PM CEMS and PS11 & Procedure 2

National Lime Association
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Terminology

- Particulate Matter Continuous Emission Monitoring Systems (PM CEMS)
- Performance Specification 11 (40CFR60 Appendix B, PS 11)
- Procedure 2 (40CFR60 Appendix F, Procedure 2)

Types of PM Monitors

- **Light Attenuation (Extinction)**
- **Light Scattering**
  - **Back Scatter**
  - **Side Scatter**
  - **Forward Scatter**
- **Beta Radiation Attenuation (PM on Filter)**
- **Other Techniques**
  - **Scintillation**
  - **Charge Transfer “Triboelectric” or Modulation “Electrodynamic”**

All PM Monitors are Inferential Measurement Devices

- Instruments sense parameters related to PM concentration
- PM calibration established by correlation of output to independent measurements
- Instrument stability checked by audit filters or audit devices
- Instruments can not be directly calibrated with “PM standards” equivalent to calibration gases

Basic EPA PS11 Approach

- Minimal Equipment Specifications
- Technical Burden Transfers to User
- Conduct 7-Day Zero and Upscale Drift Test
- Establish Calibration through Correlation to Manual Test Method (i.e., Method 5 or alternative)
- Record Emissions in Units of Standard
  - Requires Concurrent Monitoring of Effluent Flow Rate and Clinker Production Rate for Cement Kilns and Clinker Coolers

Basic EPA Approach

- Patterned after ISO 10155 Method
- Minimal Equipment Specifications
- Technical Burden Transfers to User
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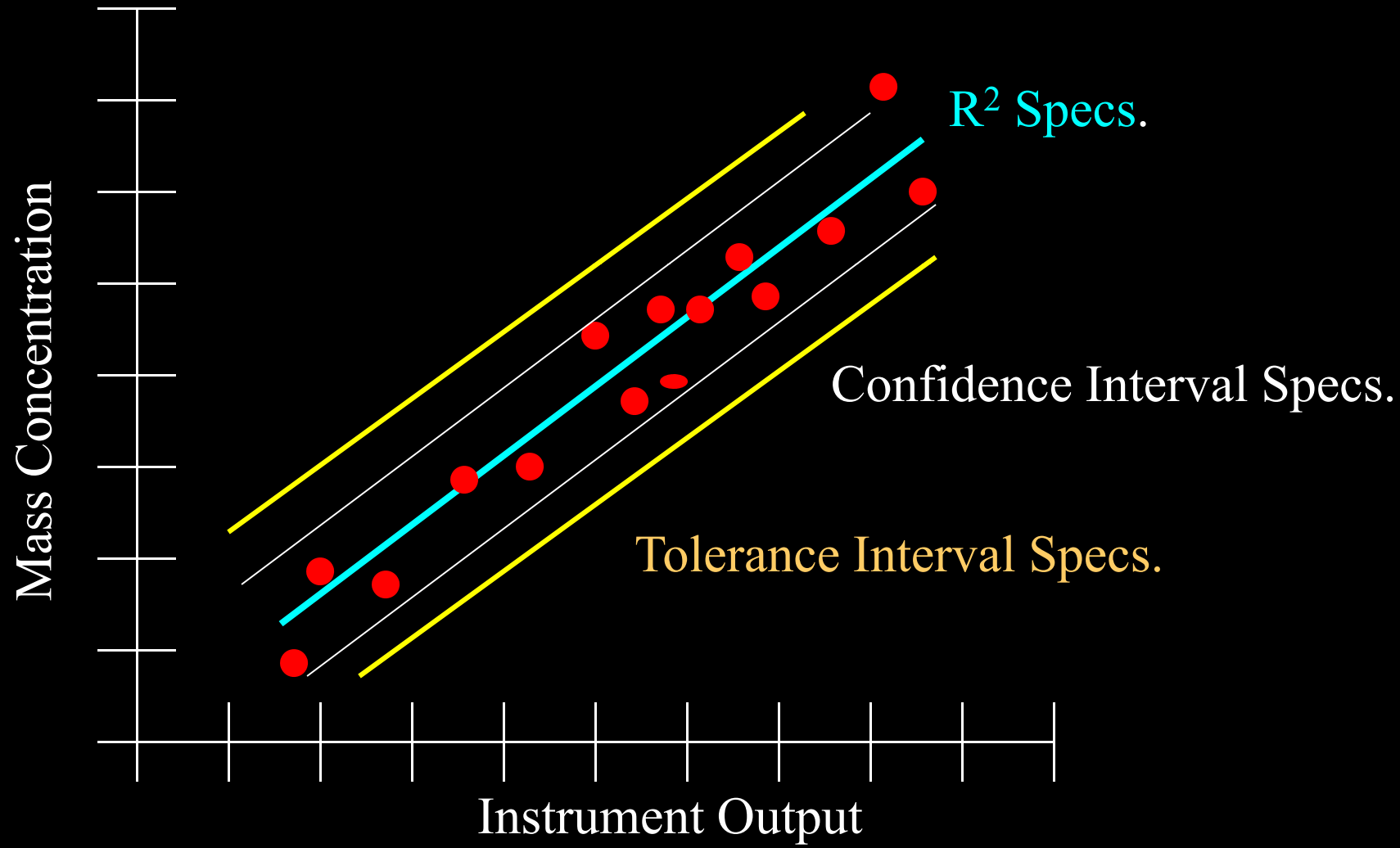
- Record Emissions in Units of Standard

