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Thermo Scientific PM CEMS

October 2011

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The world leader in serving science

Headlines

- Thermo Fisher Scientific: The world leader in serving science
- Recent regulations are requiring the use of PM CEMS
- PM CEMS overcome the significant limitations of Opacity Monitors
- Many existing PM CEMS technologies use surrogate methods
- Thermo Scientific PM CEMS applies an advanced hybrid approach

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Global Industry Leadership

We are the leading provider of analytical instruments, equipment, reagents and consumables, software and services for research, analysis, discovery and diagnostics.

The world leader in serving science

Scale
- $10 billion in revenues
- 35,000 employees in 40 countries
- 350,000 customers in 150 countries
- #234 on Fortune 500

Depth
- Innovative products
- Applications expertise
- Productivity partner

Leading Brands
- Thermo Scientific: innovation
- Fisher Scientific: convenience

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Air Quality Instruments Overview

- Headquartered in Franklin, Massachusetts
- Three global manufacturing sites, four systems integration facilities
- Global sales presence, more than 100 distributors in 30+ countries
- More than 100 products using innovative, advanced technologies

Ambient Air

Source

Industrial Hygiene

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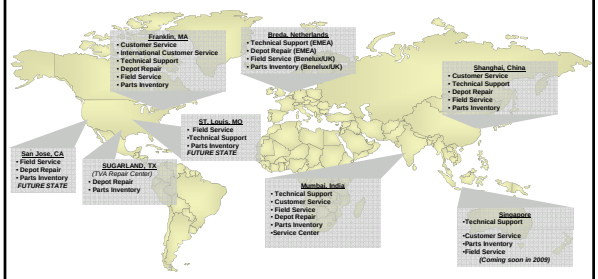
Global CEMS integration and Service locations



Global resources, local support

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Three Recent MACT rules require PM CEMS

- Utility MACT (proposed on May 3, 2011)
  - Coal-fired, IGCC and solid-oil derived fuel sources
  - Filterable PM measurement will be a surrogate for non-Hg metals
  - PM CEMS will also replace the need for opacity monitors
- Industrial Boiler MACT (indefinitely postponed)
  - Units combusting coal, biomass, or residual oil with heat input capacities of 250 MMBtu/hr or greater
- Portland Cement MACT (compliance by October 2013)
  - PM CEMS required at exhausts of cement kiln and clinker cooler

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Opacity monitors have many limitations

- Light attenuation measurement is surrogate
- Adversely affected by
  - Particle size, shape, density changes
- Measures liquid drops as PM
- Not sensitive to low PM concentration
- Correlation to PM mass concentrations not linear

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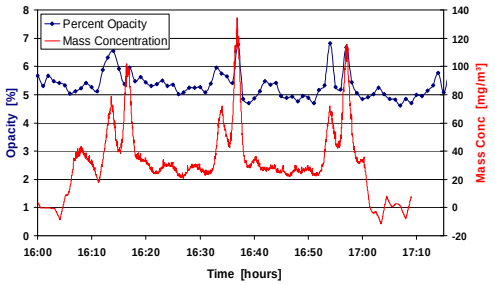
Inertial Microbalance Stack Sampler vs. Opacity



Plot demonstrates that opacity monitors do not respond to changes in particulate concentrations

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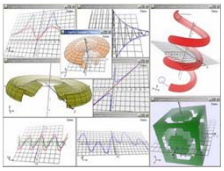
Most measurement methods are surrogate

- Light scattering — *f* (scattered light)
- Beta attenuation — *f* (beta reduction)
- Light extinction — *f* (attenuation of light)
- Inertial microbalance — *f* (frequency)



Surrogate methods are inadequate for particulate measurement under varying plant conditions

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Thermo Scientific PM CEMS uses a hybrid method

- Measures filterable particulate, in accordance with PS-11
- Hybrid technology combines the light scattering and inertial microbalance methods
- Methods 5 and 17 are the reference methods used for comparison
- Early R&D effort was targeted at measuring primary particulate
- Field demos performing under different plant conditions

