

# Experience With Continuous Emission Monitoring Systems

*A love, hate Relationship*

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***Eli Lilly, Retired***

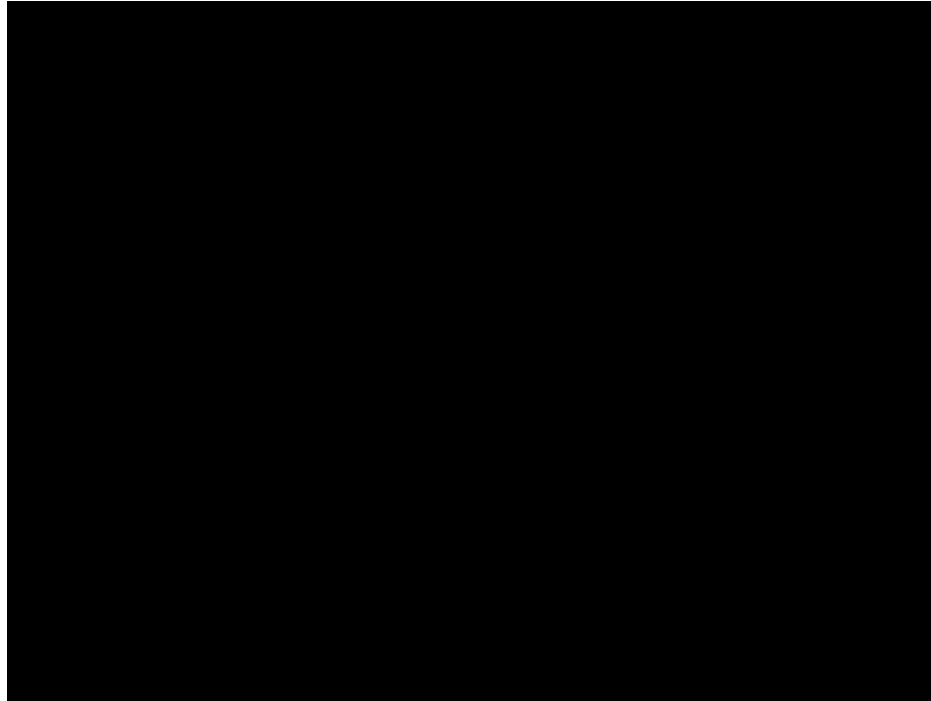
# Overview

- Safety Brief
- Use of Continuous Emission Monitoring Systems are Important
- Typical Continuous Emission Monitoring System
- Lessons Learned over 35 Years with Monitoring Systems
  - Importance of thorough Pre Planning for Monitoring Systems
  - Importance of thorough Start up Verification and Documentation
  - Importance of Training, Ownership
  - Importance of On Going QC, Spare parts, Maintenance
  - Operational Surprises

# Hazards of Static Electricity and Filling a Plastic Container with Fuel



# DO NOT Fill a Gas Container in a Truck Bed



# Safety Summary

- Always fill portable fuel containers by placing the container on the ground
  - Allows grounding
  - Placing the portable container on plastic bed liners or carpet creates static electricity
- Adding fuel to plastic containers creates enough static electricity to ignite the fuel vapors
  - Touch the container with the gas dispenser nozzle before removing the container lid to dissipate the static charge
  - Keep the nozzle in contact with the container inlet when filling to dissipate

