Predictive Emissions Monitoring Systems (PEMS)

What You Need to Know

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Purpose of the Presentation

- What are PEMS?
- How are PEMS developed?
- Initial and ongoing compliance requirements.
- Avoiding pitfalls.
  - Data reliability.
  - Issues with certain PEMS installations.
Regulatory Authority for PEMS

- 40 CFR 60, Subpart Db
  Industrial Steam Generating Units
  - Promulgated November 25, 1986
  - Boilers between 100 and 250 million Btu/hr, HHV
  - NOx monitoring required through the use of CEMS or alternative Operations Monitoring Plan to PREDICT NOx
Operations Monitoring Plan to Predict NOx
(also known as Predictive Emissions Monitoring System, PEMS)

• Operations Monitoring Plan requires Agency approval
  - Protocol required to address the regulatory requirements
  - Requires records for operating parameters (e.g. fuel flow, Oxygen) and methodology of how you will predict NOx emissions.
Operations Monitoring Plan to Predict NOx (also known as Predictive Emissions Monitoring System, PEMS)

- Operations Monitoring Plan requires Agency approval
  - State agencies usually require submittal of the plan to the applicable USEPA regional office.
- In the early 90’s, California regulators also accepted PEMS if it could predict a malfunction condition or excess emissions.
  - HEINZ seasonal boilers complied with the additional requirements.
  - Required “test data collection” in a range that caused high emissions!
Performance Specification 16

• Texas developed PEMS guidelines in the mid-1990s.
• USEPA adopted much of it in the PS 16 requirements.
Performance Specification 16 Requirements

- Pass a three load RATAs confirming the PEMS prediction programming was successful. Low, mid, and high (>80%). 9 test runs each.
- PEMS requires a sensor validation to demonstrate sensors are working, and in range. Establish operating ranges.
- Minimum of three input parameters.
- Statistical tests for model accuracy.
- Relative Accuracy Audits quarterly first year, semi-annual thereafter.
- Annual RATA with one load, 9 test runs.
The First PEMS – Auxiliary Boiler

- Auxiliary boiler at Fisk Generating Station in Chicago
  - 141 million Btu/hr on natural gas
  - Flue gas recirculation with low NOx burners
  - Data collection in early 1987
  - 30 day NOx monitoring program (temporary CEMS system) for compliance and concurrent boiler operating data collection.

- Published in the Air Pollution Control Association (APCA) conference, June, 1988.
  - Titled “Development of an Operations Monitoring Plan for a Subpart Db Industrial Boiler”
  - Model built to cover the full load range of operation.

- The auxiliary boiler used the PEMS model from 1987 through its retirement circa 2012!
PEMS Development – Part I

• 1. Develop protocol for submittal to regulators. Understand the permit requirements!
• 2. Instrument calibrations of all boiler sensors used for prediction of NOx.
• 3. Install data acquisition system to collect boiler data and temporary “continuous” emissions monitoring system.
  – CEMS calibrations every 8 hours.
• 4. Operate the boiler across the load range, including startups and shutdowns.
  – Typically over a few weeks. The more data, the better.
  – Recommend pushing the unit and control settings to expand model(s) and sensor ranges.
PEMS Development – Part 2

• 5. Data analysis to develop emission prediction models.
  – Typically use a separate model to deal with ultra low load and startup/shutdown events.

• 6. Sensor analysis to determine acceptable ranges for each boiler operating sensor.
  – e.g. Boiler O2 range as a function of load level.
  – Establish boundaries for the sensor signals.
  – System must “flag” operations of the boiler outside the PEMS sensor ranges.

• 7. Program the PEMS data acquisition computer with the prediction models.

• 8. Conduct a three (3) load Relative Accuracy Test Audits to demonstrate accurate predictions.

• 9. Submit a PEMS Certification Report to regulators demonstrating compliance with PS 16 requirements.
PEMS Ongoing – Part 3

- After the initial Certification testing of the PEMS …
  - Conduct quarterly Relative Accuracy Audits (RAA, not RATA) consisting of 3 x 30 minute runs. 10% criteria.
  - Can be performed by site personnel using portable combustion analyzer.
- Annually … conduct a RATA at one load condition.
- Software needs to generate emission reports for demonstration of emissions compliance – daily, monthly, annual.
PEMS Cost vs. CEMS

- Generally … half the cost of CEMS
- Initial development including computer hardware is roughly $80,000 with testing.
  - Additional cost to add CO (e.g. state permit requirement) and other pollutant calculations.
- Quarterly RAA and annual RATA test is roughly $10,000 per year.
- No calibration gases.
- No CEMS preventative maintenance.
- No need to have backup monitoring.
- Reliability is typically 99.5% or higher.
• The operations inputs are typically:
  – Fuel flow (gas, oil)
  – Oxygen (%, from in situ analyzer)
  – Air flow signal
  – Steam flow
  – Flue Gas Recirculation (damper position, %, if variable)
  – Steam pressure (informational)
  – Boiler inlet and exit temperature
  – Others (depends on the boiler).

