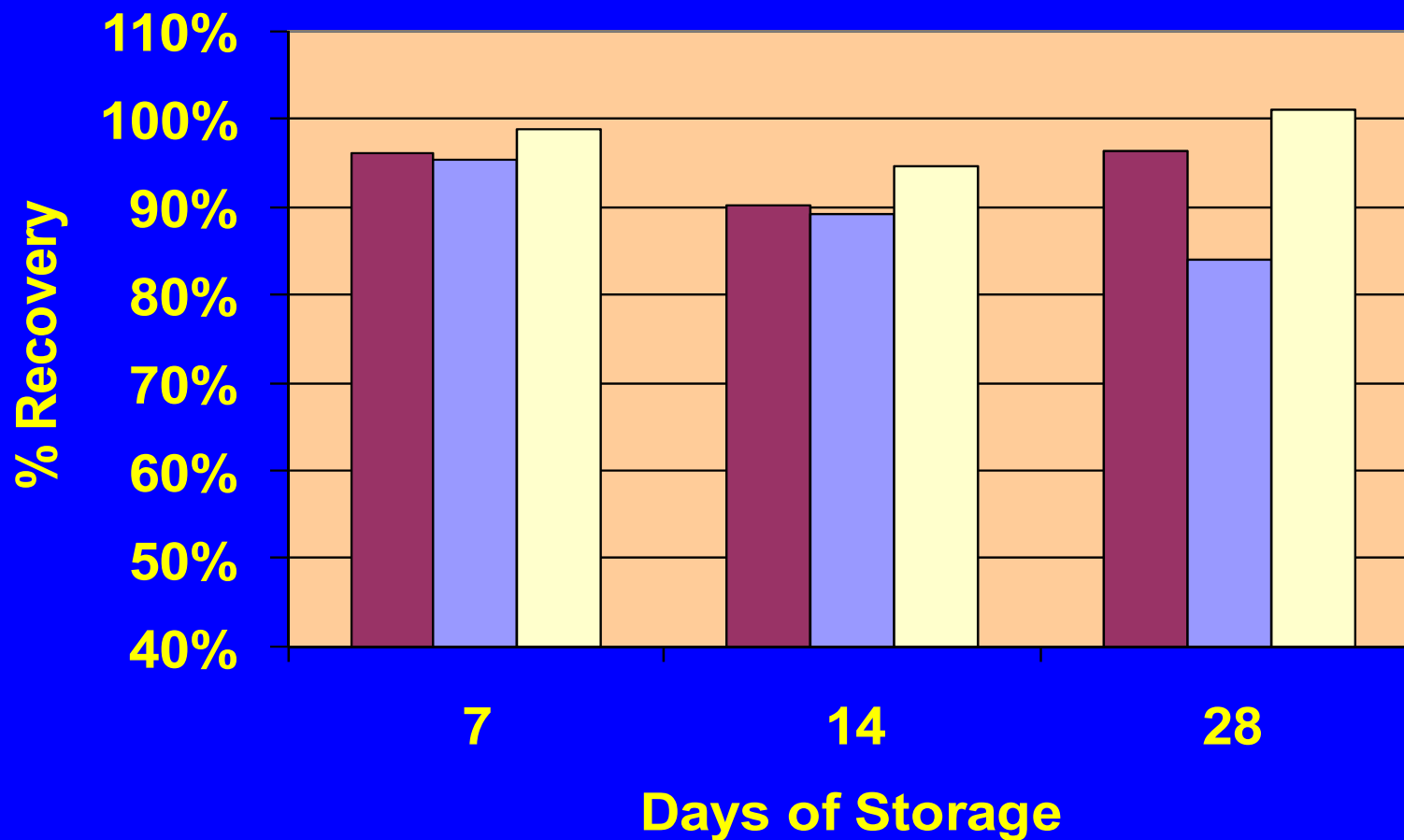
CAP ON CAP OFF Container



STABILITY of HEXANE

(0.03ppm for 28 days = 0.03 mg on Sampler 541)

