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Effective Stack Test Management

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Your Presenter

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What We’ll Cover

1. Planning Considerations
2. Flow Measurement
3. Particulate Measurement
4. VOC Measurement

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Test Requirement Basis

- Engineering Study/Diagnostic
- Manufacturer Performance Guarantee
- Permit Conditions
- Ministry of Environment Rules
  - New Source Performance Standards
  - NESHAPs
  - PSD or Title V Avoidance

Test Requirement Basis

- Engineering Study/Diagnostic
- Mfg Performance Guarantee

"Formal" Tests

- Permit Conditions
- EPA &/Or DEQ Rules
  - New Source Performance Standards
  - NESHAPs
  - PSD or Title V Avoidance

Test Requirement Basis

"Informal" Tests

- > Engineering Study/Diagnostic
- > Mfg Performance Guarantee
- > Permit Conditions
- > Ministry of Environment Rules
  - New Source Performance Standards
  - NESHAPs
  - PSD or Title V Avoidance

Common Test Method Sources

NSPS: Part 60, Appendix A

NESHAP: Parts 61 and 63

Others at EMC

SW-846

Planning Considerations - 1

- Detection Limits
  - Will test show rule/permit compliance?
- Interferences
- Location Accessibility
- Safety
  - Plant Safety Training Required?
  - Contractor Safety Plan

Planning Considerations - 2

- Production/Process
  - Data capture
  - Maximum rate
- Power!
  - Typically: 1 15v circuit/method/location
- Access
- On site analysis?
- Sampling ports cleaned & open

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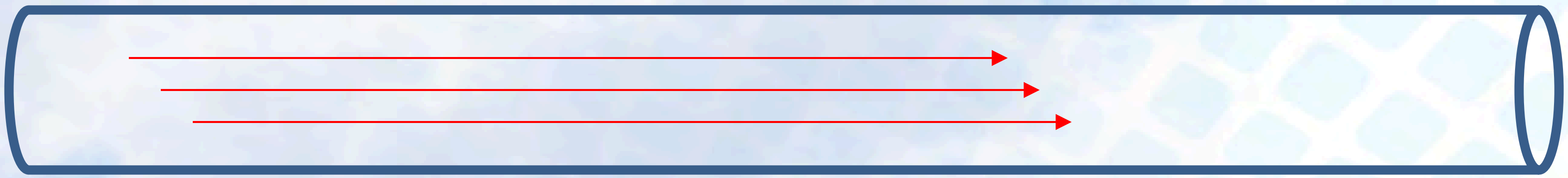
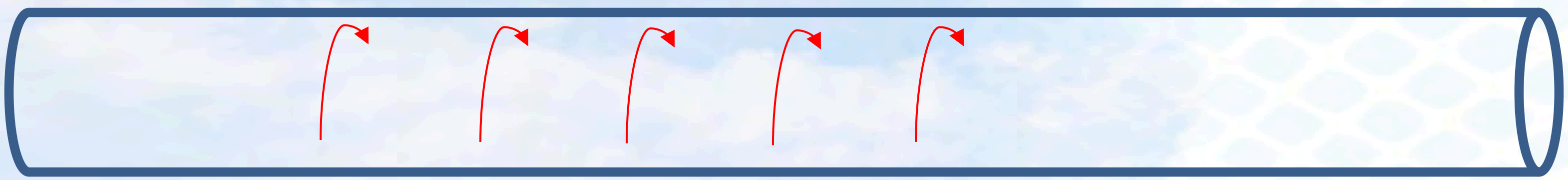
Air Flow Measurement

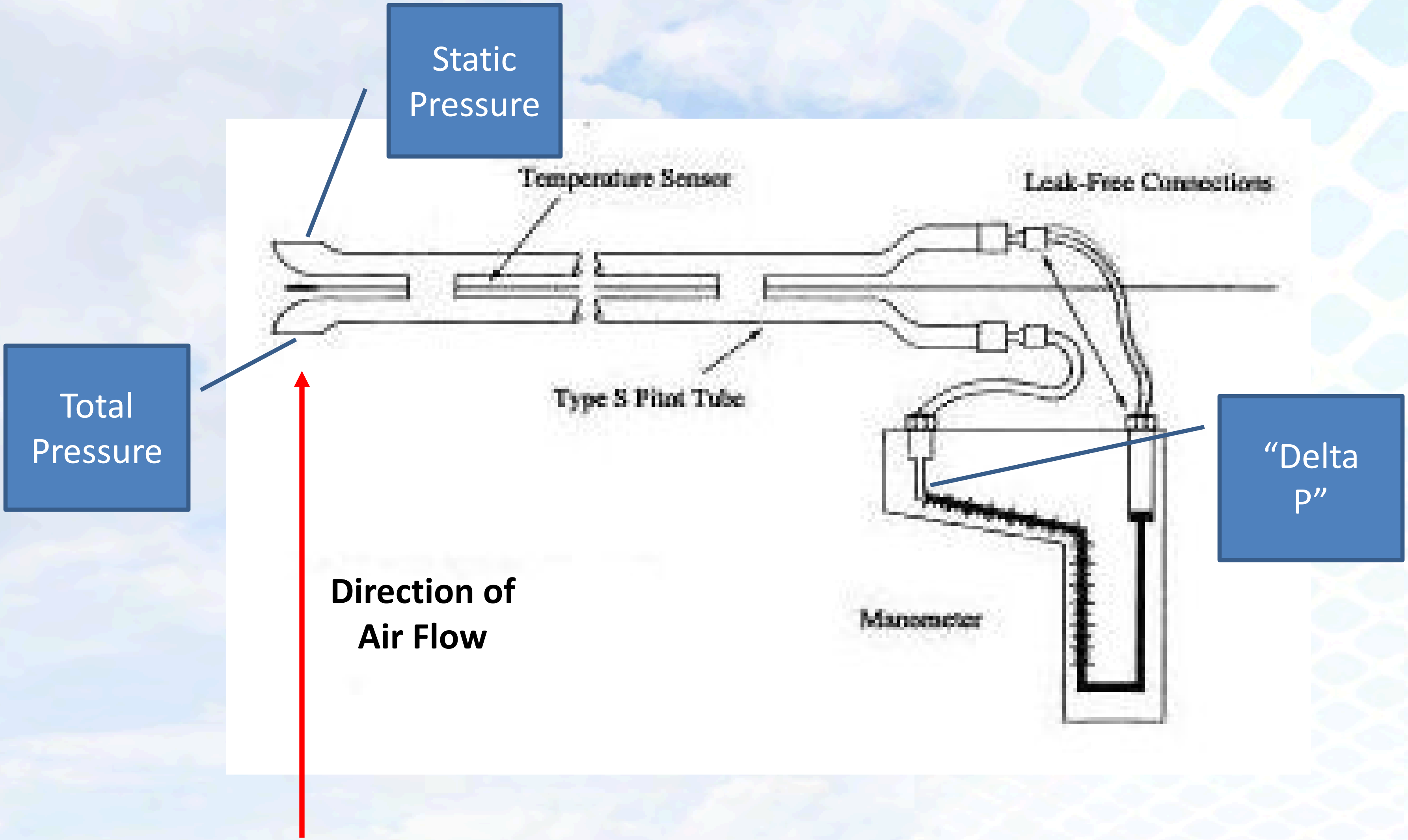


Laminar Flow



Turbulent or Cyclonic Flow

Pitot Tube Operation



USEPA Method 2

- Gas velocity measurement using pitot tube and temperature sensor
- Measure at points selected using Method 1 (mark pitot before starting)
  - Offset for port size
  - Allow temperature to stabilize
- Keep test ports sealed during measurement
- Typically, 1 “probe pusher” + 1 data recorder

