Predictive Emissions Monitoring Systems (PEMS)

What You Need to Know

Council of Industrial Boiler Owners
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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

Title 40: Protection of Environment
PART 60—STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES

Subpart Db—Standards of Performance for Industrial-Commercial-Institutional Steam Generating Units

Contents

SOURCE: 72 FR 32742, June 13, 2007, unless otherwise noted.

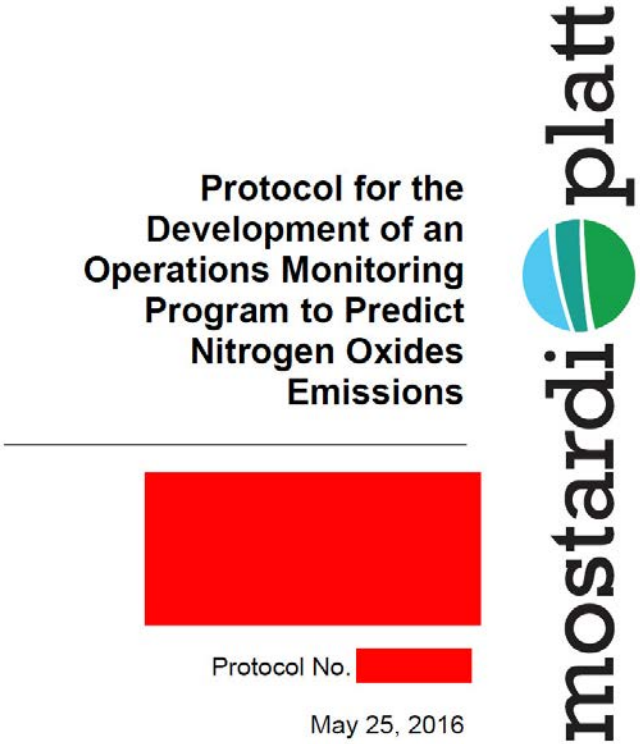
Operations Monitoring Plan to Predict NOx (also known as Predictive Emissions Monitoring System, PEMS)

- 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.

(c) The owner or operator of each affected facility subject to the NO_X standard in §60.44b who seeks to demonstrate compliance with those standards through the monitoring of steam generating unit operating conditions in the provisions of §60.48b(g)(2) shall submit to the Administrator for approval a plan that identifies the operating conditions to be monitored in §60.48b(g)(2) and the records to be maintained in §60.49b(g). This plan shall be submitted to the Administrator for approval within 360 days of the initial startup of the affected facility. An affected facility burning coke oven gas alone or in combination with other gaseous fuels or distillate oil shall submit this plan to the Administrator for approval within 360 days of the initial startup of the affected facility or by November 30, 2009, whichever date comes later. If the plan is approved, the owner or operator shall maintain records of predicted nitrogen oxide emission rates and the monitored operating conditions, including steam generating unit load, identified in the plan. The plan shall:

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.

While we have taken steps to ensure the accuracy of this Internet version of the document, it is not the official version. Please refer to the official version in the FR publication, which appears on the Government Printing Office's eCFR website
HTTP://WWW.ECFR.GOV/CGI-BIN/TEXT-IDX?SID=C7836E6FF67E5AD001BCB19CCFD99C1A&NODE=40:8.0.1.1.1&RGN=DIV5#40:8.0.1.1.1.0.1.1.9

PERFORMANCE SPECIFICATION 16—SPECIFICATIONS AND TEST PROCEDURES FOR PREDICTIVE EMISSION MONITORING SYSTEMS IN STATIONARY SOURCES

1.0 Scope and Application

1.1 *Does this performance specification apply to me?* If you, the source owner or operator, intend to use (with any necessary approvals) a predictive emission monitoring system (PEMS) to show compliance with your emission limitation under 40 CFR 60, 61, or 63, you must use the procedures in this performance specification (PS) to determine whether your PEMS is acceptable for use in demonstrating compliance with applicable requirements. Use these procedures to certify your PEMS after initial installation and periodically thereafter to ensure the PEMS is operating properly. If your PEMS contains a diluent (O_2 or CO_2) measuring component and your emissions limitation is in units that require a diluent measurement (*e.g.*lbs/mm Btu), the diluent component must be tested as well. These specifications apply to PEMS that are installed under 40 CFR 60, 61, and 63 after the effective date of this performance specification. These

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.

