CEMS for Measurement of Ammonia, SO_3, and Low Level NOx

McIlvaine Company Hot Topic Hour

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Presentation Overview

- Compliance versus process control
- In situ versus extractive
- EPRI monitor evaluation approach
  - Lab assessment
    - Establish monitor accuracy
  - Field demonstration
    - Operability and reliability characteristics
  - Cost benefit application demonstration
- Low level NOx measurement
- Ammonia measurement
  - Issues and approaches taken to address
  - Successful applications
- SO_3 measurement
  - $SO_3 + H_2SO_4$

Compliance vs Process Control

- Compliance Measurements
  - Stack gas application
    - Near particulate free
    - Lower temperature
  - Representative average concentration
  - Daily zero & span checks
  - Span gases meet NIST traceability standards
  - Quarterly and annual QA/QC requirements
  - Availability
- Process Control
  - Economizer exit / air heater inlet applications
    - Ash particles
    - Higher flue gas temperature (i.e. 650 +/- 50 F)
  - Spatial differentiation more important
  - Less rigorous QA/QC required
  - Typically less documentation

In Situ vs. Extractive Measurement

- Issue of getting reactive species to monitor favors ***in-situ* methods**
  - Typically dealing with trace level concentrations
  - SO_3 / NH_3 reactive with potential reactions including:
    - $SO_3 + H_2O \longrightarrow H_2SO_4$ Acid dewpoint
    - $SO_3 + CaO_{(s)} \longrightarrow CaSO_{4\ (s)}$ < 2000 F
    - $NH_3 + SO_3 + H_2O \longrightarrow (NH_4)HSO_{4\ (l)}$ 400–500 F
    - $2NH_3 + SO_3 + H_2O \longrightarrow (NH_4)_2SO_{4\ (s)}$ 400–500 F
  - Sample stream temperature needs to be maintained above highest reaction temperature
  - Potential impacts of sample stream contact with filtration media
- In situ measurements provide potential benefits over extractive approach
  - Limited measurement bias
  - Faster system response
  - Line of sight measurements more representative relative to single point

EPRI Monitor Evaluation Approach

Three Step General Approach

1. Laboratory Assessment
   - Establish accuracy, detection limits, and possible interferences
     - Test over range of target gas concentrations and cell conditions
       - Vary temperature, moisture, background gas composition
2. Single Path Field Demonstration
   - Establish operability and reliability characteristics
     - Test over range of path lengths with particulate laden flue gas
     - Assess alignment and signal to noise ratio over time and operating conditions
     - Assess maintenance requirements
3. Cost Benefit Application Demonstration
   - Structured test with end use of data stream (i.e. process control, operator advisory, etc.)
   - Document implementation specification, capital and installation costs, benefits from end use

CEM Measurement of Low Level NOx

- Important issues identified
  - Instrument Performance
  - NO_2 - NO Converter
  - Linearity / Drift Studies
  - Sample Conditioning Systems
  - Sample Lines

CEM Measurement of Low Level NOx

NO_2 Converter Efficiency

Converter Type	Efficiency %
Molybdenum	96.9
Molybdate-Carbon	94.3
Molybdate-Carbon (hot & wet)	85.5
Stainless Steel	97.3
Vitrous Carbon (hot & wet)	83.3

wet

Linearity and Drift

Converter Type	Linearity	Zero Drift	Calibration Drift
Molybdenum	0.9999	0.26	0.24
Stainless Steel	1.0000	0.74	0.13
Moly-Carbon	0.9999	0.29	0.82
Vit.-Carbon h/w	0.9997	NA	NA
Moly-Carbon h/w	0.9985	1.24	6.07

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CEM Measurement of Low Level NOx

Sample Conditioning Systems

- Dilution extractive
- Permeation dryer
- Thermoelectric cooler (impinger type)
- Refrigerated (coil type) condenser
- Glass impingers in ice bath
- Duel type (ambient temp. water removal followed by permeation dryer)

Sample Lines

- Stainless Steel 25°C
- Stainless Steel 175°C
- Silcosteel 107°C
- Silcosteel 175°C
- PFA Teflon 107°C
- Dilution extractive sampling probe
- Hot converter & analyzer
- Upfront converter/thermal-electric