Method 2 Data Example

Point	Delta P (inches H20)	Temp (oF)
A-1	0.52	170
A-2	0.55	172
A-3	0.55	172
A-4	0.49	171
B-1	0.47	173
B-2	0.54	175
B-3	0.54	173
B-4	0.52	173

Duct Diameter:	2.3	feet
Static Pressure:	- 0.5	in H2O
A Distance:	5	ft
B Distance:	20	ft
Barometric Pressure:	29.71	ft Hg

Common Method 2 Errors

- Turbulent flow
- Very low velocities (< ~ 5 ft/sec)
- Very high velocities (> ~ 75 ft/sec)
- In-leakage (negative static pressure stacks)
- Insufficient "soak" time for thermocouple

Method 2 Errors - Example 1

Point	Delta P (inches H20)	Temp (^oF)
A-1	0.43	170
A-2	0.15	172
A-3	0.77	172
A-4	1.2	171
B-1	1.3	173
B-2	0.47	175
B-3	0.35	173
B-4	0.99	173

Wide variation in Delta P suggests turbulent flow

Method 2 Errors - Example 2

Point	Delta P (inches H20)	Temp (oF)
A-1	0.52	75
A-2	0.55	92
A-3	0.55	110
A-4	0.49	115
B-1	0.47	112
B-2	0.54	117
B-3	0.54	118
B-4	0.52	118

Pattern suggests in-leakage or insufficient soak time

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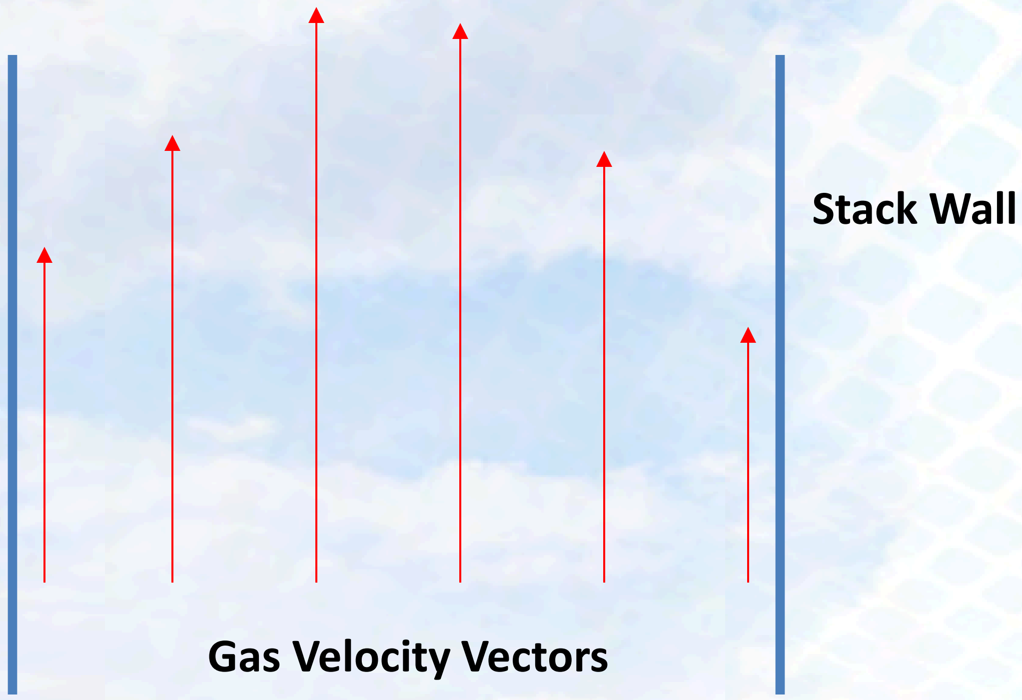
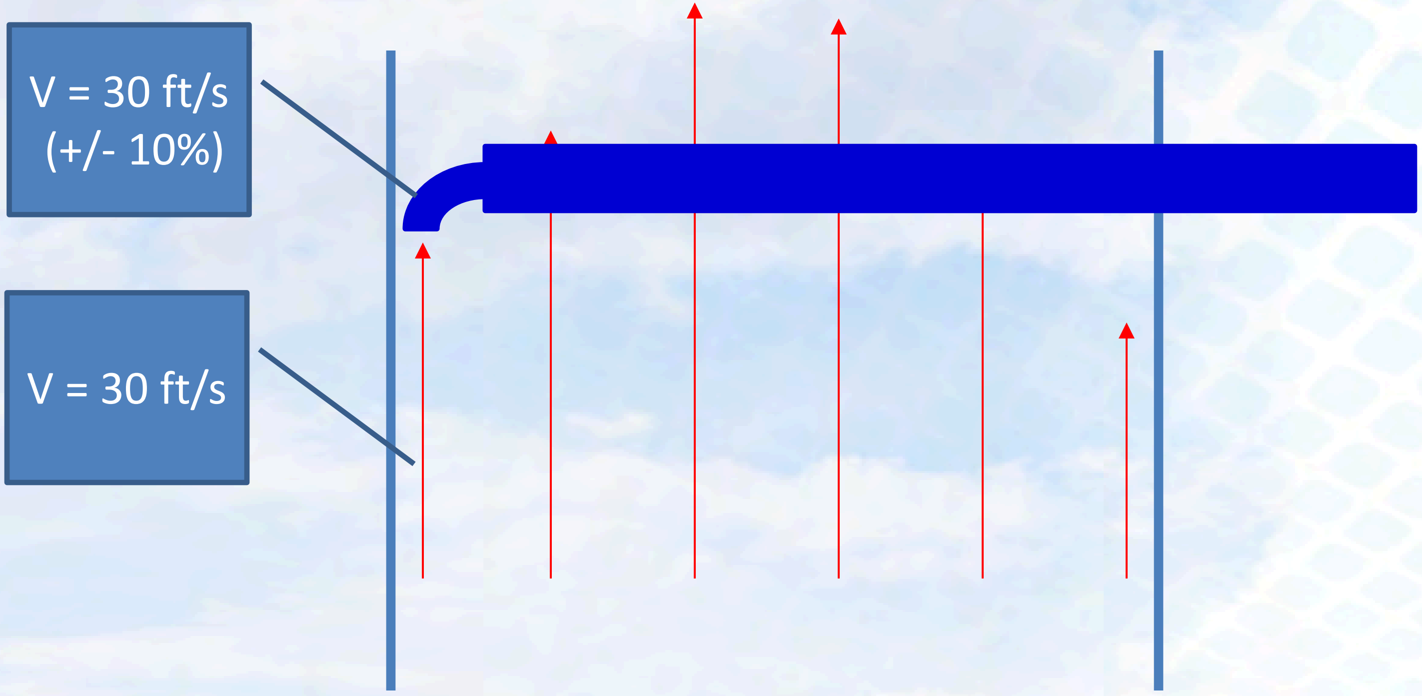
Particulate Distribution

