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
What We’ll Cover

1. Planning Considerations
2. Flow Measurement
3. Particulate Measurement
4. VOC Measurement
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
- Permit Conditions
- EPA &/or DEQ Rules
  - New Source Performance Standards
  - NESHAPs
  - PSD or Title V Avoidance

“Formal” Tests
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
What We’ll Cover

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

Laminar Flow

Turbulent or Cyclonic Flow
Pitot Tube Operation

Direction of Air Flow

Static Pressure

Total Pressure

“Delta P”

Type S Pitot Tube

Temperature Sensor

Leak-Free Connections

Manometer
**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

<table>
<thead>
<tr>
<th>Point</th>
<th>Delta P (inches H2O)</th>
<th>Temp (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>0.52</td>
<td>170</td>
</tr>
<tr>
<td>A-2</td>
<td>0.55</td>
<td>172</td>
</tr>
<tr>
<td>A-3</td>
<td>0.55</td>
<td>172</td>
</tr>
<tr>
<td>A-4</td>
<td>0.49</td>
<td>171</td>
</tr>
<tr>
<td>B-1</td>
<td>0.47</td>
<td>173</td>
</tr>
<tr>
<td>B-2</td>
<td>0.54</td>
<td>175</td>
</tr>
<tr>
<td>B-3</td>
<td>0.54</td>
<td>173</td>
</tr>
<tr>
<td>B-4</td>
<td>0.52</td>
<td>173</td>
</tr>
</tbody>
</table>

- **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

<table>
<thead>
<tr>
<th>Point</th>
<th>Delta P (inches H20)</th>
<th>Temp (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>0.43</td>
<td>170</td>
</tr>
<tr>
<td>A-2</td>
<td>0.15</td>
<td>172</td>
</tr>
<tr>
<td>A-3</td>
<td>0.77</td>
<td>172</td>
</tr>
<tr>
<td>A-4</td>
<td>1.2</td>
<td>171</td>
</tr>
<tr>
<td>B-1</td>
<td>1.3</td>
<td>173</td>
</tr>
<tr>
<td>B-2</td>
<td>0.47</td>
<td>175</td>
</tr>
<tr>
<td>B-3</td>
<td>0.35</td>
<td>173</td>
</tr>
<tr>
<td>B-4</td>
<td>0.99</td>
<td>173</td>
</tr>
</tbody>
</table>

Wide variation in Delta P suggests turbulent flow
Method 2 Errors - Example 2

<table>
<thead>
<tr>
<th>Point</th>
<th>Delta P (inches H20)</th>
<th>Temp (oF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>0.52</td>
<td>75</td>
</tr>
<tr>
<td>A-2</td>
<td>0.55</td>
<td>92</td>
</tr>
<tr>
<td>A-3</td>
<td>0.55</td>
<td>110</td>
</tr>
<tr>
<td>A-4</td>
<td>0.49</td>
<td>115</td>
</tr>
<tr>
<td>B-1</td>
<td>0.47</td>
<td>112</td>
</tr>
<tr>
<td>B-2</td>
<td>0.54</td>
<td>117</td>
</tr>
<tr>
<td>B-3</td>
<td>0.54</td>
<td>118</td>
</tr>
<tr>
<td>B-4</td>
<td>0.52</td>
<td>118</td>
</tr>
</tbody>
</table>

Pattern suggests in-leakage or insufficient soak time.
What We’ll Cover

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

> Based on: particle size and gas velocity
Isokinetic Sampling

> Gas Velocity = Sampling Velocity

V = 30 ft/s (+/- 10%)

V = 30 ft/s
Isokinetic Sampling

> Gas Velocity = Sampling Velocity

\[ V = 36 \text{ ft/s} \pm 10\% \]
Isokinetic Sampling

> Gas Velocity = Sampling Velocity

\[ V = 45 \text{ ft/s} \pm 10\% \]
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
<table>
<thead>
<tr>
<th><strong>On Site</strong></th>
<th><strong>Off Site</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>“Immediate” results</td>
<td>Wait and see</td>
</tr>
<tr>
<td>Can adjust process as obtain results</td>
<td>Make return trip if results not OK</td>
</tr>
<tr>
<td>Requires facilities</td>
<td>No extra facilities</td>
</tr>
<tr>
<td>Extra cost</td>
<td>Less expensive</td>
</tr>
</tbody>
</table>
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 ft³

SO:

1 hr PDL = 5 mg/30 ft³ (0.0026 gr/dscf)

4 hr PDL = 5 mg/120 ft³ (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
Artificial PM can form - e.g.:

> \( \text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 \)
> \( \text{H}_2\text{SO}_4 + \text{NH}_3 \rightarrow (\text{NH}_4)\text{SO}_4 \)
> \( \text{HCl} + \text{Na} \rightarrow \text{NaCl} \)
> \( \text{HNO}_3 + \text{NH}_3 \rightarrow \text{NH}_4\text{NO}_3 \)
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
What We’ll Cover

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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
  - CO₂ and H₂O 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
Flame Ionization Detectors

H-C-O

C⁺ O⁻ C⁺

Flame ignition coil

Collector electrode

+ 300V Polarising Voltage

Air Hydrogen Column
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 ppmv “as propane” in 15,000 wscfm

As C:

\[ 450 \times 15,000 \times 12 \times 1.554 \times 10^{-7} = 12.58 \text{ lb/hr} \]

As C\(_3\)H\(_8\):

\[ 150 \times 15,000 \times 44 \times 1.554 \times 10^{-7} = 15.38 \text{ lb/hr} \]
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!