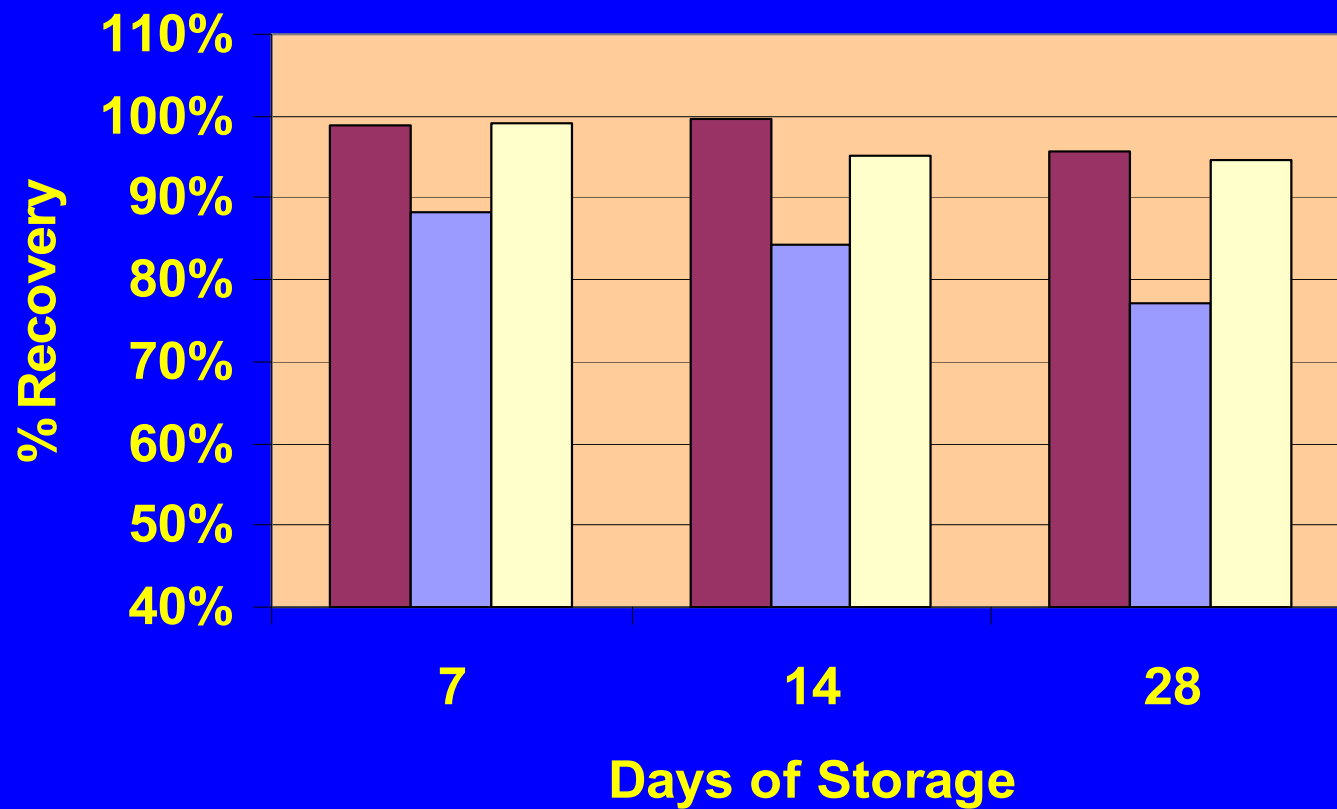
CAP ON CAP OFF Container



STABILITY of 1,1,1-TRICHLOROETHANE