> Based on: particle size and gas velocity



Isokinetic Sampling

- Gas Velocity = Sampling Velocity



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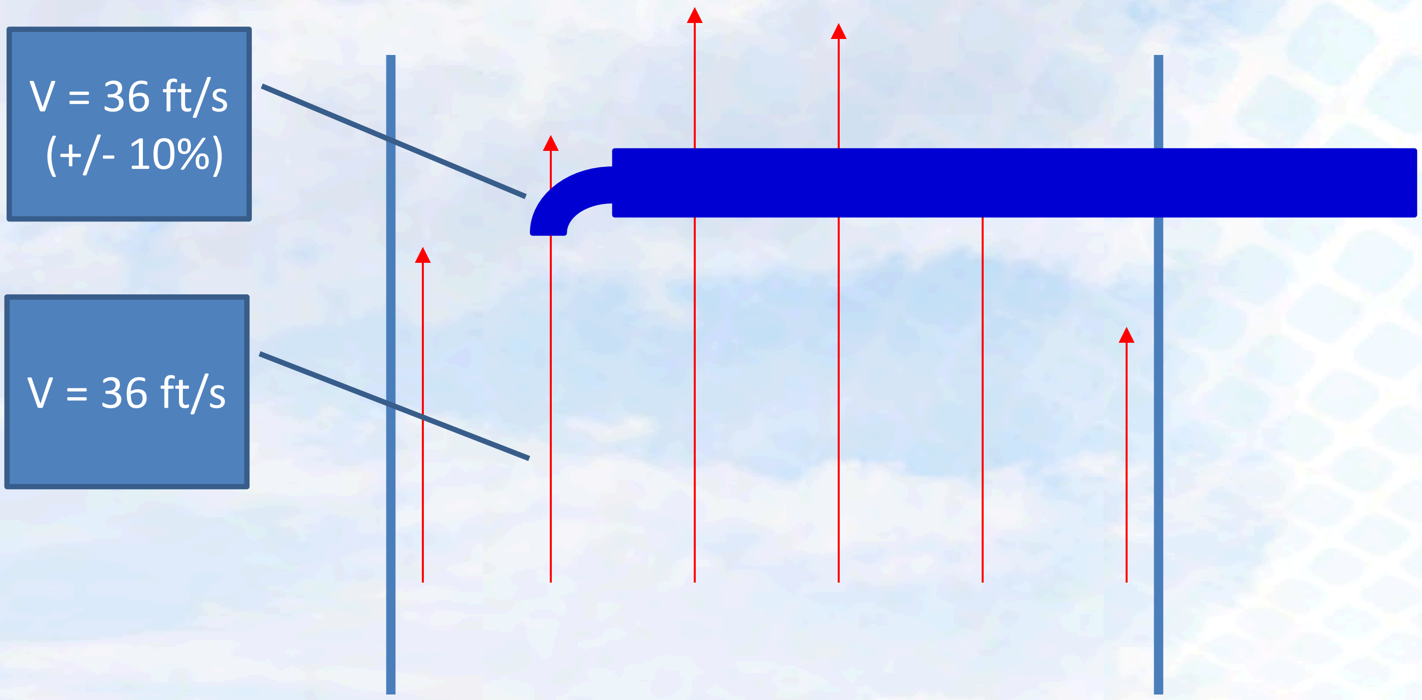

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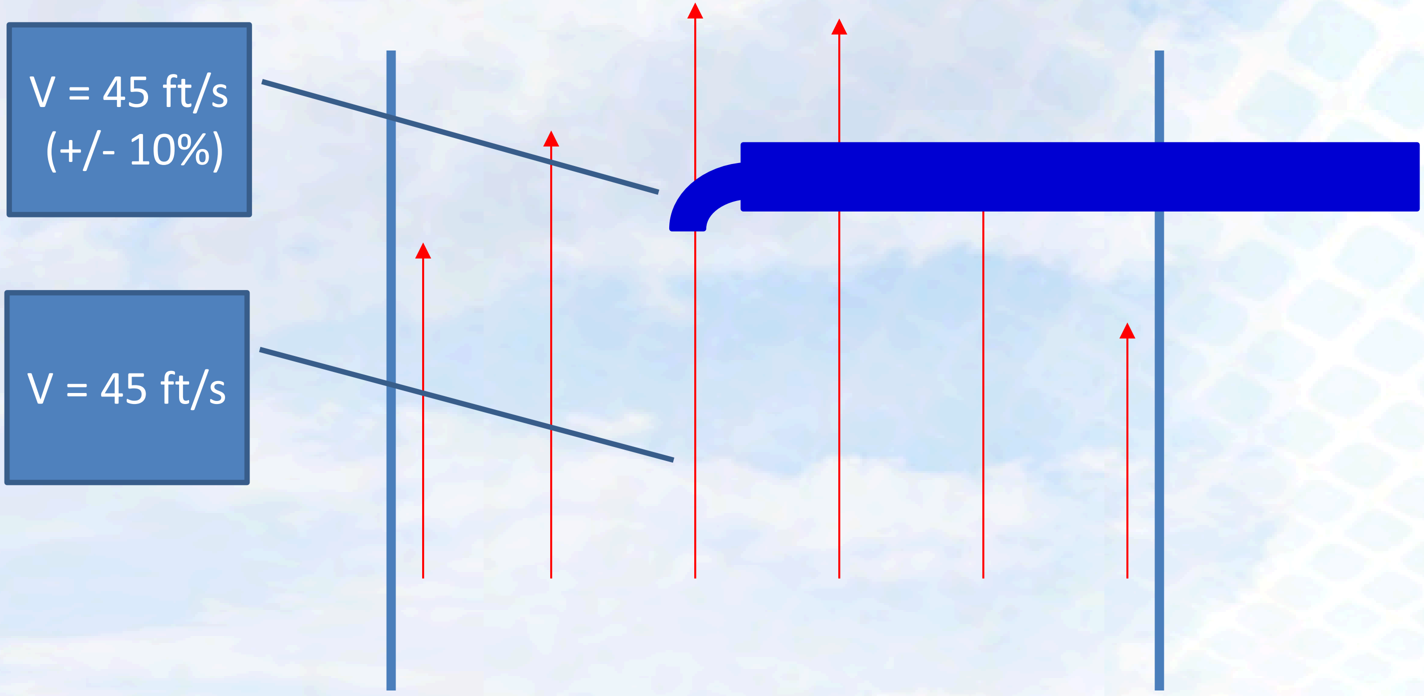
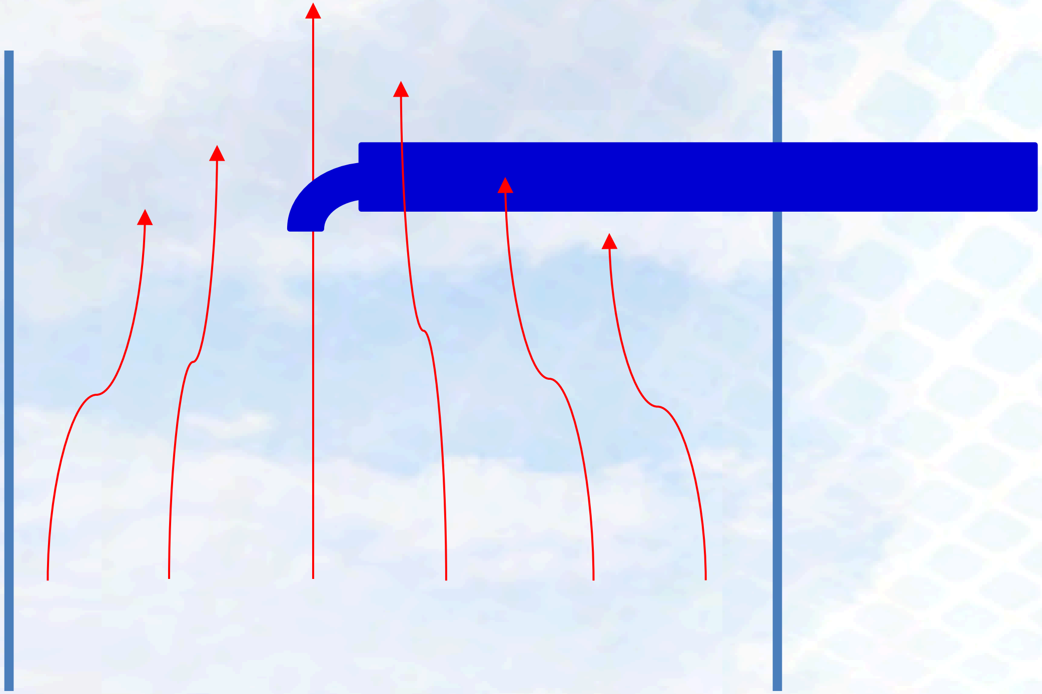