PM CEMS "Calibration" Established by Comparison with Manual Testing



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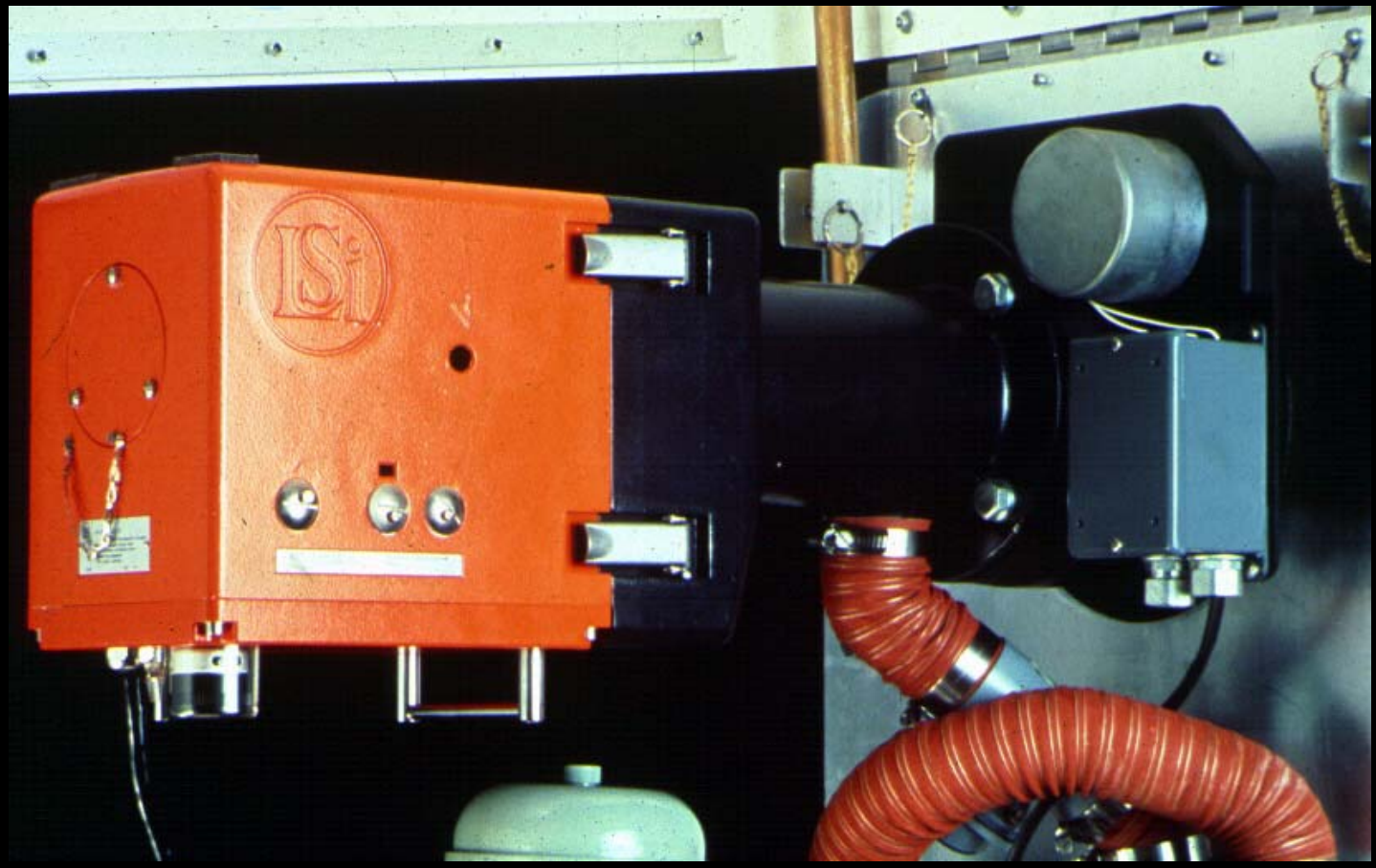
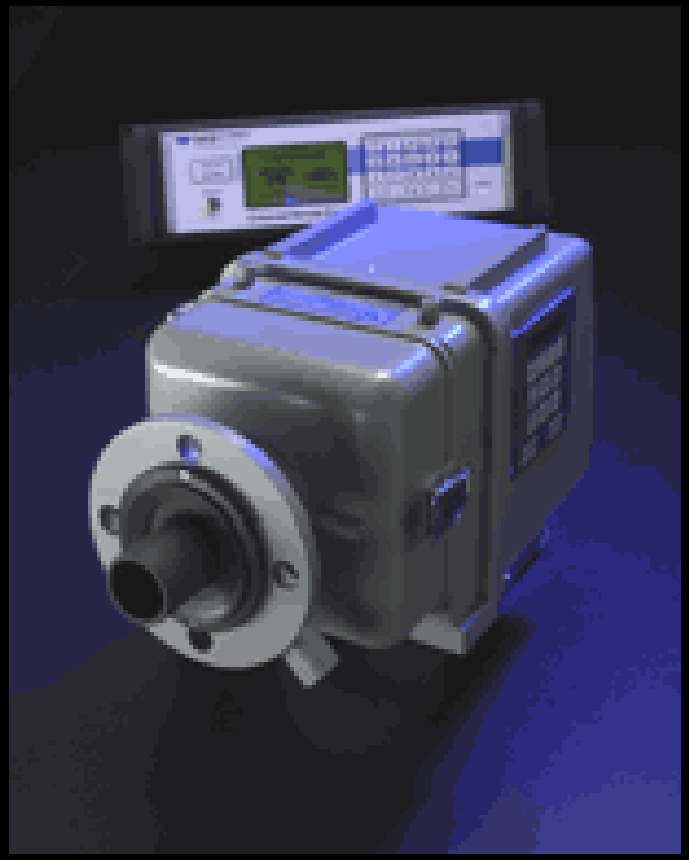