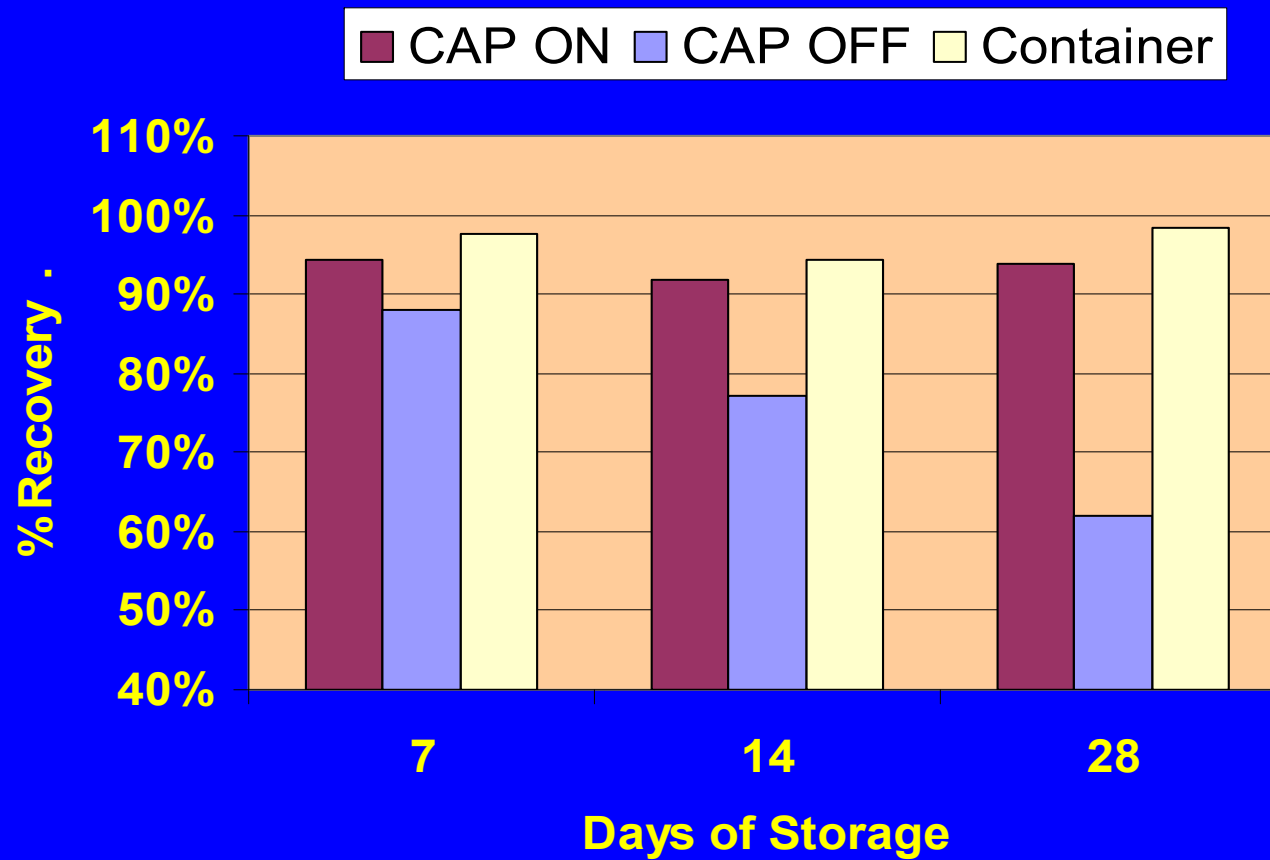
(0.2ppm for 28 days = 0.06 mg on Sampler 546)