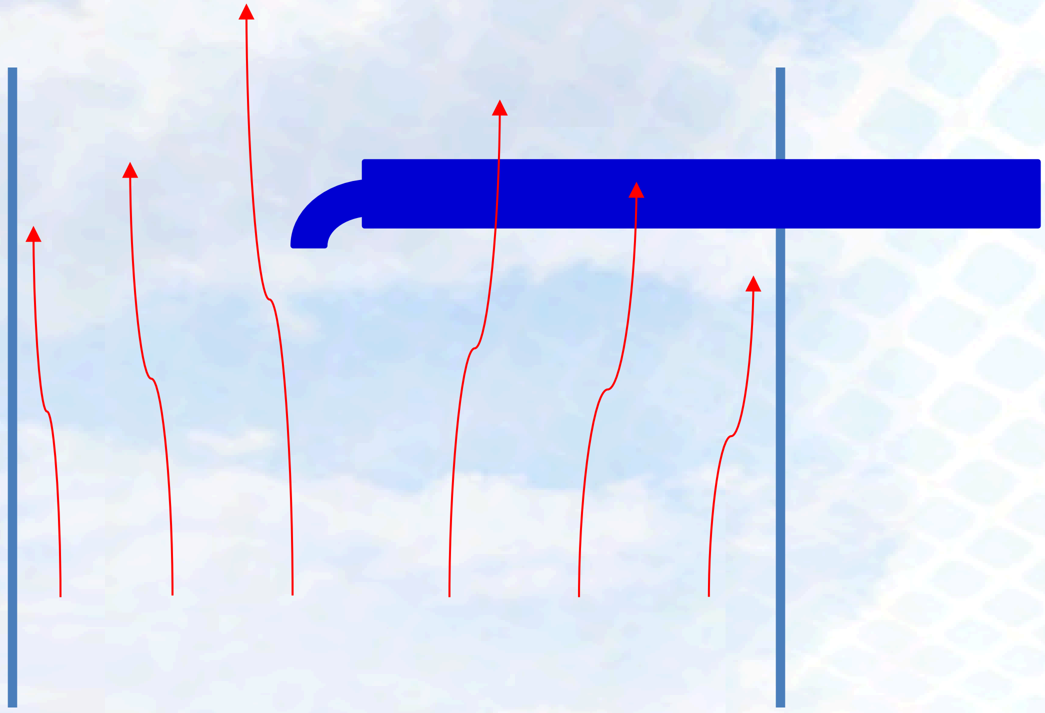
Super-Isokinetic

- Gas Velocity < Sampling Velocity



Sub-Isokinetic

- Gas Velocity > Sampling Velocity



On Stack vs "Clean Room" Recovery

- On Stack
  - Quicker
  - More chances of contamination
  - Wind, elements come into play
- Clean Room
  - Adds time
  - Less chance of contamination
  - No wind or elements to deal with

On Site vs Off Site Analysis

<u>On Site</u>

- "Immediate" results
- Can adjust process as obtain results
- Requires facilities
- Extra cost

<u>Off Site</u>

- Wait and see
- Make return trip if results not OK
- No extra facilities
- Less expensive

Outside Lab Issues

- Participate in audit program?
  - Internal
  - External
- Experience with air methods?
- Mark up for quick turn-around?
- Other work/priorities?
  - Water work “base load” for many

Method 5 – Typical Problems

- Contamination (especially with low emission limits)
- Leaking sample train
- High condensables
  - Organic
  - Inorganic
- Hygroscopic materials on filters

Method 5 – Detection Limits

- Practical Lab Detection Limit (PDL): 5 mg
- Typical Sample Volume (1 hr): 30 ft^3

SO:

1 hr PDL = 5 mg/30 ft^3 (0.0026 gr/dscf)

4 hr PDL = 5 mg/120 ft^3 ((0.00065 gr/dscf)

Method 5 - Alternates

- Method 5B
  - Non-sulfuric acid PM
  - Typically for high sulfur coal or oil combustion
- Method 5F
  - PM from FCCUs
- Method 17
  - In stack filtration
  - Typically for high-concentration sources

Method 201A

- Constant rate method
- May not sample at all points
- Requires 6” sampling ports
- Isokinetic variance expanded
  - 80% to 120% OK

Method 202 – The Basics

- Dry impinger method
- Separates inorganic from organic condensable matter
- Inorganic
  - Typically: acids, salts
- Organic
  - Typically: products of incomplete combustion, semi-volatiles

Artifact Formation

Artificial PM can form – e.g.:

- $SO_2 + H_2O \rightarrow H_2SO_4$
- $H_2SO_4 + NH_3 \rightarrow (NH_4)_2SO_4$
- $HCl + Na \rightarrow NaCl$
- $HNO_3 + NH_3 \rightarrow NH_4NO_3$

Method 202 Changes

- Changed 12/1/2010
- Highlights:
  - Wet to “dry”
  - Purge
  - Blank subtraction
  - Sulfuric acid titration

4/8/14 EMC Interim Guidance

- Recognizes continued concerns re: artifact formation
- Non-binding
- “Blank” advice
  - Field-proof blank use OK (5.1 mg max)
  - Field-train recovery blank (2.0 mg max) traditionally used more often

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Method 18

- To determine type and amount of organic compounds
- "Free form"
- Spike and recovery goals
- Pre-test survey often a good idea
  - GC/MS good tool for this
  - Get "Tentatively Identified Compounds" (TICs) if targets unknown