LSi

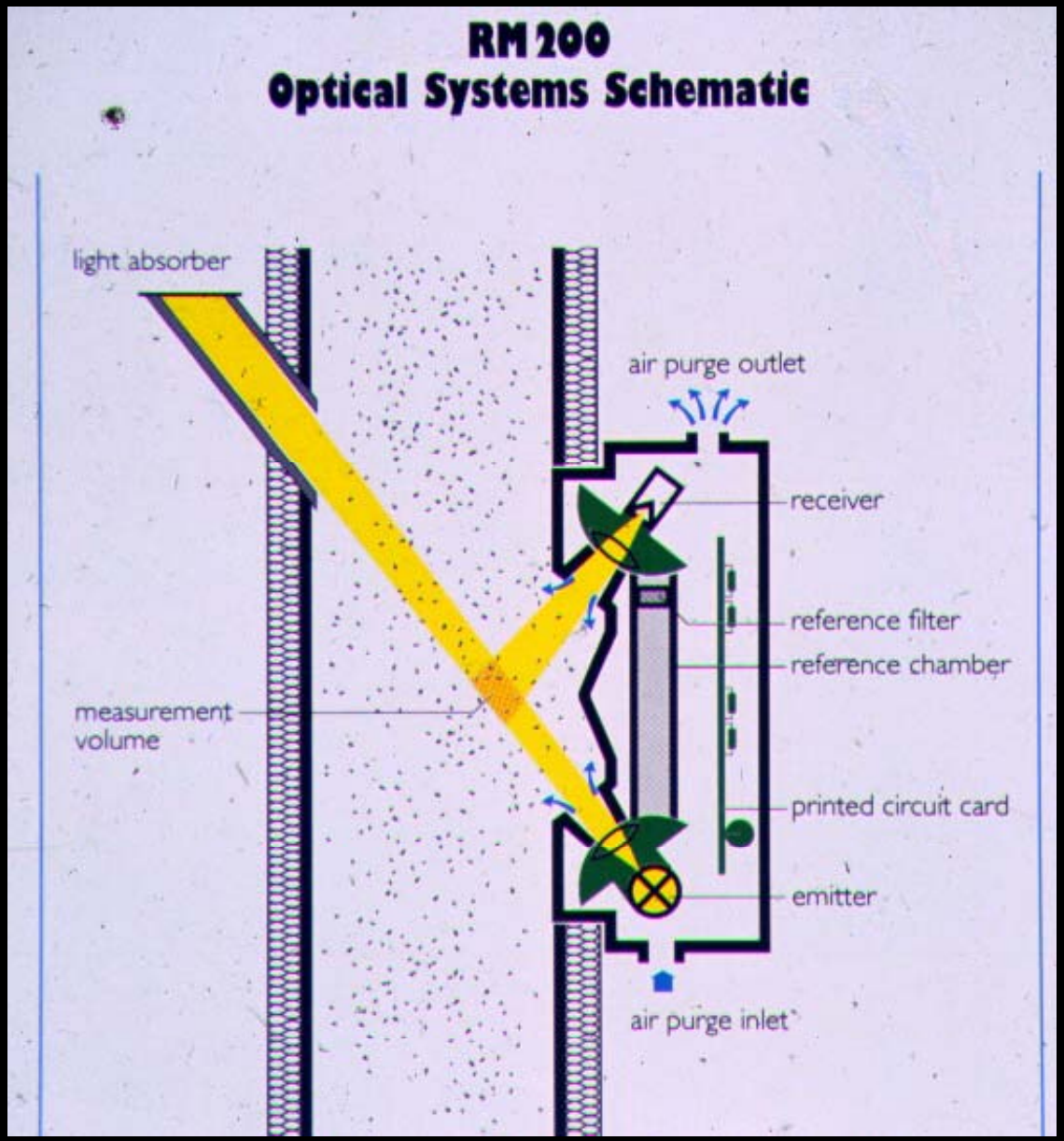
LightHawk 560
COMS or PM Detector



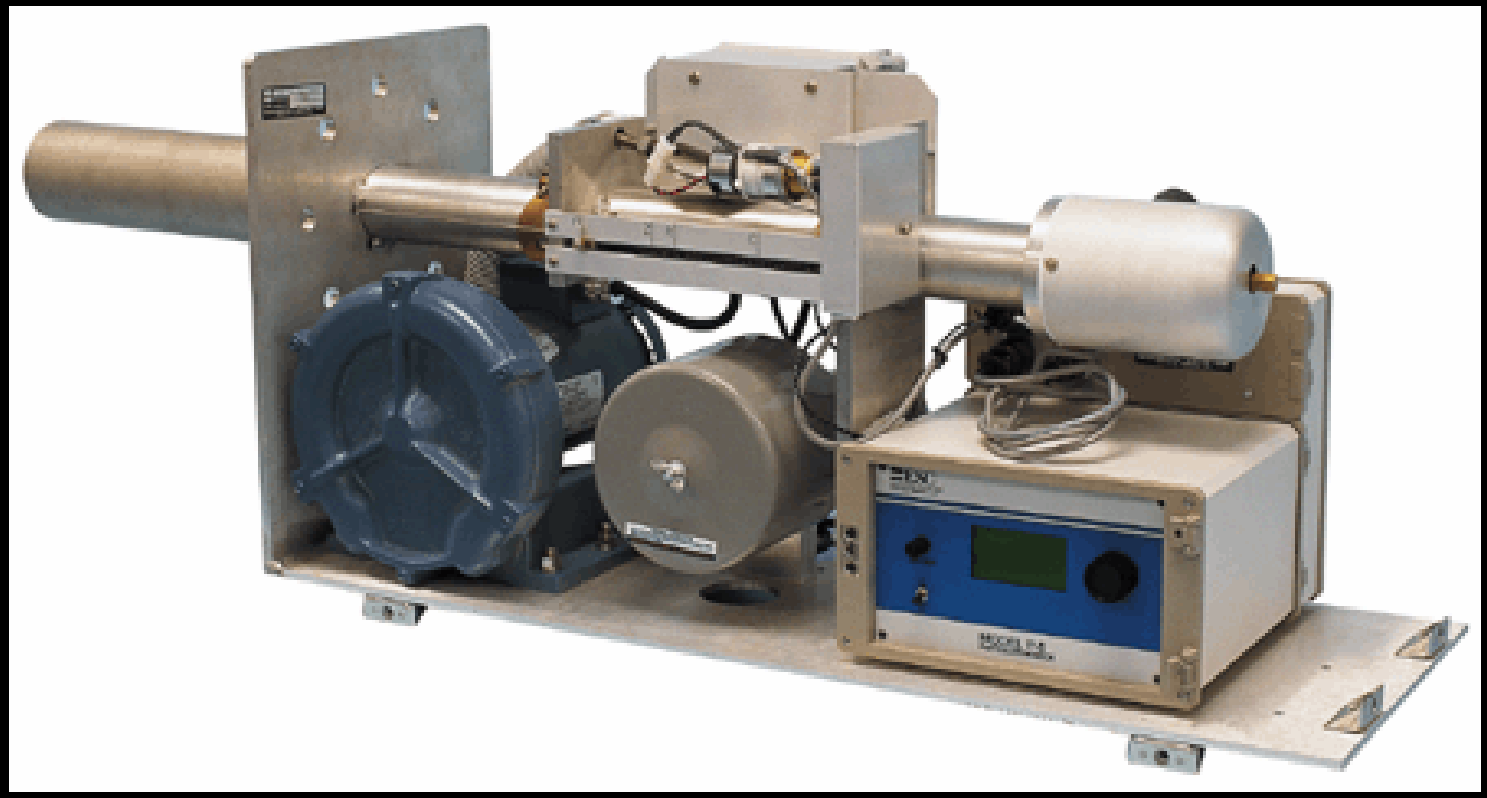
Sick Optic

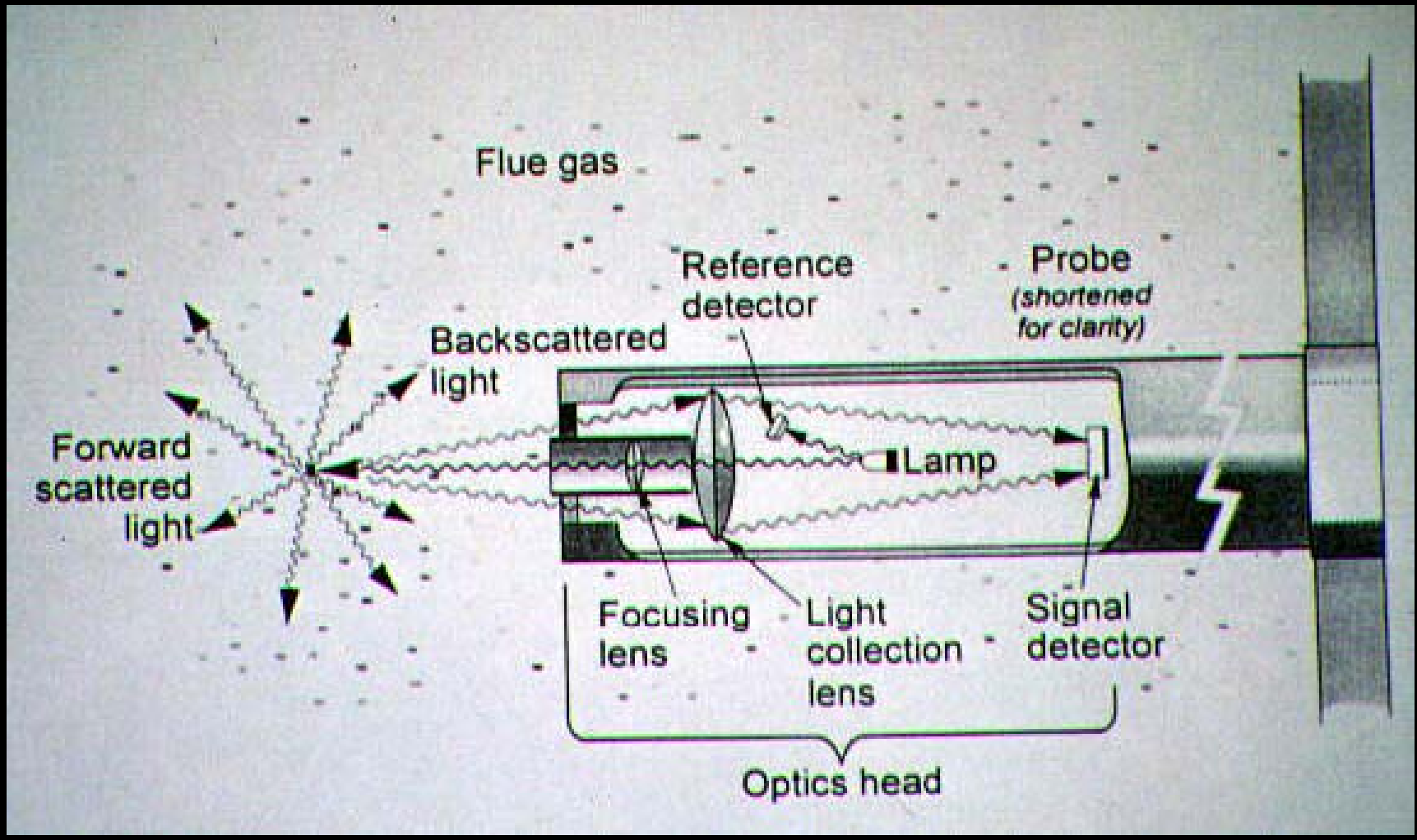
RM210
Particulate Monitor

RM 200
Optical Systems Schematic