Ammonia Measurement Status

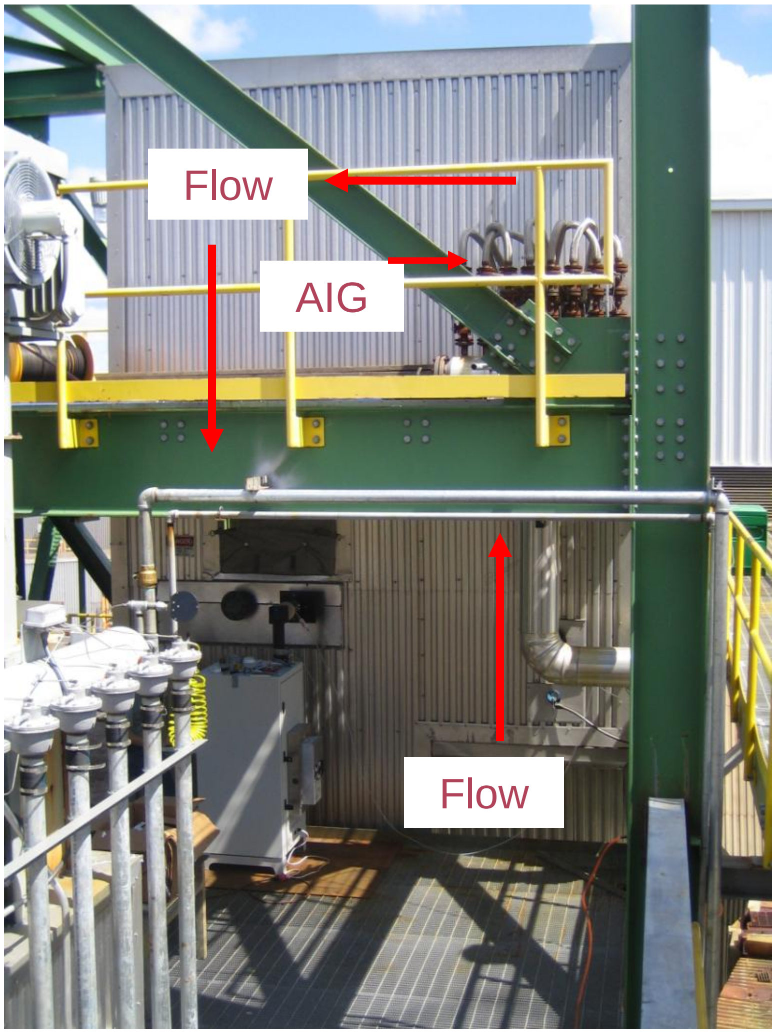
- Lab evaluations indicate TDL ammonia monitors tested work well under controlled conditions
- Application to coal-fired boilers introduce complications
  - Optical measurement issues
    - Port installation and alignment
      - Laser signal implications
    - Variable fly ash in flue gas
      - Laser beam attenuation and variable S/N
    - Long path lengths (reduced power and maintenance of alignment)
  - Current uses
    - Non-spatially resolved measurements for data trending
    - Spatially resolved measurements for open loop control
    - Process control and/or optimization

Ammonia Monitor Field Applications

- **Successful ammonia monitor field applications**
  - SCR process control with NEO monitor
    - 1200 MW unit
    - 15’ line of sight cuts corner of reactor
      - Excellent mixing going into SCR
      - Just downstream of expansion joint
  - SNCR process control with Siemens monitor
    - 140 MW unit
    - Hot side ESP eliminates particle effects
    - Nominal 18 foot path length
  - SNCR process control with Unisearch monitor
    - 300 MW unit
    - Partial shielded path
      - Reduces 20’ path to ~14’ path

Continuous SO_3 Measurements FTIR Measurement Location

SCR Inlet



- **MRC FTIR tests not able to attain target detection limit for SO_3**
  - New high power IR source developed
  - Increased signal to be tested for improved SO_3 detection
- **FTIR used at MRC for continuous monitoring of HCl, SO_2, NH_3 during SCR testing**
  - FTIR results used to vary additive injection rates to compensate for variations in coal used
- **System operated completely by MRC personnel**
- **System maintained alignment over 2 meter path after restarting of SCR**