Sample Rack Mount Data Logger with Internal Computer

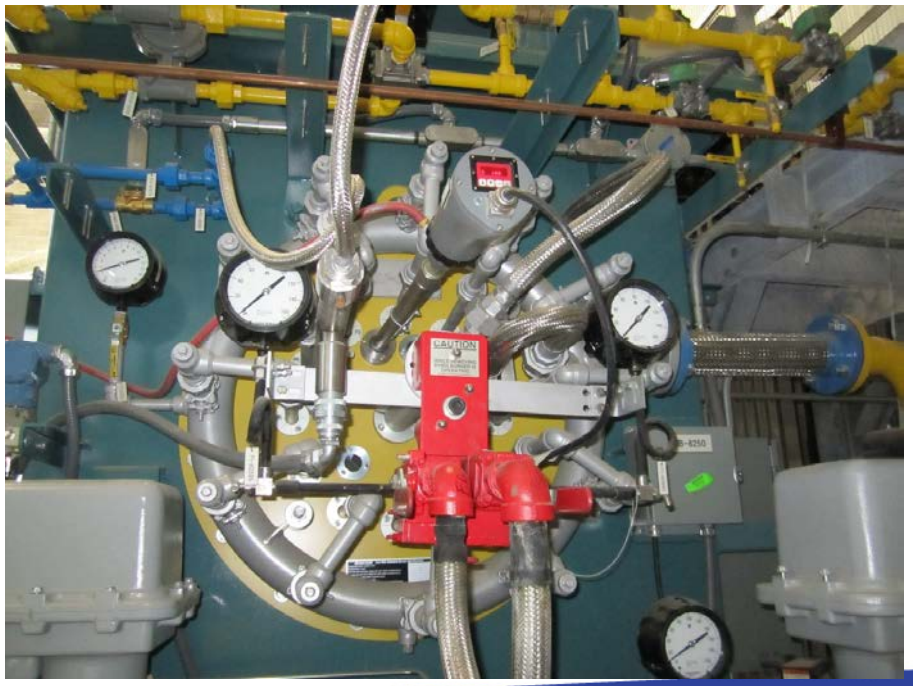
PEMS Ongoing – Part 3

- 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.

Sample Portable Analyzer for RAA

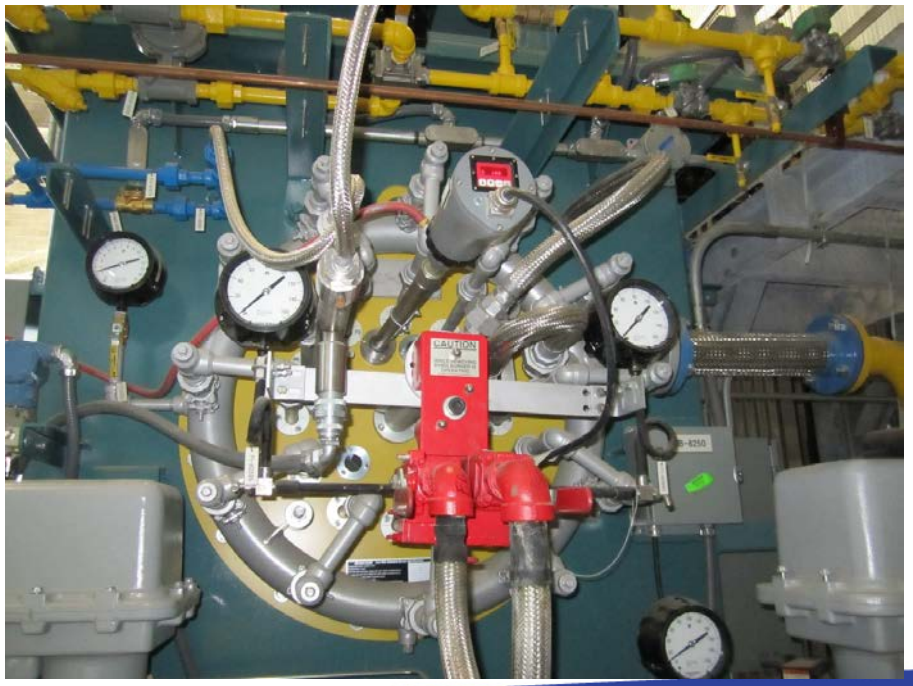
PEMS Cost vs. CEMS

- 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.