ESC Model 5B Particulate Monitor

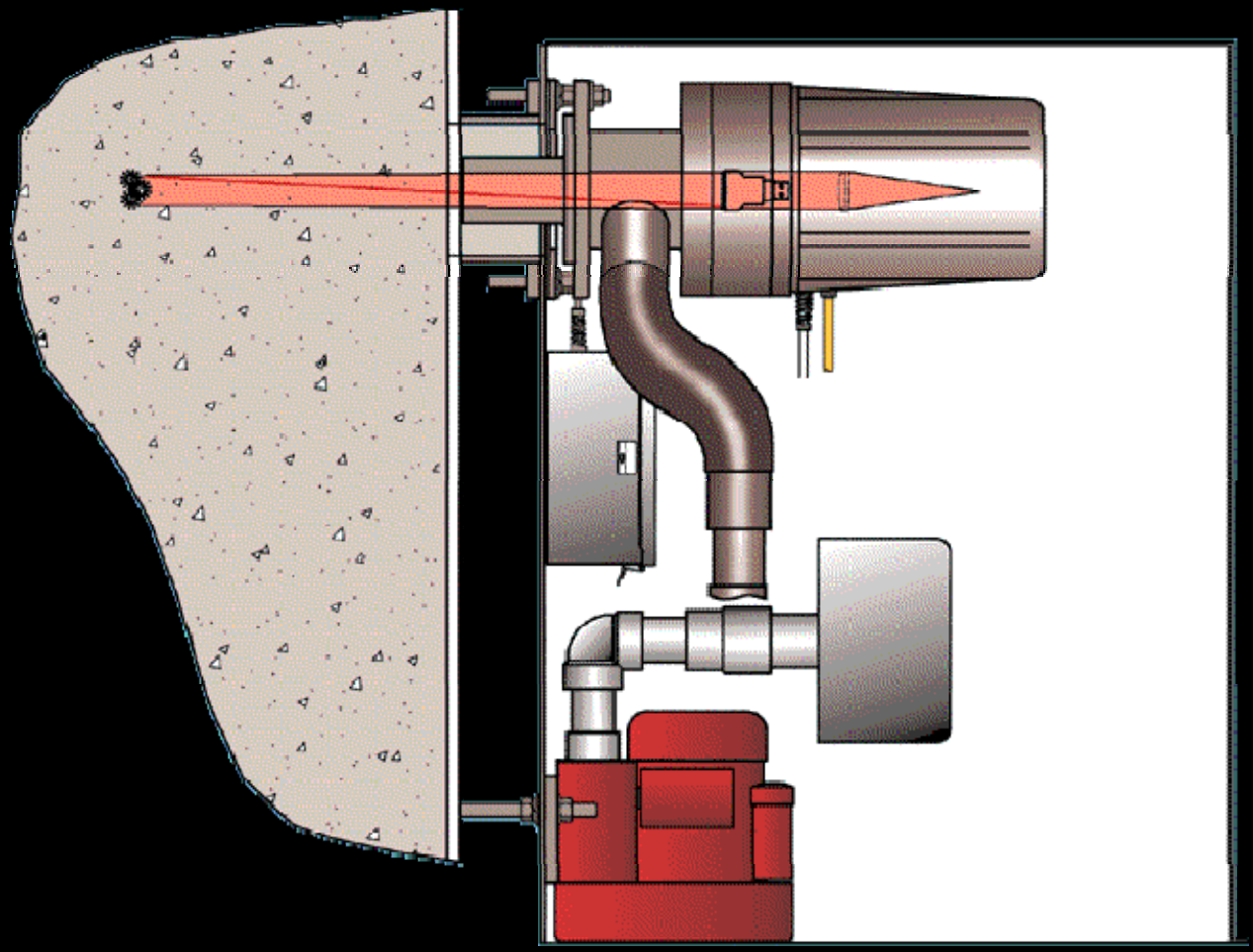



Flue gas
Reference detector
Probe
(shortened for clarity)
Backscattered light
Forward scattered light
Lamp
Focusing lens
Light collection lens
Signal detector
Optics head