Method 18 – Sample Media

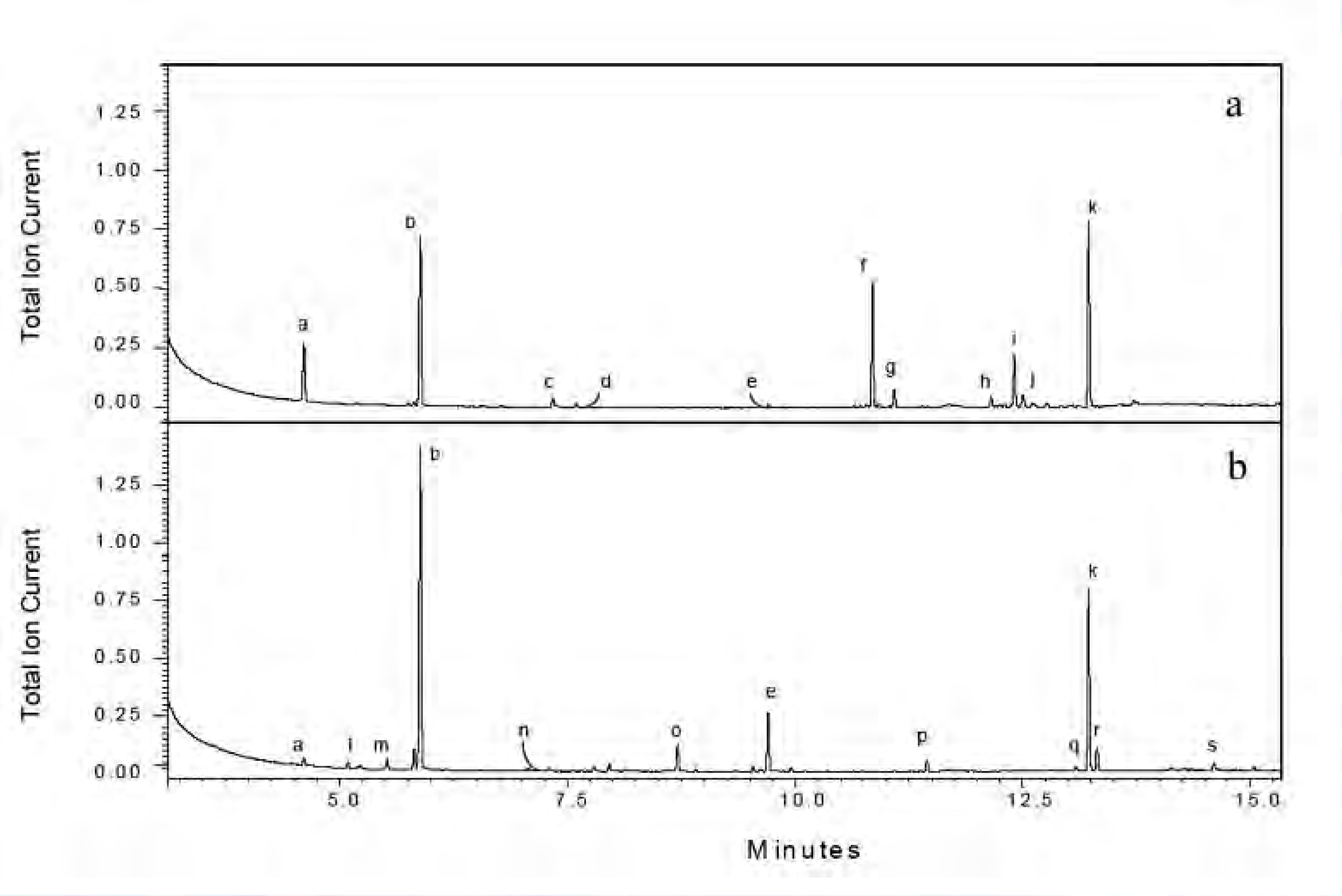
Sorbent Tubes
(charcoal, XAD, etc.)