■ CAP ON ■ CAP OFF ■ Container

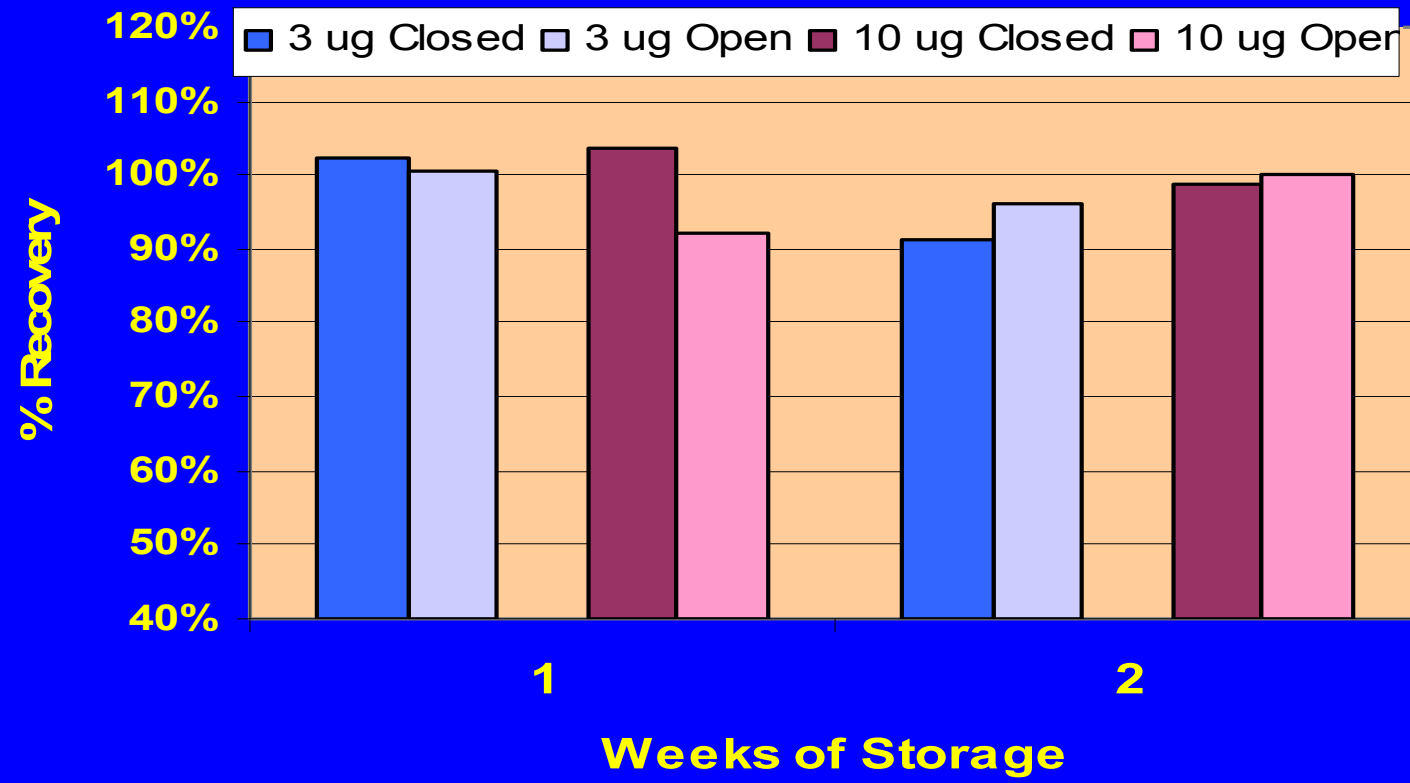


STABILITY of 1,1,1-TRICHLOROETHANE