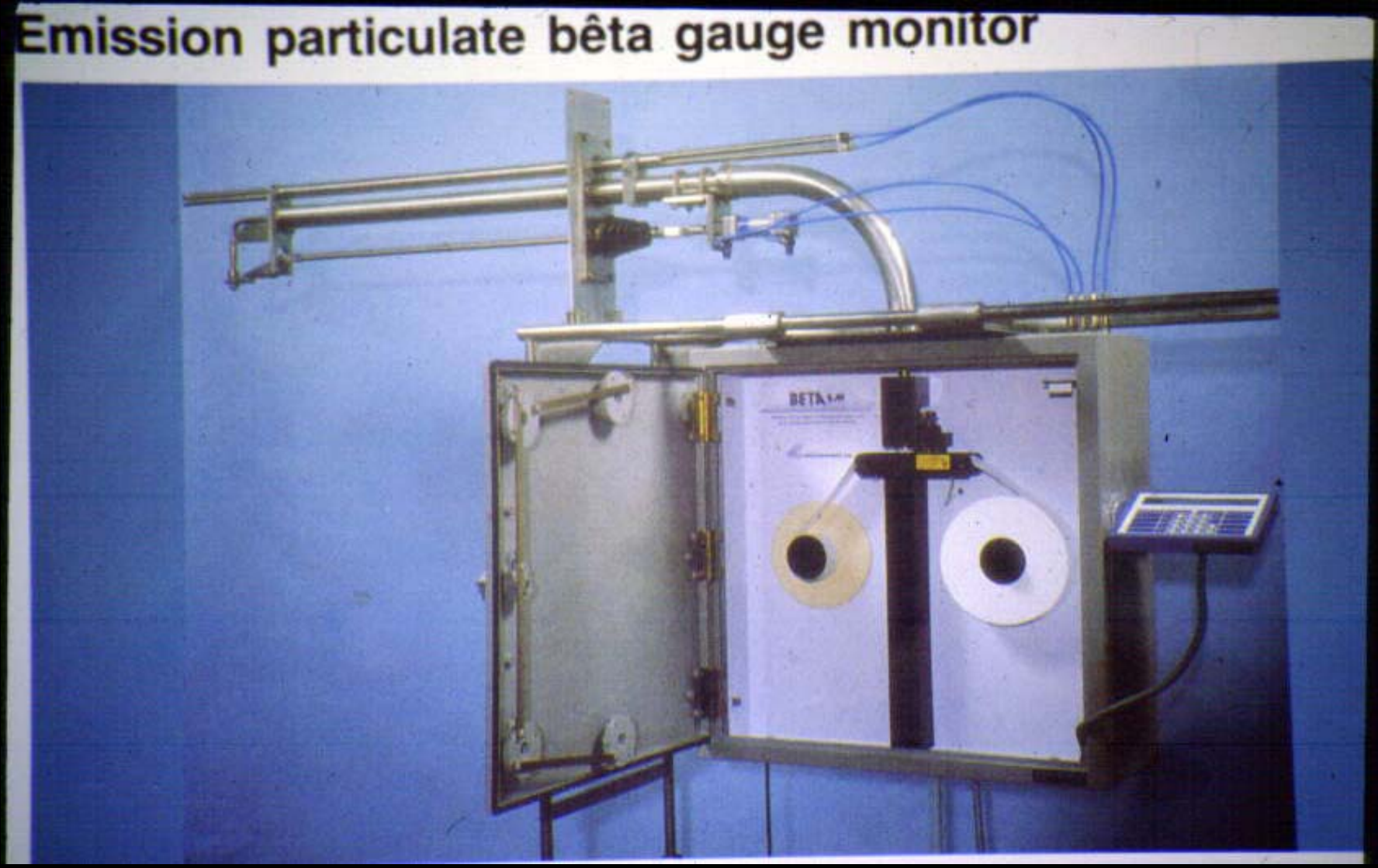
Monitor Labs

Model 300
Laser Backscatter
Particulate Monitor

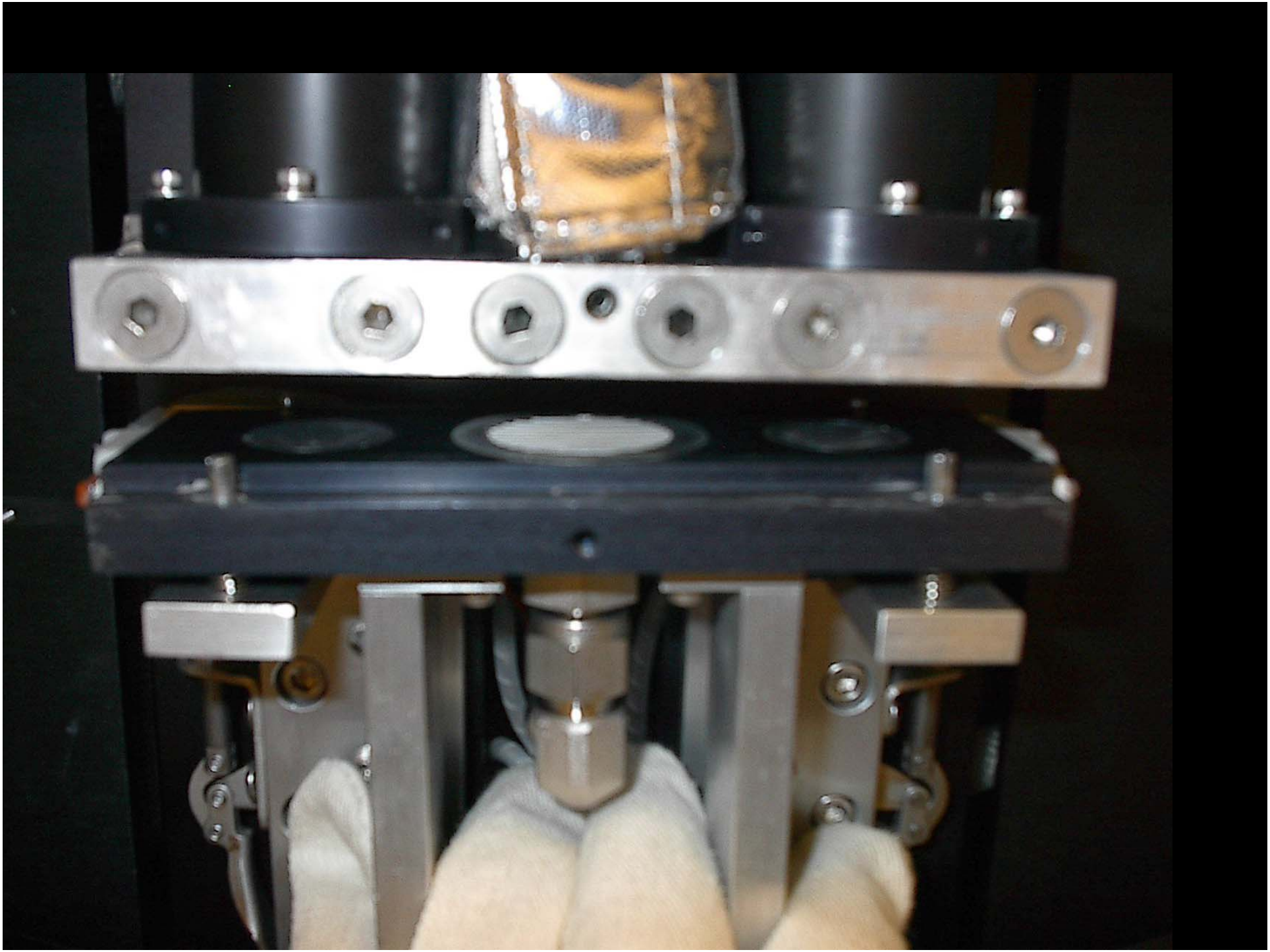
Monitor Labs Model 300 Particulate Monitor



Emission particulate bêta gauge monitor




CAUTION
WATCH
YOUR STEP
NO
SMOKING




ACUUM
EDUCTER VACUUM

Optical Instrument Considerations

- Affected by changes in particle size
- Affected by changes in refractive index
- Affected by changes in particle density
- Sense particulate matter at stack conditions
  - (Must correct to standard temperature and pressure)
- Water droplet interference

Extractive System Considerations

- Single point sampling
- Probe losses and effects
- Sample dilution for transport (some designs)
- Slower integrated response
- Filtration temperature and corresponding particulate changes from condensables

Original EPA Regulatory Development

- Concurrent with Development of MACT Standards for:
  - Portland Cement Plants
  - Hazardous Waste Burners
  - Control of Particulate as Surrogate for Control of Hazardous Metals

Previous EPA Regulatory Actions

- Dec. 30, 1997 Notice of Data Availability and Request for Comments
- Dec. 12, 2001 Proposal
  - Performance Specification 11
  - Appendix F, Procedure 2 (QA)
- Separate Regulatory Application from Technical Specifications

More EPA Regulatory Actions

- 1/12/04 promulgation of PS 11 and Procedure 2
- Implementation deferred for Portland Cement and HWC pending additional rulemakings
- 4/20/04 HWC Proposed Rules drop PM CEMS in favor of "bag leak detector" or "PM detector" requirements

EPA Enforcement Actions

- EPA implementing PM CEMS requirements at selected electric utilities through enforcement actions and consent decrees (30 to 50 units)
- EPA adding and "negotiating" requirements that would be in regulations
- Users forced to extreme measures to comply
  - Non-Representative APCD Test Conditions
  - PM Monitoring Data of no use to plant operators

Recent EPA Regulatory Actions

- 5/6/2009 Proposed PC MACT Revisions
  - Proposed Bag Leak Detectors for Kilns and allowed PM CEMS as Option
  - Requested Comments on PM CEMS
- 9/9/2010 Promulgated PC MACT Revisions
  - Requires PM CEMS on all kilns and clinker coolers
- 6/2/2010 Proposed "Boiler MACT" requires PM CEMS > 250 MMBTU units (> 500 affected units)
- PM CEMS expected in Utility MACT

Final PS11 Versus Proposed

- Changed many controversial requirements to suggestions or recommendations
- EPA references existing and future guidance documents
- Shifts much burden to industry users:
  - Selection of appropriate type PM CEMS
  - Assessment of PM stratification at PM CEMS location
  - Provisions to account for condensable PM
  - Methods for accomplishing PM Correlation at multiple levels

Brief Summary of PS 11

- Record and report data in units of the standard
- Initial Operational period to assess range and variability of PM concentrations
- 7-Day Drift Test (zero and upscale) within ±2% of upscale value
- PM CEMS Correlation
  - Correlation coefficient ≥0.85
  - 95% CI half range ≤ 10% of standard
  - TI half range 95% confidence that 75% of all possible values within 25% of standard

PS 11 Correlation Testing Requirements

- 20 Reference Tests Runs (typical 4-5 day test)
  - Can discard 5 runs
  - Must report at least 15 valid runs
- PM results over complete operating range experienced by source; 20% or runs in each of following three levels:
  - 0-50% of max PM concentration
  - 25% - 50% of max PM concentration
  - 50% to 100% of max PM concentration