Tedlar Bags

Liquid Sorbents

On-Line GC

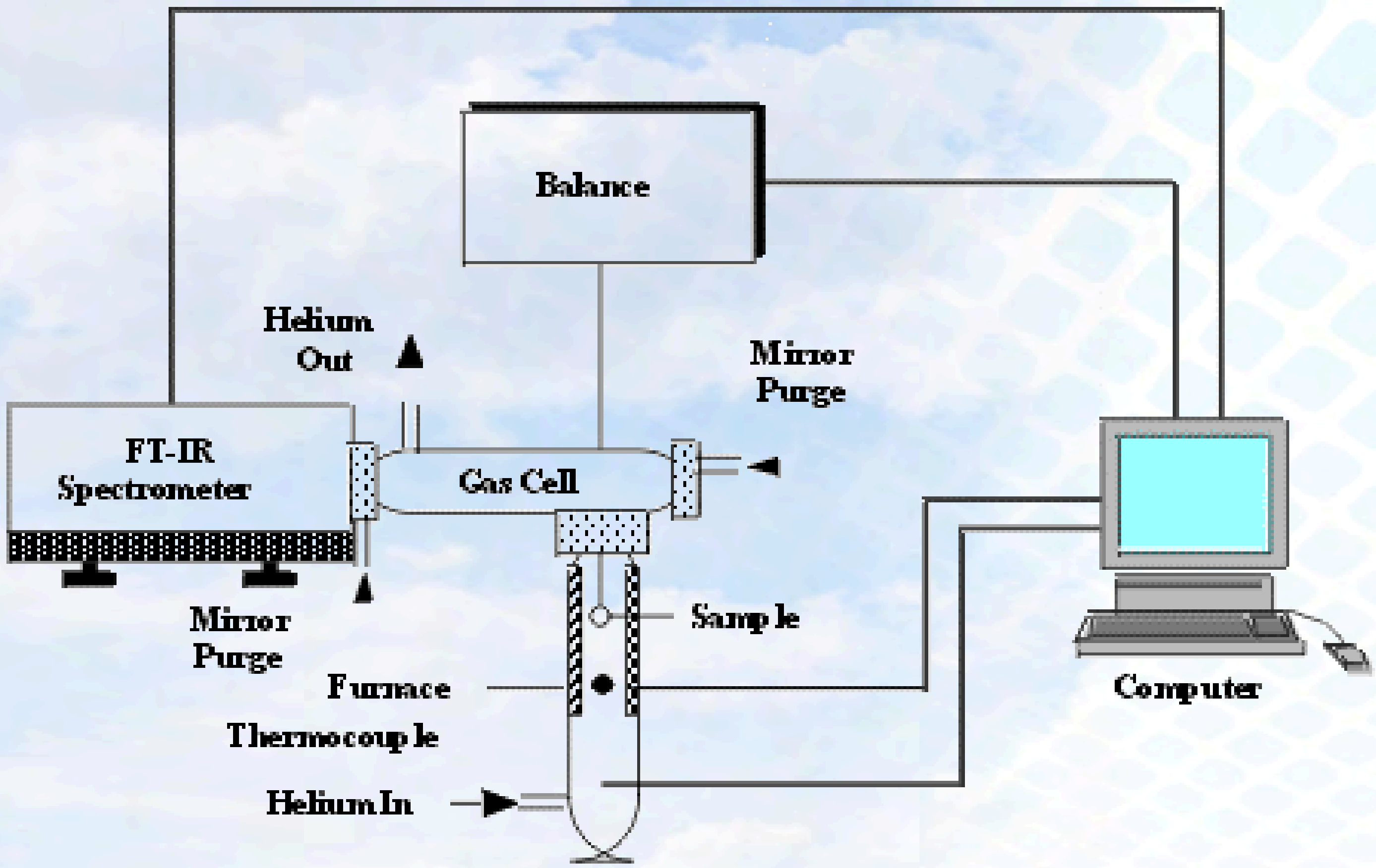
GC/MS Spectra



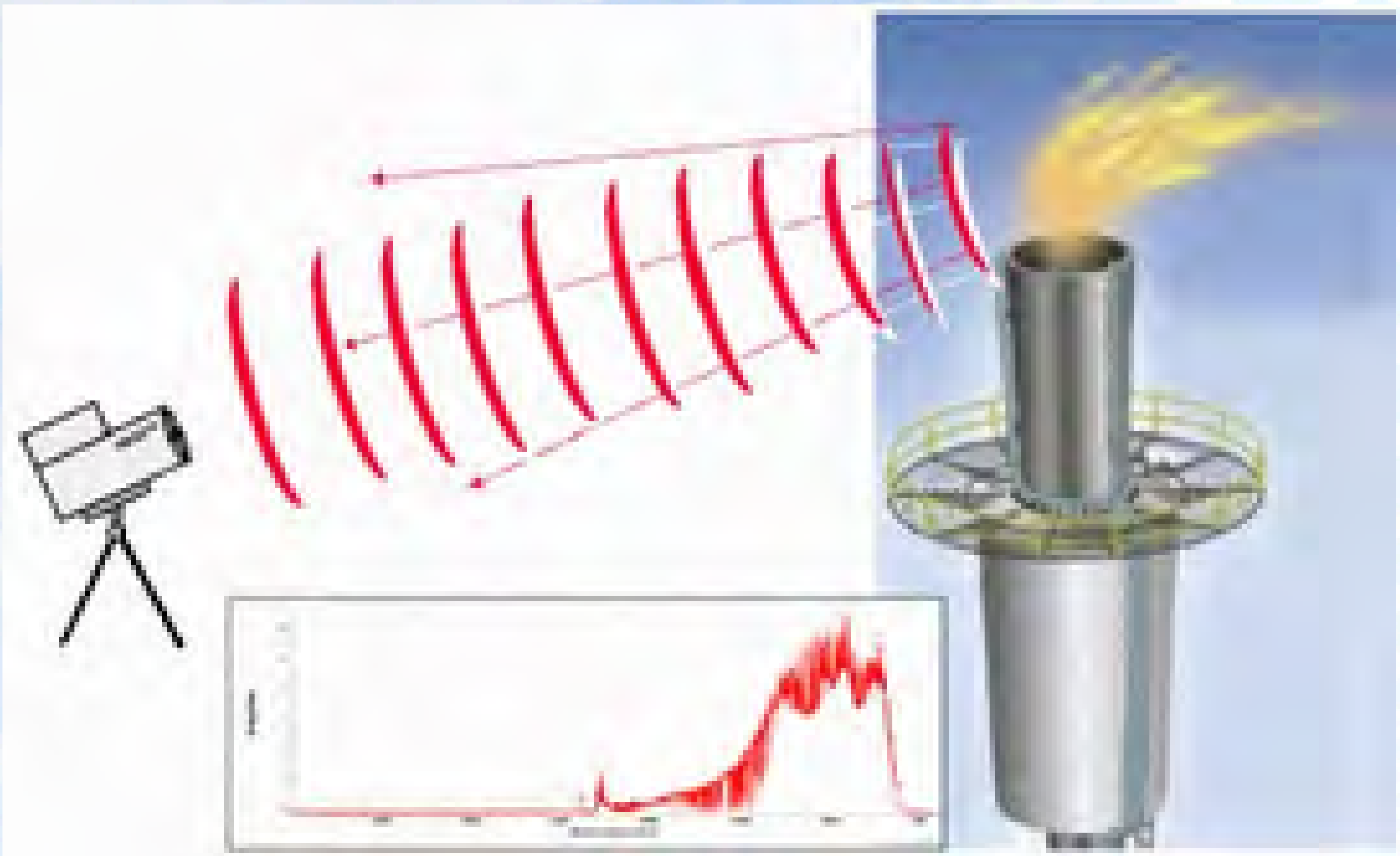
Trace Organic Compounds

- Method 23
  - Dioxin/Furans
- Method 320
  - Fourier Transform Infrared Spectroscopy (FTIR)
- SW-846 0010
  - Semi-Volatile Organics
- TO-15
  - Highly Volatile Organics
  - VOC in Ambient Air

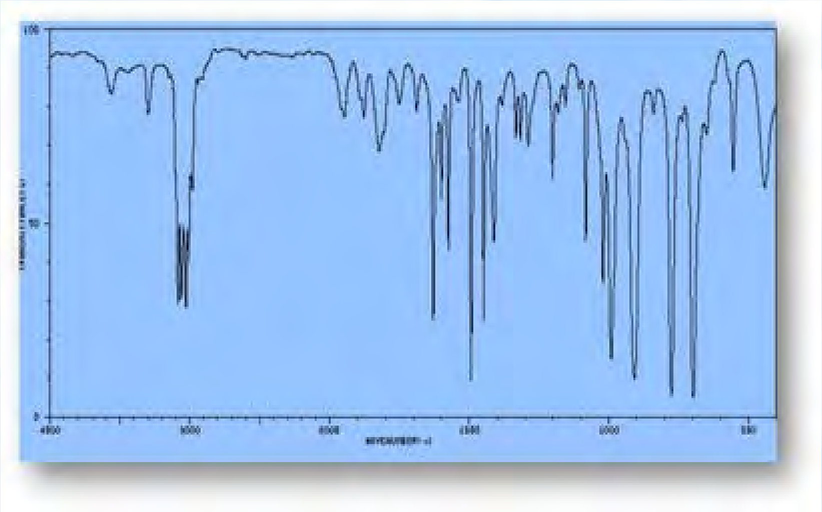
Types of FTIR - Active



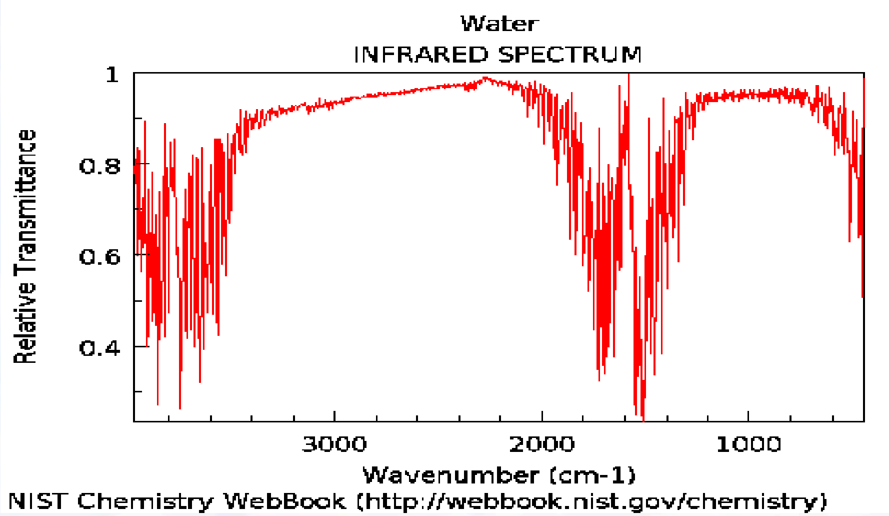
Types of FTIR – Passive (SOF)



FTIR Limitations



Organic Compound Spectra (styrene)