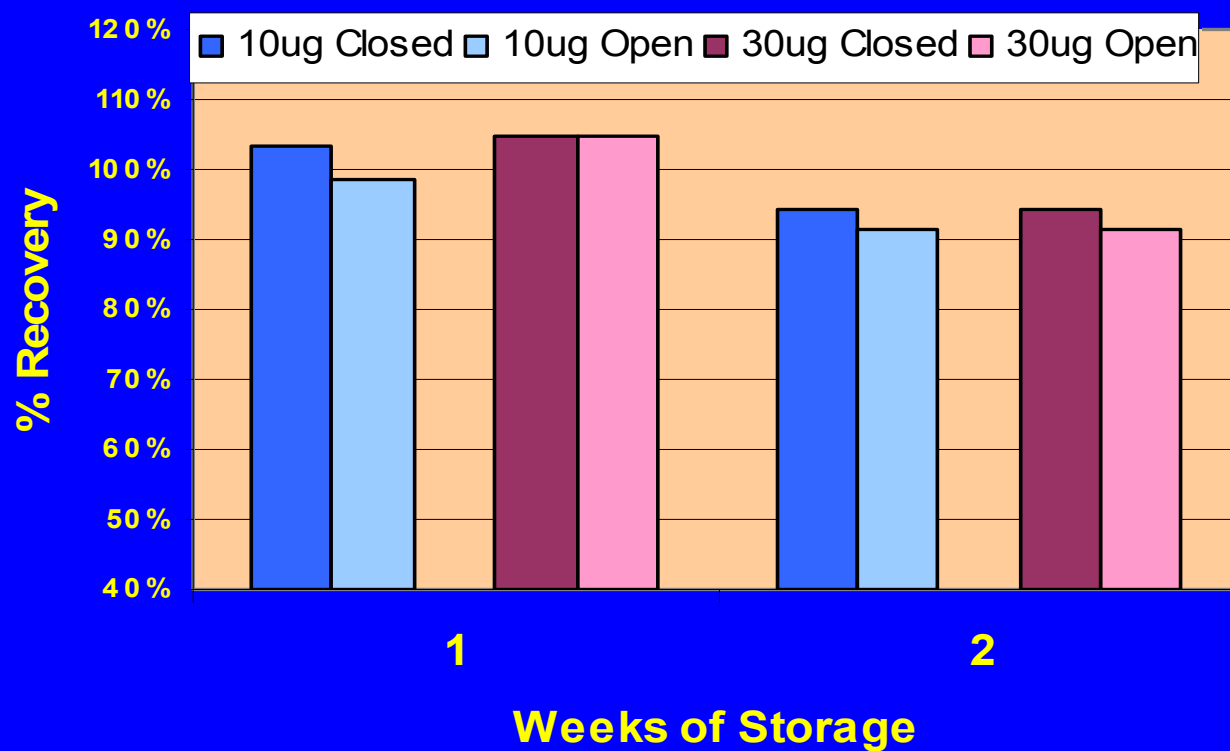
(0.04ppm for 28 days = 0.06 mg on Sampler 541)



Formaldehyde (Stability of 571 Sampler; 3 & 10 mcg)