PS11 Correlation Methods

- Linear
- Polynomial
- Logarithmic
- Exponential
- Power

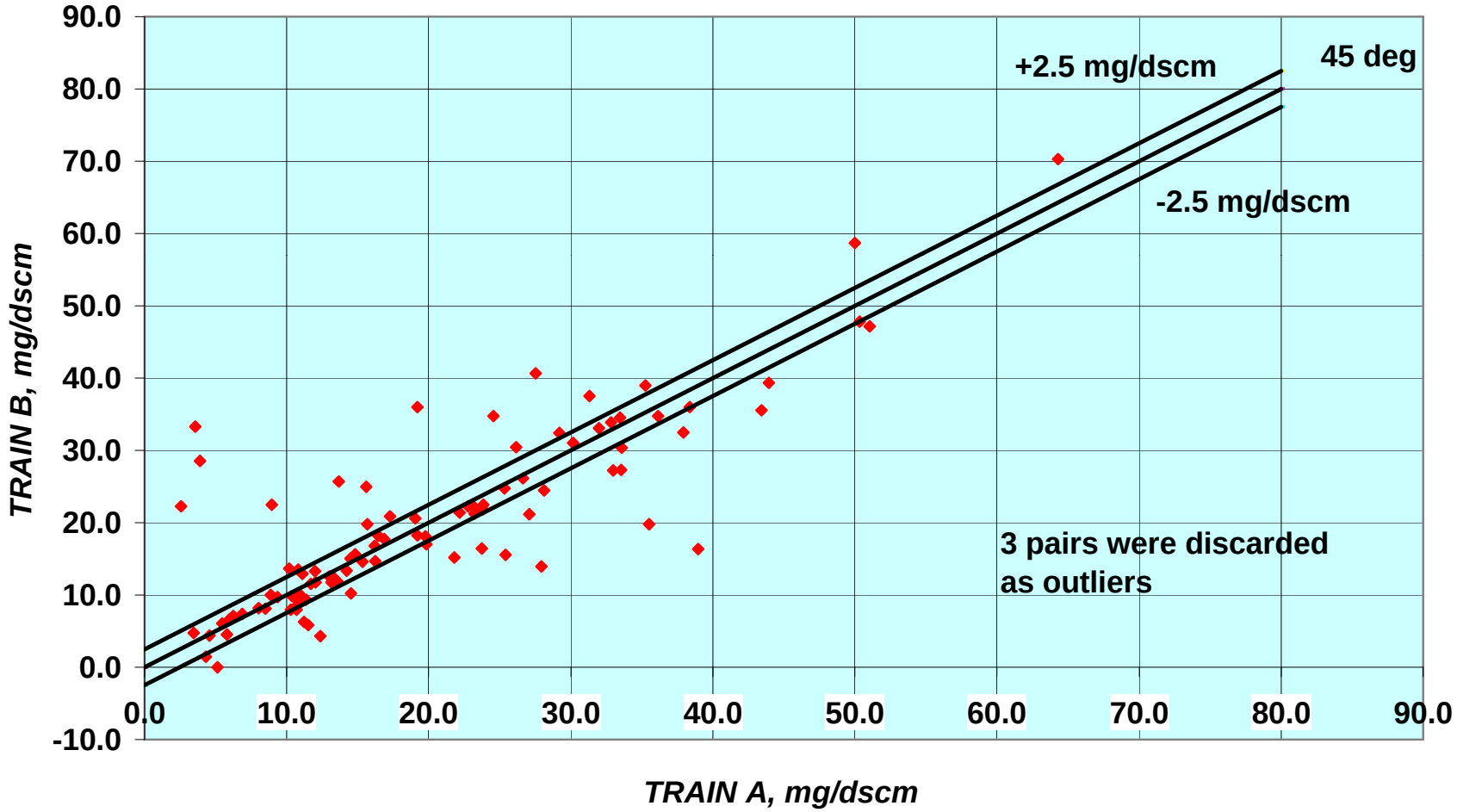
PM Correlation Range Limitations

- Repeat correlation or conduct additional tests if PM measurements exceed 125% of highest value for:
  - 24 consecutive hours
  - 5% operating hours during previous 30 days

Reference Testing Requirements

- Use EPA Test Method specified in applicable regulation (e.g. Method 5, 5I, 17) or approved alternative
- Test runs can be shortened (e.g. 20-30 minutes)
  - For EPA Methods, longer sampling times required for low PM concentrations
- EPA strongly recommends paired trains
- EMI recommends discarding runs when pairs do not agree within ±10% of average or ± 2.5 mg/m^3

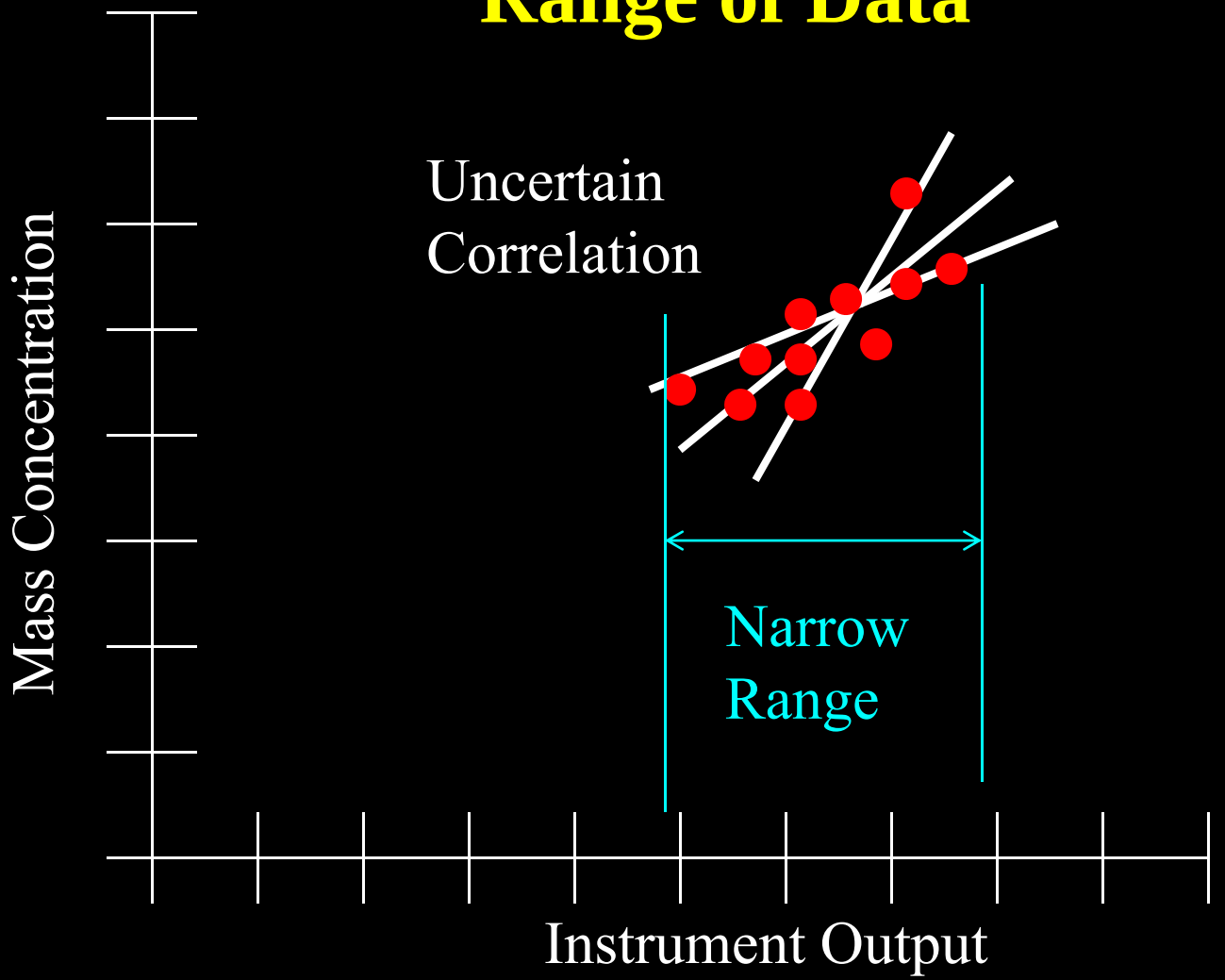
COMPARISON OF PAIRED DATA
(Train B vs. Train A)