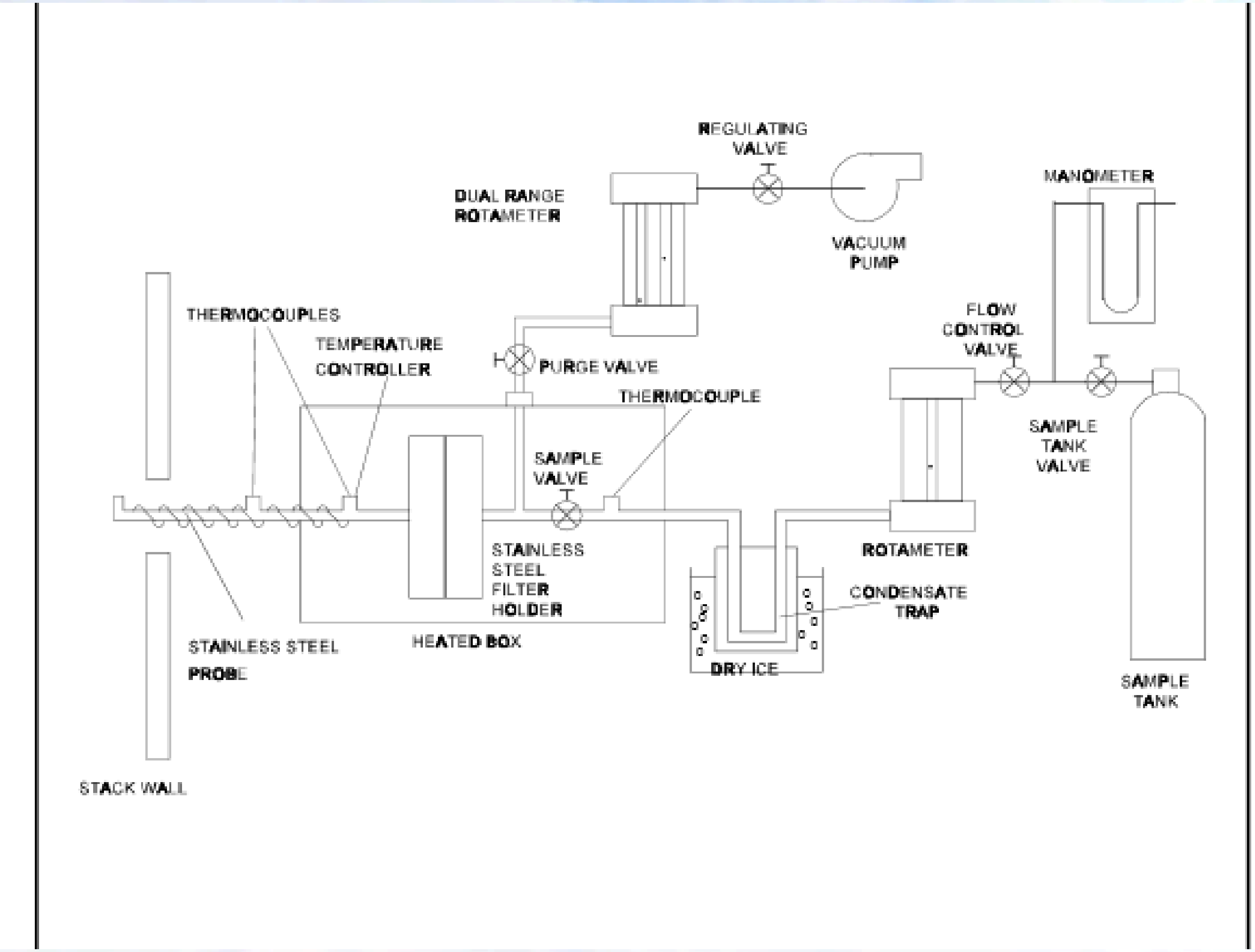


Water Spectra

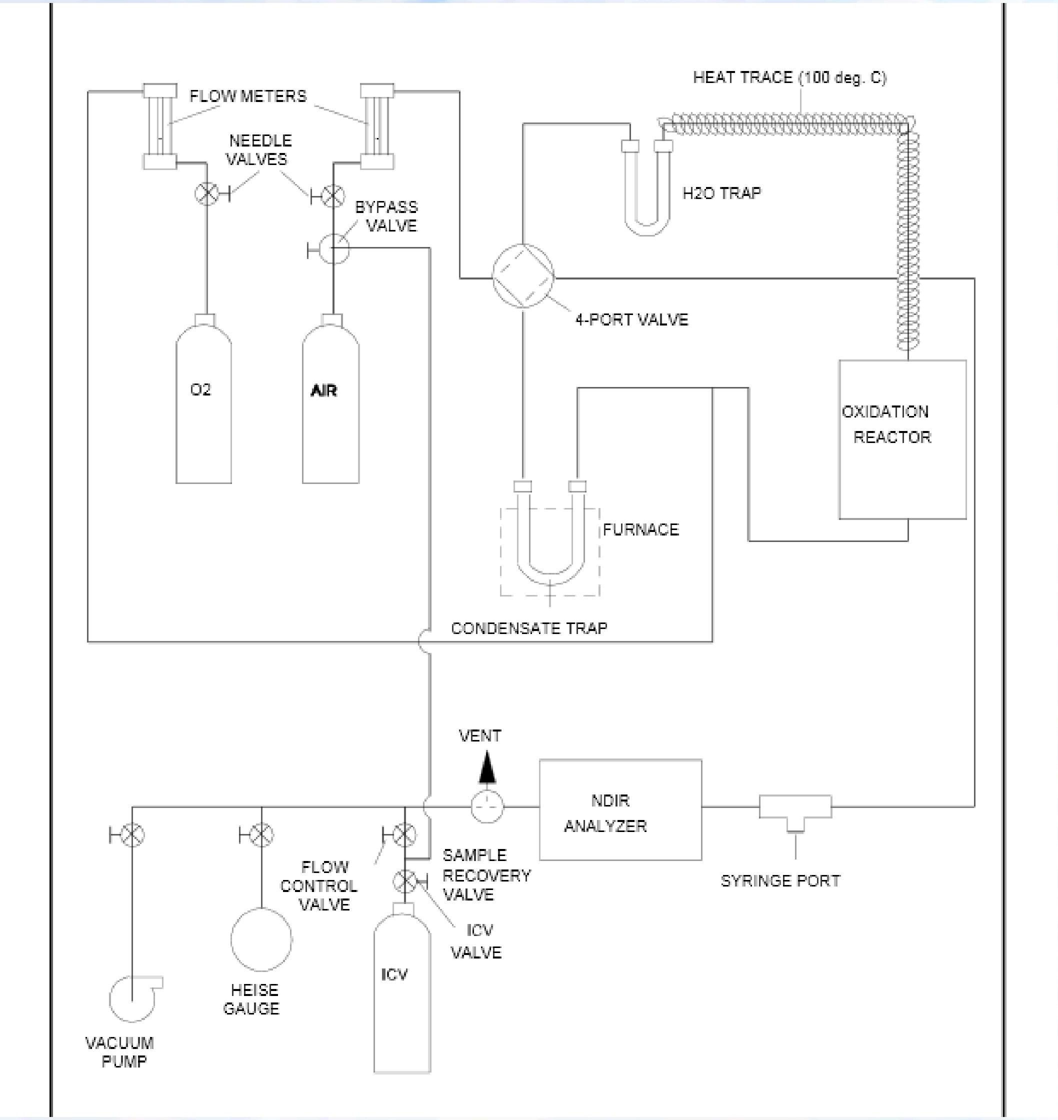
Method 25

- VOC determination (wet method)
- Very interference prone
  - ~1 mg organic contamination = 500 ppm VOC positive error
  - CO_2 and H_2O may also interfere
- Rarely used in US any more
- If forced to use, do duplicates!