# Use of Monitoring Systems are Valuable

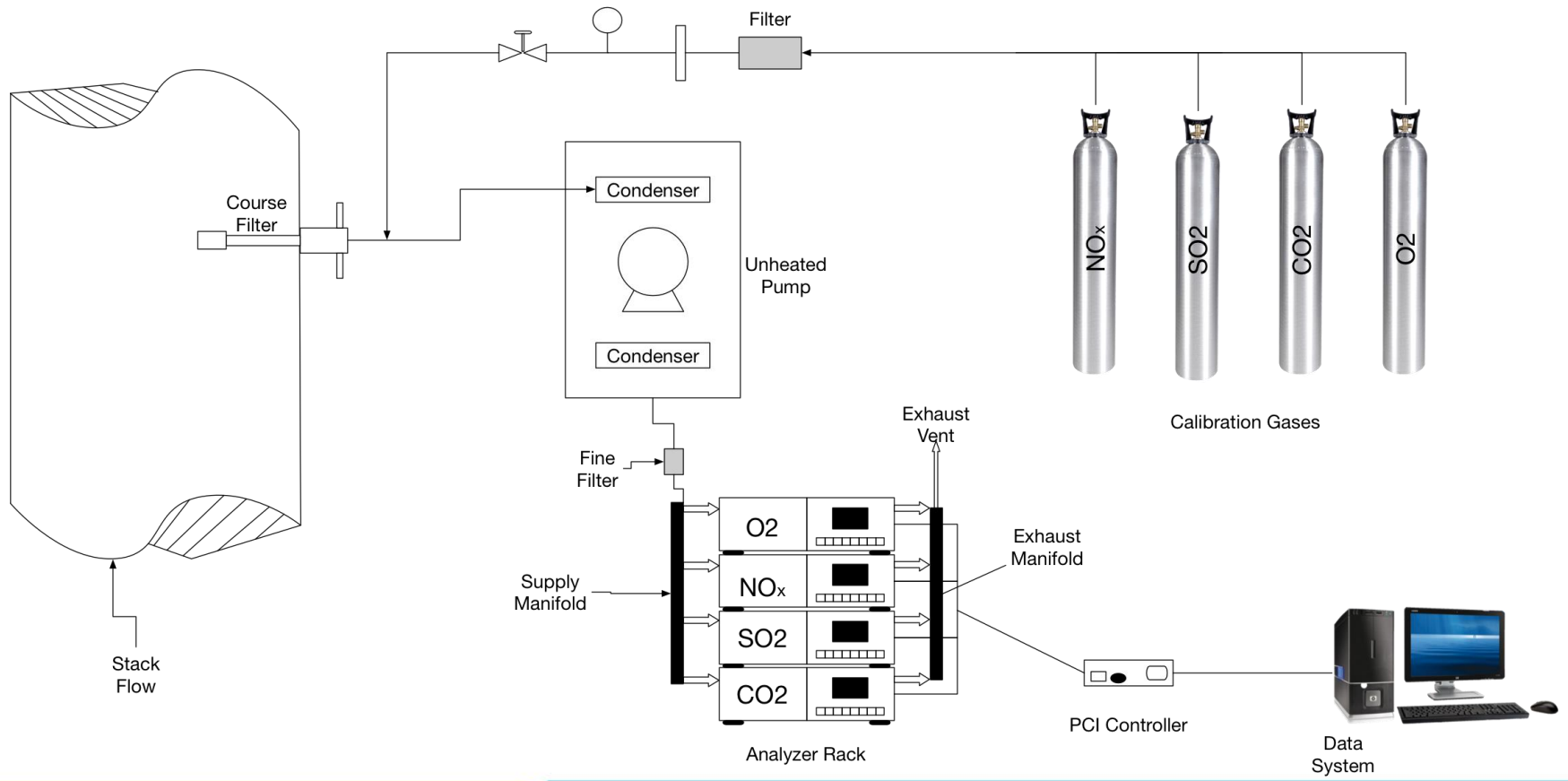
- Environmental Compliance
  - NIR/IR for NO, NO<sub>2</sub>, SO<sub>2</sub>, CO, CO<sub>2</sub>, H<sub>2</sub>O, O<sub>2</sub>, HCL
  - ED-XRF for multi metals CEMS
  - Refractive Light/beta gauge for total particulate
  - Microchip GC for organic vapors/sulfur compounds
  - FID for VOC
  - Mass and pitot for flow
- Process Monitoring and Quality Assurance
  - HPLC for product purity/recovery
  - Mass spectroscopy for fermentation off gases

# Use of Monitoring Systems are Valuable

- Process Monitoring and Quality Assurance, Continued
  - XRF for metal catalyst concentrations in reaction vessels
  - IR for product purity
  - GC for product purity/excipients
  - Laser diffraction for headspace O2 in vials
  - IR for product purity
  - Chemical sensors for LEL, halogens

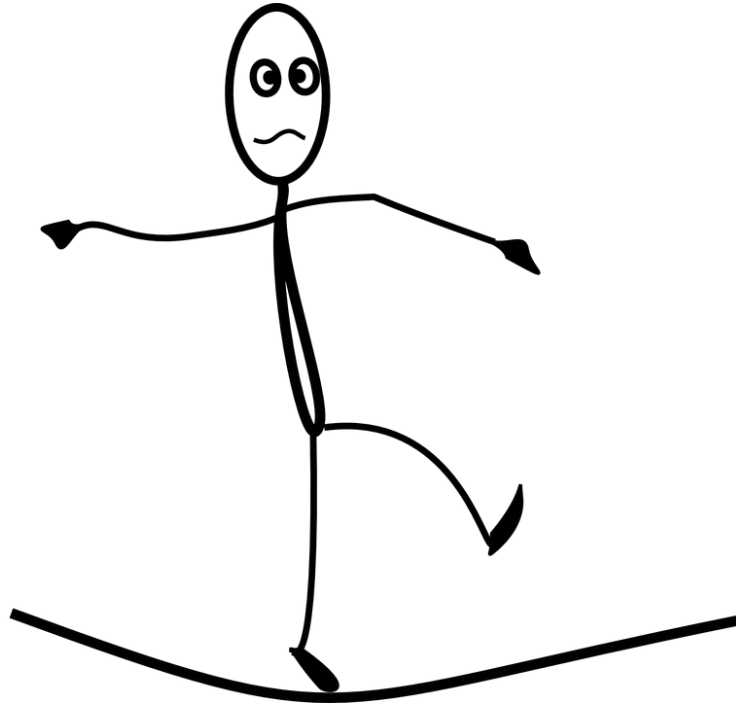
*Appropriate Use of Continuous Emission Monitoring Systems can be a Strategic and Cost Effective Method for Compliance and Process Optimization Quality Assurance*