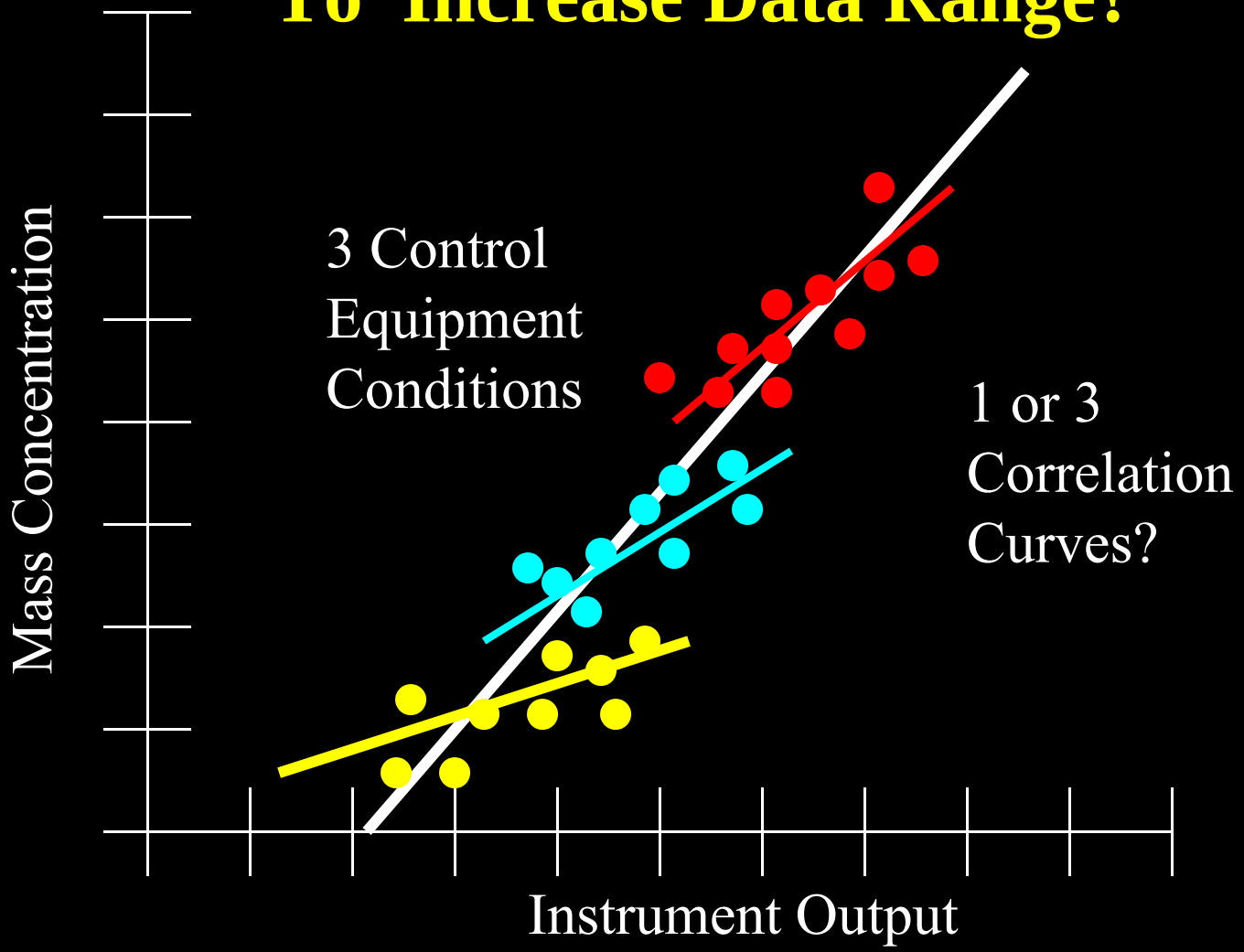
Options for Achieving PM Concentrations for Correlation Test

- Vary process operating conditions
- Detune control device
  - Change ESP operating conditions
  - Partial bypass of control device
- PM spiking (Not yet demonstrated)

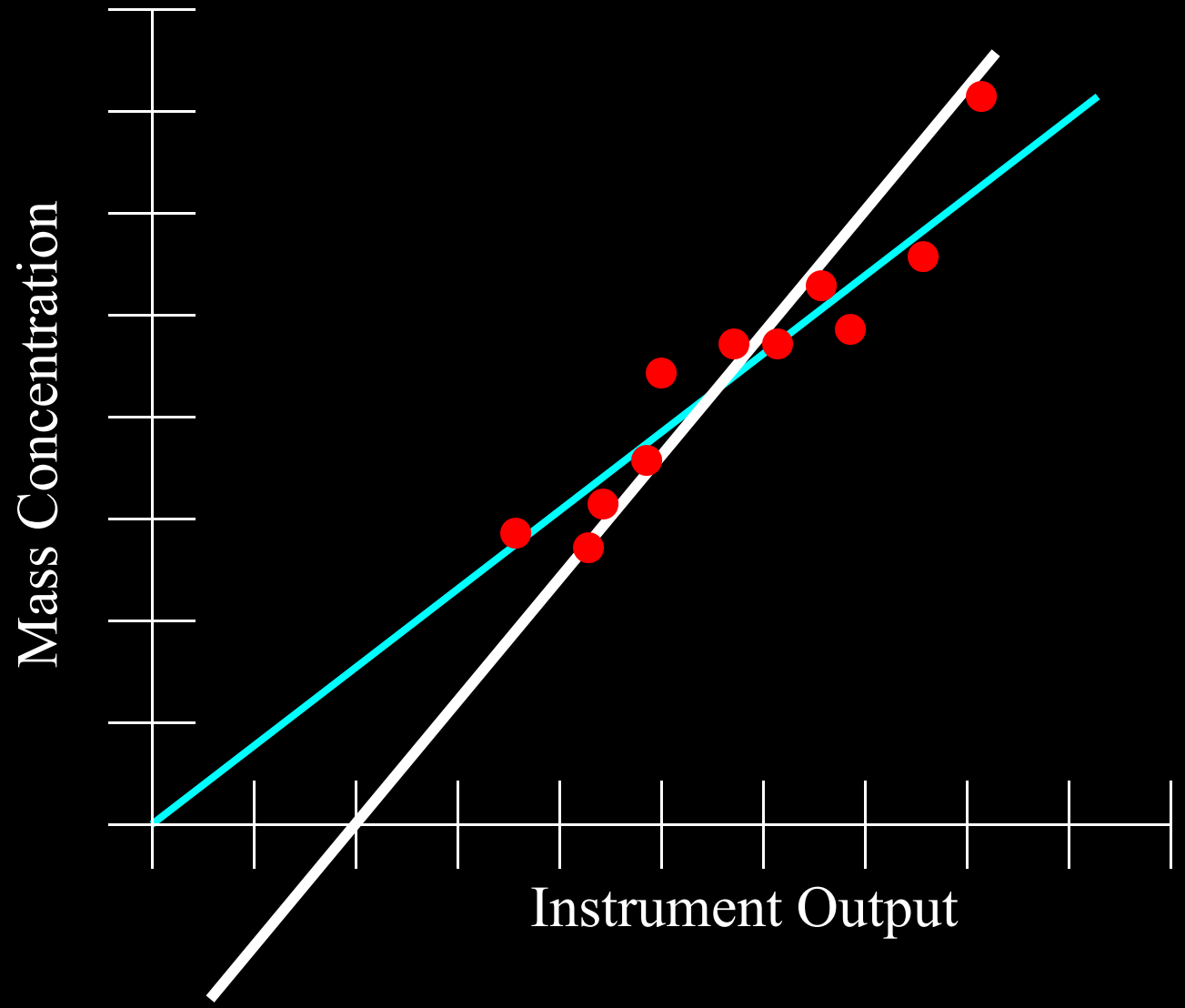
Source Operational Constraints Can Limit Range of Data