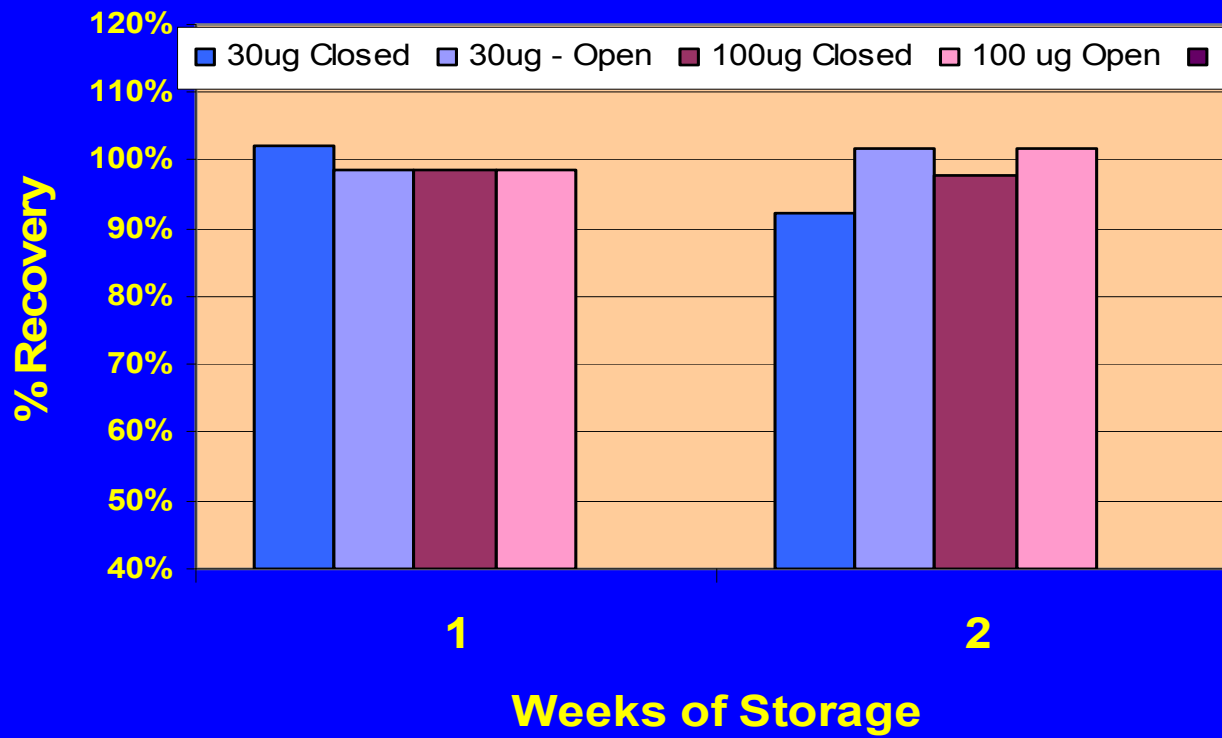


Acetaldehyde (Stability on 571 Sampler; 10 & 30 mcg)



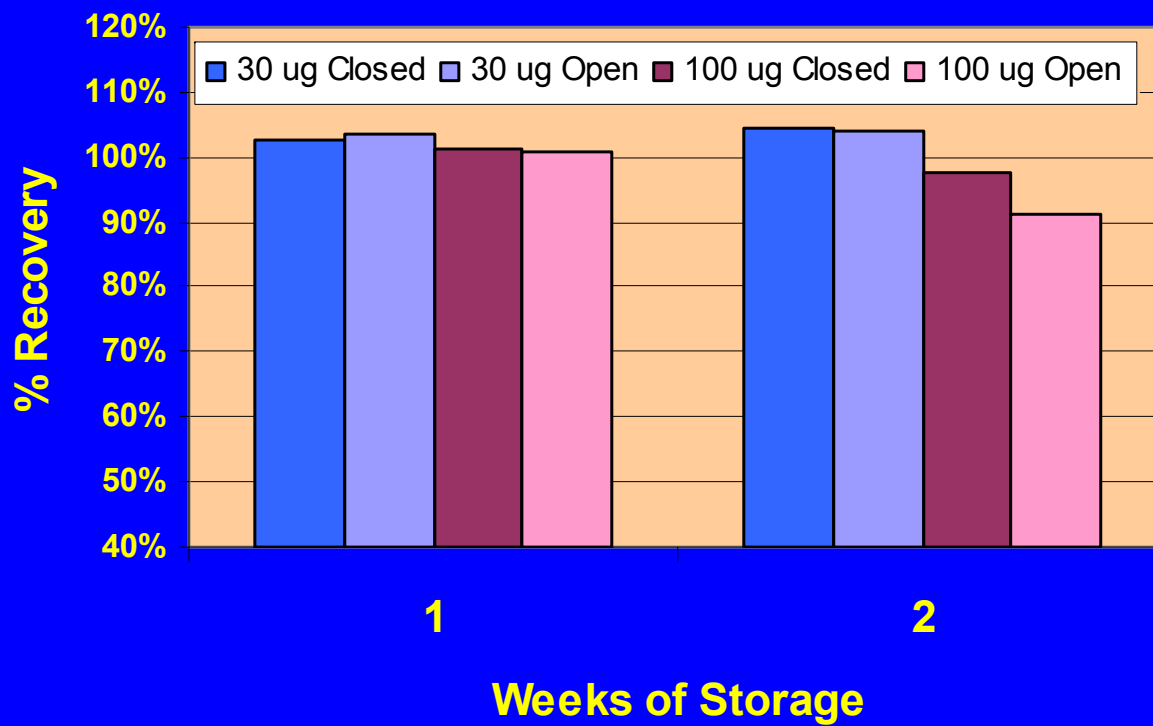
Ethanolamine

(Stability on Sampler 585; 30 & 100 mcg)



Ethylenediamine

(Stability on Sampler 585; 30 & 100 mcg)



CONCLUSIONS

- Many ANALYTES can be sampled and stored for weeks on a Diffusive Sampler optimized for Long-Term Sampling
 - VOCs, aldehydes, organic amines, etc.
- Diffusive Samplers can be useful in performing Indoor Air Quality studies if you know what you are looking for, and can be somewhat patient.

The End

Thank You !