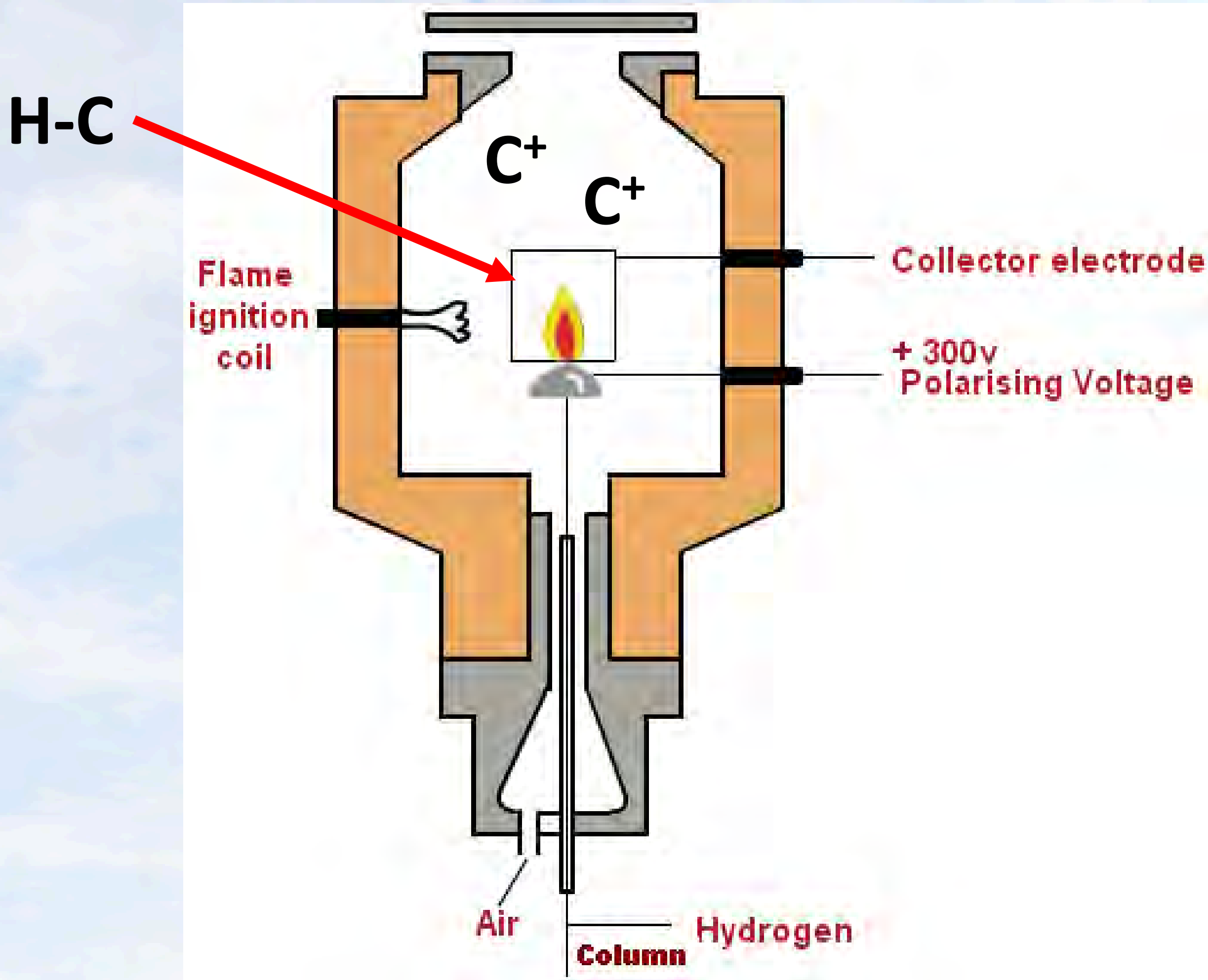
Method 25 – Sample Train



Method 25 – Sample Prep



Flame Ionization Detectors



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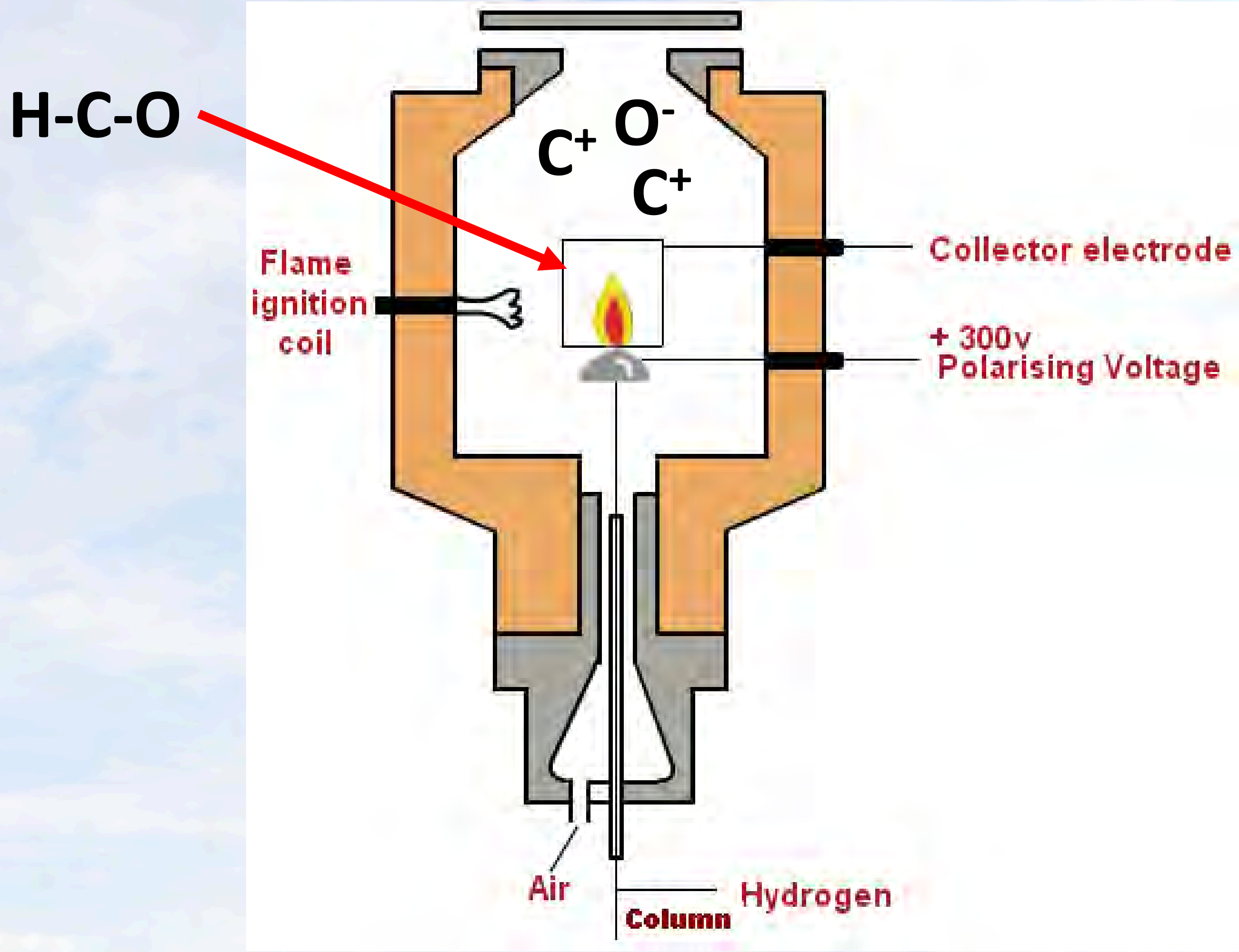

Method 25A

- VOC determination (instrumental method)
- Utilizes Flame Ionization Detector (FID)
- Response factor sometimes an issue
  - Especially very oxygenated or halogenated organic compounds
- Usually calibrate with propane or methane
- Concentrations are **wet**
- Report results “as ______”

Method 25A – Reporting "as"

- 1 ppmv C_3H_8 = 3 ppmv CH_4 = 3 ppmv C

BUT

- 1 mole C_3H_8 = 44 g
- 1 mole CH_4 = 16 g
- 1 mole C = 12 g

SO:

The Mass Emission Rate will change, depending on what compound you assume

Method 25A – Reporting "as"

Example: 450 ppm "as carbon" vs. 150 <u>ppmv "as propane" in 15,000 wscfm</u>

As C:

$450 \times 15{,}000 \times 12 \times 1.554\ x\ 10^{-7}$ = 12.58 lb/hr

As C_3H_8:

$150 \times 15{,}000 \times 44 \times 1.554\ x\ 10^{-7}$ = 15.38 lb/hr

Other Method 25A Notes

- Allowable at Oxidizer outlet in US, if ppmv < 50 ppmv, as methane
- Can subtract methane and ethane in stack (don't count as VOC)
- Other compounds exempt too
  - E.g.: acetone, methyl acetate
- May need higher sample line temps for heavy organics
- High moisture content can cause positive interference

Thank You!