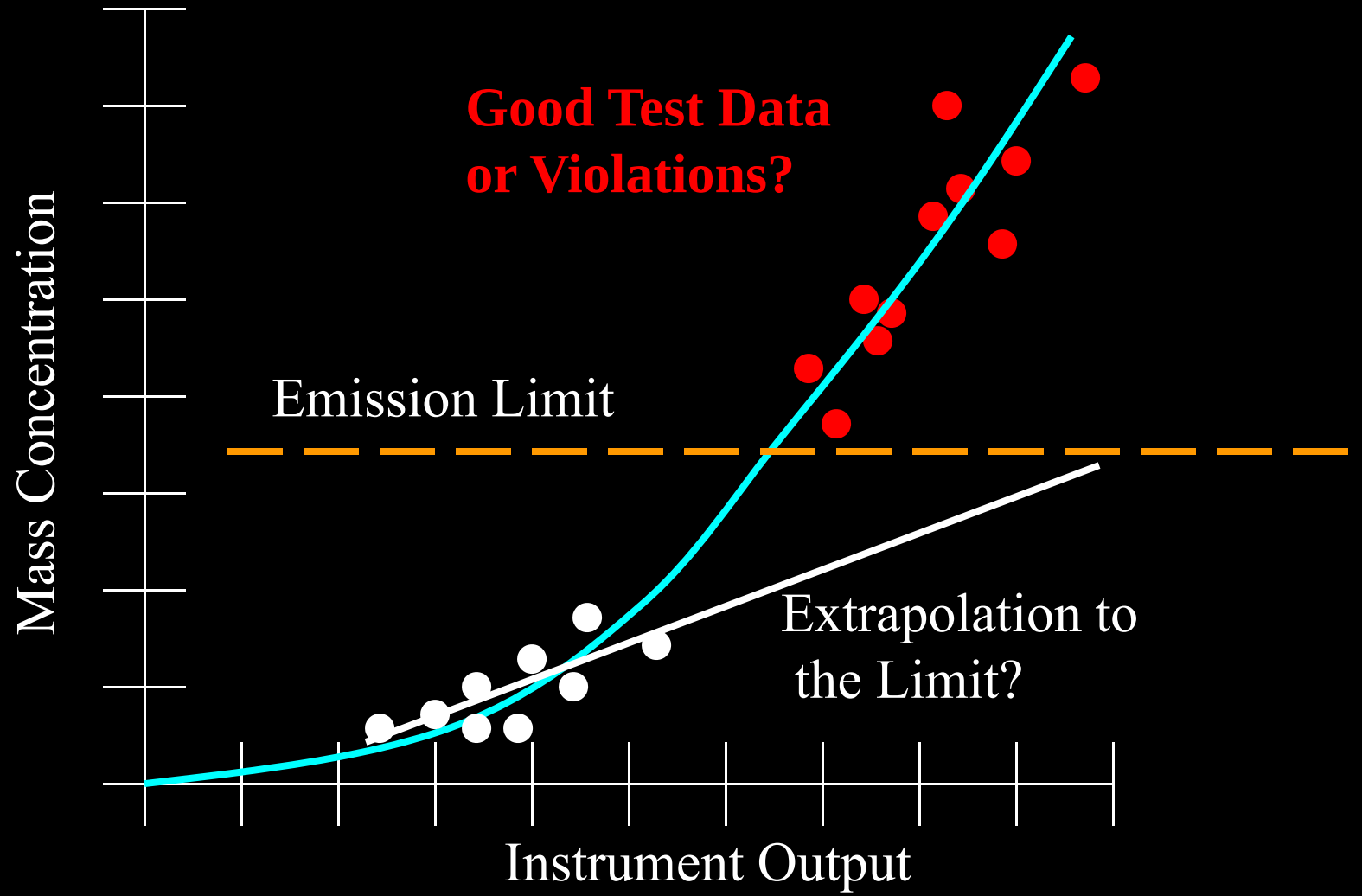
Change Control Equipment Parameters To Increase Data Range?



Does the Correlation Pass Through Zero?



Data Well Below or Above the Limit



Brief Summary of Procedure 2

- Written Procedures for:
  - Zero and upscale drift checks
  - Methods for adjustment of PM CEMS
  - Preventative maintenance and spare parts
  - Data recording, calculations and reporting
  - RCA and RRA audit procedures
  - ACAs and SVAs audit procedures
  - Corrective action procedures
  - Extractive system checks

Procedure 2 Audits

- ACA Absolute Correlation Audit
  - Quarterly
  - Use external audit standards
  - Audit at three levels
- SVA Sample Volume Audit
  - Quarterly and before RCA or RRA
  - Check extractive system sampling rate or volume measurement

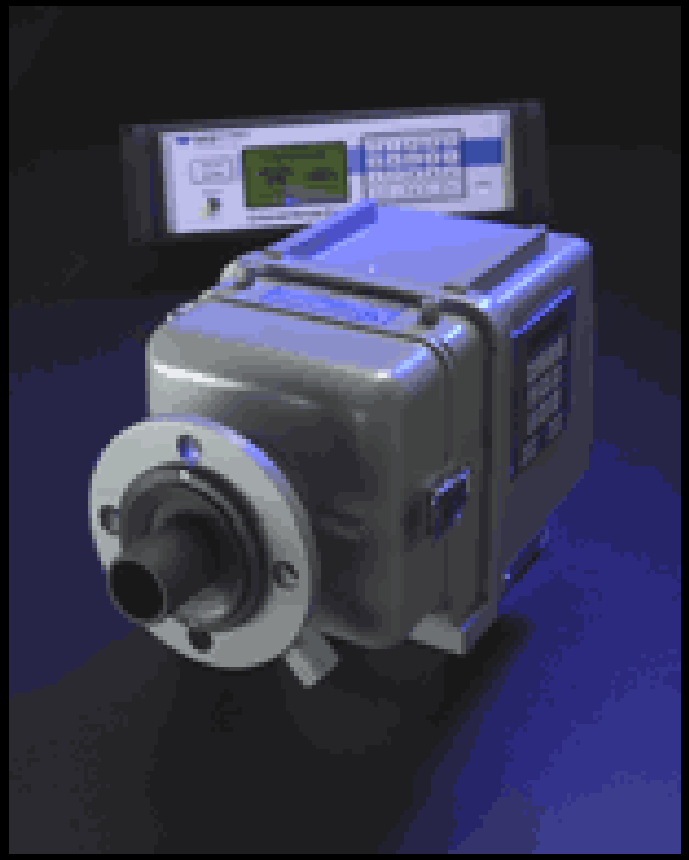
Procedure 2 Audits, continued

- Relative Response Audit
  - Frequency specified in regulation or permit
  - (Annually for Cement)
  - 3-Run Reference Method versus CEM comparison
- Response Correlation Audit
  - Frequency specified in regulation or permit
  - (Every Three years for Cement)
  - Repeat initial correlation test using a minimum of 12 runs. If unsuccessful, start over.

COMS and PM CEMS?

- EPA removes COMS requirement from federal regulations where PM CEMS is required or used as option
- COMS requirements may remain:
  - State Regulation
  - Title V Permit

Potential Use of LightHawk 560 COMS for PM CEMS



COMS Not Appropriate When Water Droplets are Present

- Transmissometers and In-Situ light scattering monitors “see” water droplets
- Do not use in saturated or super saturated gas streams
- Do not install downstream of wet scrubber if droplets may be present

COMS Specific Challenges

- Sensitivity – Ability to Measure at Low PM Concentrations
- Accuracy of Clear Path Calibration – True Zero Calibration
- Technicalities of Zero and Upscale Calibration Checks in PS11
- On-Going QA

Sensitivity of LightHawk 560

- Conventional wisdom: Transmissometers limited to quantitative PM measurement above 10 mg/m3 for 1 meter path length
  - (Sensitivity increases with path length: e.g.,
    - 20 mg/m3 for 2 meter path
    - 30 mg/m3 for 3 meter path
- LightHawk 560 at HWC cement plant demonstrated to meet ASTM D7392 requirements for PM Detectors at low PM concentrations
- Recent EMI field tests suggest better capability

Clear Path Calibration

- True “Zero” calibration for COMS must be performed off stack in dust free environment
- When installed, clear path calibration can be biased due to scintillation effects or gas lens effects caused by cool purge air/hot stack gas interface
- Clear path calibrations are infrequently performed
  - Proposed EPA Appendix F, Procedure 3 QA and other MACT standards will require annual clear path calibrations

Minimum Clear Path Calibration Recommendations

- Purchase upgrade with new flange stand-offs for each LightHawk 560 to be used as PM CEMS to minimize gas lens effects
- Install upgrades and perform new clear path calibration
- Acquire test stands and equipment to facilitate clear path calibrations at each plant
- Train plant technical staff to perform clear path calibrations annually and after major repairs

On –Going QA

- Zero and Upscale drift check criteria for COMS are too lenient for use as PM CEMS
  - Will need to tighten up drift tolerances for adjustment and window cleaning and perform maintenance more frequently
- Procedure 2 requires calendar quarterly audits
  - Plant personnel can do with optical filters
- Clear path calibrations
  - Needed periodically and after major repairs
  - Plant personnel must become skilled at this