# Typical Continuous Monitoring System





# Lessons Learned



# Preparation and Planning

- Understand EXACTLY what you need to measure and what you will be doing with the data
  - Averaging Times
  - Frequency of sampling – matching process dynamics
  - Cost of Equipment, Installation, Shelters, DATA SYSTEM, START UP and SUPPORT
  - Draft a detailed functional specification for internal use and for CEMS Vendor/Consultants
  - Document any regulatory and process requirements for data, operation, calibration

# Start Up and Operational Verification

- Create a detailed Start up plan which includes
  - Timelines
  - External resources required ( testing firm, vendors, IT)
  - Is process running when you start up
  - Check list/matrix to step through start up plan
  - Appropriate training of personnel/owners
  - Detailed validation plan to ensure the data provided by the system meets your functional requirements
  - THIS STEP TAKES TIME

# Training and Ownership (Resources)

- Establish ownership of system and data and have this resourced appropriately
  - Management understanding
- Have procedures and protocols in place for start-up, validation testing, on going QC
  - Train personnel on all aspects
- Resource for around the clock coverage
- Vendors/Consultants good resources for training

# On Going QC

- Document that explains how you will “care and feed “ the system
  - Spare parts
    - What testing is required after part/unit replacement
  - How to react to down time from calibration/system in error
  - Maintenance program
  - Quarterly audits if required
  - External support contracts

# Operational Surprises

- Interference of Detector with Radios, HVAC
- Heat/Cool blowing on instrument will cause issues
- Every FID Analyzer Has a UNIQUE RESPONSE FACTOR to identical gases
- FID analyzers ARE affected by barometric pressure
- Introduce calibration gas at same TEMPERATURE and PRESSURE as the process gas
- Consistent pressure control of process gas to FID, NIR, NDIR, FTIR IS ESSENTIAL
- Calibrate in the same matrix as the process... DYNAMIC SPIKING, especially with spectral techniques
- Certified calibration cylinders ARE NOT always accurate, especially reactive gases
- Take time to condition the sample lines when introducing calibration gases, especially reactive gases such as HCL, H2S, mercaptins, polar solvent gases (alcohols), “sticky solvent vapors (acetates, .acn )

# Operational Surprises

- There is a hysteresis around the value on calibration cylinders
- Enter the specific value of the gas from the calibration cylinder into your data system
- Track shelf life of calibration cylinders/materials in your data systems
- Use appropriate rounding of data (decimal place) for calibrations, analytical, QC data
- Data averaging times mean everything
- Have a way to flag bad data that enters into calculations/averages
- Pay attention to your data and calibrations, it will many times tell you if you are having a problem before it becomes an issue
- Pay attention to the material of construction for all parts in sampling interface and analyzers
- Spectrophotometric Analyzers need more calibration than spectral libraries and are affected by concentration and matrix

# Operational Surprises

- How do you treat down time when the instrument is not providing data for calibrations or errors
- Have specific spare parts available
- Understand what validation/documentation is required for the system for EACH type part or instrument replacement
- Keep GOOD/Detailed records of all maintenance and QC activities
- Understand company and regulatory record retention requirements (data compression, how long and what type of data must you save)
- Appropriate training of technicians and resourcing... monitor systems don't discriminate time when going down
- Thorough inspection/maintenance at quarterly audits is a good practice



# Operational Surprises

- Don't be afraid to use service contracts... few companies have in depth monitoring system expertise
- The sample system means everything to a CEMS
- Heated sample interface and dilution sampling are your friends
- Sample probes are VERY important and the filters in them are dependent on the sample matrix
- Flow meters and spectrophotometric analyzers many times have factors that are used to adjust the instrument output to calibration values. UNDERSTAND how these factors are used, and CHECK/ADJUST them at least annually
- LOCATION of sample probes and flow Monitors are IMPORTANT
- DATA for effluent MATRIX... constituents and concentrations are ALWAYS different than you expect/calculate
- Grounding is important as well as clean power