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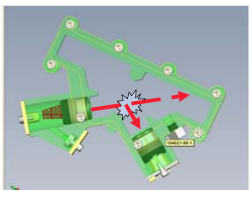
CEMS Design - Light Scattering

Strengths

- Easy to install
- Low maintenance
- Sensitive to low PM concentration



Limitations

- Indirect mass measurement
  - Measures secondary properties of PM
- Affected by particle size, density, shape
- IR light better than visible light
- Measures liquid drops as PM

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CEMS Design - Inertial Microbalance

- Real-time Mass Measurement
- NIST Traceable Mass Sensing
  - Direct relationship between mass and frequency change
  - Tapered element oscillates at its natural frequency
  - Frequency decreases with accumulation of mass on filter
- ASTM D 6831-02
  - Equivalent to Methods 5 and 17
  - Recently Renewed
- Limited Duration for sampling

TEOM creates the possibility of self-referencing

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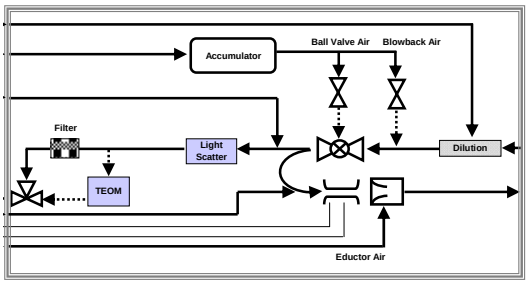
Functional block diagram of PM CEMS



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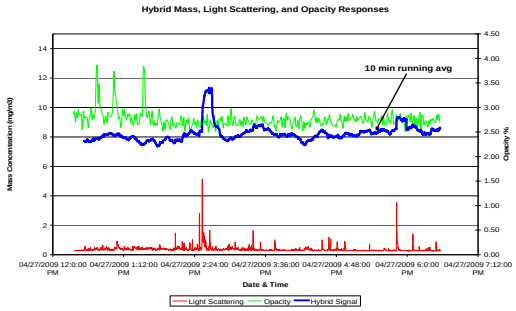
Hybrid Signal- 2009 Testing Coal w/Baghouse



Early testing depicting hybrid signal for true continuous measurement

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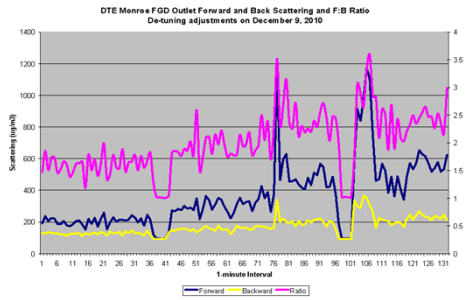
PM CEMS Prototype Installation at DTE Monroe, MI



Changing forward to backward scattering ratio points to variations in particle size characteristics

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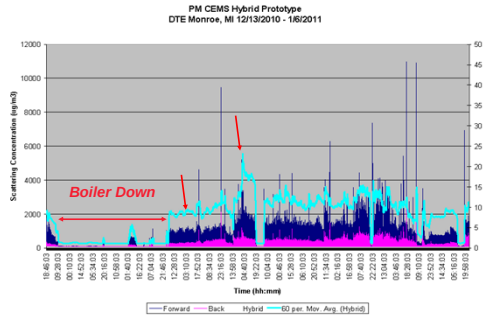

No particles go unseen…

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Summary

- Hybrid PM CEMS uses light scattering calibrated to an inline TEOM
- TEOM offers traceability to NIST standards
- Dual scattering is a dynamic “indicator” of change in particulate characteristics and/or can be a diagnostic tool
- Technology expected to support evolving industrial process needs
- Beta testing beginning in Fall 2011
- PS-11 Correlation testing is meeting U.S. EPA requirements

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