Technology for Measurements

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INTRODUCTION

- Two of the most difficult things to measure in the air quality field:
  - Fugitive emissions
  - Flare efficiency
- Fugitive emissions and flare emissions are both significant sources of VOCs and methane
- Significant advancements have been made in recent years which address both of these difficult to measure emissions
  - Optical Gas Imaging (OGI)
  - Direct measurement of flare combustion efficiency (CE)
MEASURING FUGITIVE EMISSIONS
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- Looking back over the past three decades
  - Leak Detection and Repair (LDAR) program and EPA Method 21
  - Smart LDAR and 2008 EPA Alternative Work Practice (AWP) rule
  - Shortcomings of the current program and desire for better technology
- What has happened in recent years?

Method 21

OGI Technology
**MEASURING FUGITIVE EMISSIONS**

- OGI is advancing from the era of “trial-and-error” to a standard practice guided by validated theory

**Fundamental Equation for OGI:**

\[ \Delta l = I_B - I_G \]

\[ = \left[ B(T_B, \lambda) - B(T_G, \lambda) \right] \{1 - \exp[-\alpha(\lambda)CL]\} \]

- No \( \Delta T \) \([B(T_B,\lambda) = B(T_G,\lambda)], no gas image\)
  - No IR peak \([\alpha(\lambda)=0], no gas image\)
  - No gas \([CL=0], no gas image\)
How has the theory of OGI helped us?
– Tool 1: Response Factors for nearly 400 compounds
How has the theory of OGI helped us?
- Tool 2: Leak survey validation to avoid a false negative result

If I don’t see a leak, does it mean that there is no leak?
How has the theory of OGI helped us?

- Tool 3: Quantitative Optical Gas Imaging (QOGI)

Can you tell which leak rate is higher?

0.48 lb/hr

0.48 lb/hr
How has the theory of OGI helped us?

– Tool 3: QOGI (cont’d)

QL100: to be used with FLIR GF300 or GF320

User input:
• Ambient temp.
• Distance from camera to leak point

– QL100 quantifies and reports the mass emission rate
– Units of g/hr, lb/hr, or scc/min
IDAR programs solely rely on Method 21. No one actually uses AWP for compliance
- Measures ppm, not mass emission rate
- PPM is not necessarily correlated to leak rate

Small leak area (single point) Large leak area (diffused leak)
Same leak rate (500 cc/min propane), order of magnitude difference in ppm readings

R²: 0.32-0.54
Source: EPA 1995 Leak Detection Protocol
App. B, Fig. B-3
GAP BETWEEN TECHNOLOGY AND REGULATIONS

Source: EPA 1995 Leak Detection Protocol, App. C, Fig. C-3
Benefits Brought by Technology

- Directly measure emission rate (lb/hr) instead of concentration (ppm).
- Provide a real alternative to the 30-year old inadequate and expensive “sniffing” method (not maintain two sets of methods), and truly practice “Smart LDAR”
MEASURING FLARE PERFORMANCE
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- Current regulations
  - 40 CFR 60.18
    - No visible emissions
    - Presence of flame (pilot)
    - Tip velocity < 60 ft/sec
    - Vent gas Net Heating Value (NHV) > 300 Btu/scf.
  - 40 CFR 63.670
    - Compliance deadline: 1/30/2019
    - Most significant changes:
      - Continuous monitoring
      - Combustion Zone NHV (CZNHV) > 270 Btu/scf.

- All based on measurement on what goes into the flare (not how flare performs) and assumptions derived from limited tests

There is no practical method to directly monitor flare performance … until now
MEASURING FLARE PERFORMANCE

Introducing the Video Imaging Spectro-Radiometer (VISR)

- VISR is a multi-spectral imager. It directly measures relative concentrations of combustion product, carbon dioxide (CO$_2$), and unburned hydrocarbon (HC) in the flame, and calculates flare combustion efficiency (CE) in real time.
VISR flare monitor has been field tested and validated through a series of extractive tests
- It is now commercially available
- Extremely easy to operate
- Lower cost
New regulations are based on the assumption that CZNHV > 270 BTU/scf equates to high CE

Testing shows that CZNHV is inadequate as a surrogate for flare performance

2014 Test data with both VISR and extractive methods measuring CE

Out of 20 test points
  - CZNHV only worked 7 out of 20 tests
  - Failed 13 out of 20
2016 Test Data
- Out of 28 test points
  - CZNHV worked 16 out of 28
  - Failed 12 of 28. Some of them failed by a wide margin
- Using CZNHV could under or over regulate (significantly more cases of over-regulating)
  - CZNHV > 270 BTU/scf but flare CE is very poor
  - CZNHV < 270 BTU/scf but flare CE is very good
Benefits Brought by Technology Advancements

- Direct measurement of CE is now possible, no assumptions and ambiguity
- Fast response time, less deviations/violations
- No wasted supplement fuel
  - Cost savings
  - Reduced emissions (environmental benefit)
- Remote measurement
  - Easy to maintain
  - No need to wait for turn around, no costly unplanned shutdown
- Fewer instruments to maintain
- Close loop flare operation/optimization
- Lower cost than the surrogate methods
- One VISR device monitors more than one flare – further cost saving
**Benefits Brought by Technology**

- Additional metrics for flare optimization
  - SI (Smoke Index) – Combined with measured CE to achieve incipient smoke point
  - FS (Flame Stability)
  - FF (Flare Footprint) [or flame length]
  - HR (Heat Release)
  - Monitor pilot flame

- Potential to simplify the regulations

<table>
<thead>
<tr>
<th>EPA Rule 40 CFR Part 63</th>
<th>Purpose of Rule</th>
<th>Can VISR Cover It?</th>
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<tr>
<td>§63.670 (b)</td>
<td>Presence of pilot flame</td>
<td>Yes</td>
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<tr>
<td>§63.670 (c)</td>
<td>No visible emission</td>
<td>Yes</td>
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<tr>
<td>§63.670 (d)</td>
<td>The three requirements are designed to ensure sufficient CE through surrogate parameters</td>
<td>Yes</td>
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<tr>
<td>§63.670 (e)</td>
<td></td>
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<td>§63.670 (f)</td>
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There have been quantum leaps in OGI and flare monitoring technologies in recent years.
New technologies can bring significant benefits to industry, economy, and environment.
Environmental regulations are becoming outdated and inadequate as technology advances.
Regulatory mechanisms for adoption of new technology exist (in some cases), but the approval procedures are slow and cumbersome.
Changing regulations to keep up with technological advances would be a better solution for both industry and the environment.
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