• Since the key inputs are necessary for boiler operation, they are highly reliable and no downtime.
  – If the sensors fail, the boiler is likely brought off line (trip).
Avoiding Pitfalls - 1

- Initial Operations Monitoring Plan needs to clearly identify the PEMS implementation procedure.
  - Include sensors
  - Full load range
  - QA discussion
  - Statistical methodology
  - Schedule
  - Compliance with PS-16
- Attempt to get acceptance from the Agency
  - Some states never comment, but you are covered based on what was submitted.
Avoiding Pitfalls - 2

• Calculation(s) verification
  – Make sure you know exactly how the PEMS is predicting emissions
  – EPA inspector will want to manually verify that the PEMS model that was certified initially under PS 16 is still in use.
  – Re-training models can be an issue. Black-box issues ... how do you know you have the same model?
Avoiding Pitfalls - 3

• Load Range
  – How are startup, shutdowns, and low load covered?
  – Some systems ignore those conditions!
  – Site had no idea that it was getting zeros.
Avoiding Pitfalls - 4

• **Training**
  - Boiler operators have almost no input into the PEMS since they basically continue to produce numbers.
  - Complacency sets in.
  - Need to be certain to understand the PEMS operation, and QA requirements so they don’t fall in the crack.

• **User Manual**
  - Must clearly document how to generate reports, and QA requirements.
  - Should be reviewed minimum of once per year, and modified, if necessary.

• **EXAMPLE**
  - Recent PEMS in the Midwest operated for more than a year.
  - Once it was certified, the vendor did not follow up with QA recommendations.
  - Site missed all RAA tests, and was late with the annual RATA.
  - Had to revise the PEMS.
  - Operators did not know how the PEMS worked, nor did they know what to do with it!
Avoiding Pitfalls - 5

• Procurement Specification
  – Do not buy a PEMS without a procurement specification that clearly identifies the requirements of the system.
  – Engineering firms often use a vendors information to develop a PEMS specification, but miss out on all the requirements.
Avoiding Pitfalls - 6

• Reporting
  – Site personnel must be able to generate reports for EPA inspectors, and be able to output a data file with hourly data.

• Reports must include:
  – Daily, Monthly, and Quarterly Emissions
  – Excess Emissions
  – Startup/shutdown (often in permits)
  – PEMS availability for the quarter.
  – Boiler data (steam flow, fuel flow, etc.)
  – Rolling averages to meet the permit (e.g. 30 day rolling average NOx)
Avoiding Pitfalls - 7

• Maintenance
  – Clearly define roles and responsibility for PEMS operation
  – Include routine sensor calibrations, and document before and after calibration information. Maintain a file of all work.
  – EPA inspector may ask to see records for calibrations.
Avoiding Pitfalls - 8

• Remote Access
  – Make sure the PEMS data acquisition system is accessible via VPN or some other process.
  – Don’t assume IT personnel will willingly accept the system from an outside vendor.
  – Remote access is essential to ensure the vendor can support the site without incurring travel charges.
Avoiding Pitfalls - 9

- Permit Requirements
  - Understand your permit requirements and make sure the PEMS is designed to comply with all recordkeeping and reporting requirements.
  - Some PEMS calculations are often performed by site Distributed Control System (DCS) computers and generate internal reports. Often not able to reproduce data quickly during agency inspections, nor provide five years of data.
Avoiding Pitfalls - 10

• Initial Data Collection
  – Understand your permit requirements and make sure the PEMS is
designed to comply with all recordkeeping and reporting
requirements.
  – Some PEMS calculations are often performed by site Distributed
  Control System (DCS) computers and generate internal reports.
  Often not able to reproduce data quickly during agency
  inspections, nor provide five years of data.
  – Cover the FULL OPERATING RANGE during the PEMS training
  period, and push the envelope for sensor ranges (e.g. adjust
  fuel/air ratio at several load points) to get some variation.
General Closing Comment

- PEMS can be as accurate as CEMS.
- PEMS are only as good as the quality of the input data. Bad sensor data could lead to poor PEMS predictions.
- PEMS work well for boilers that have:
  - Consistent fuel supply/quality (e.g. natural gas, #2 oil)
  - Control system that has minimal boiler operator intervention. Computer control drives the boiler = a good thing. Consistent operating methodology.
Summary

• Don’t fear PEMS, but be prepared to demonstrate it meets all the requirements.
• Significant cost savings for PEMS over CEMS.
• Training comment …. 
For further information ...

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