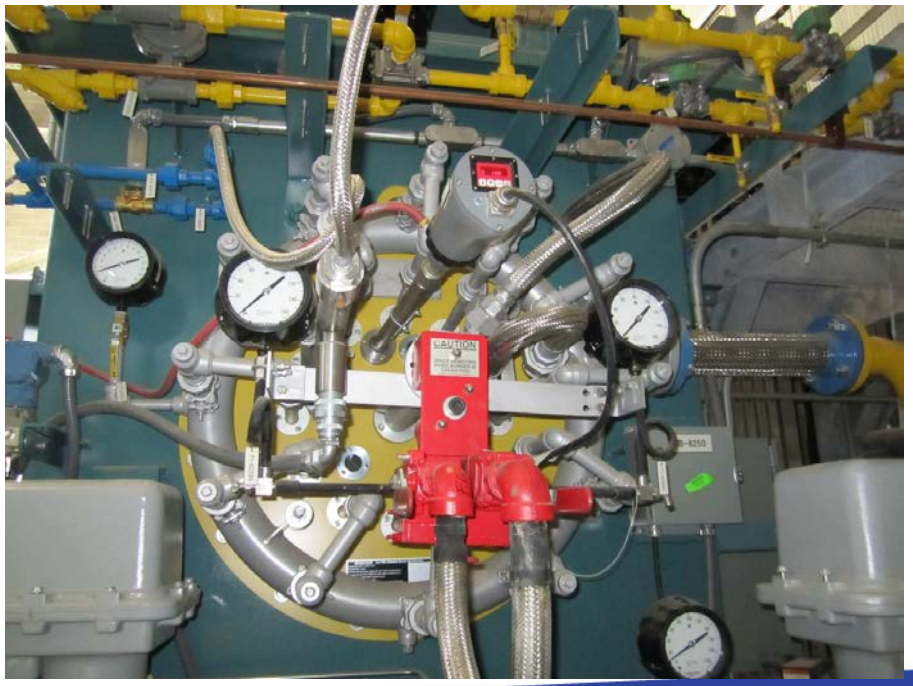
PEMS Cost vs. CEMS – Part II

- 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).



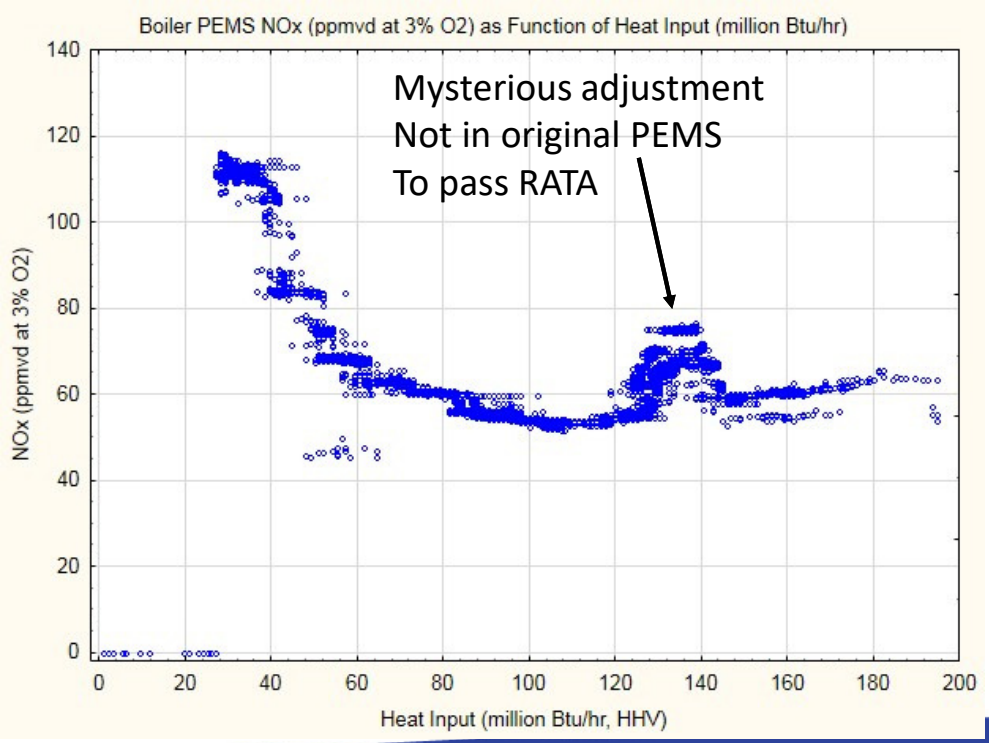
Avoiding Pitfalls - 1

- 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.



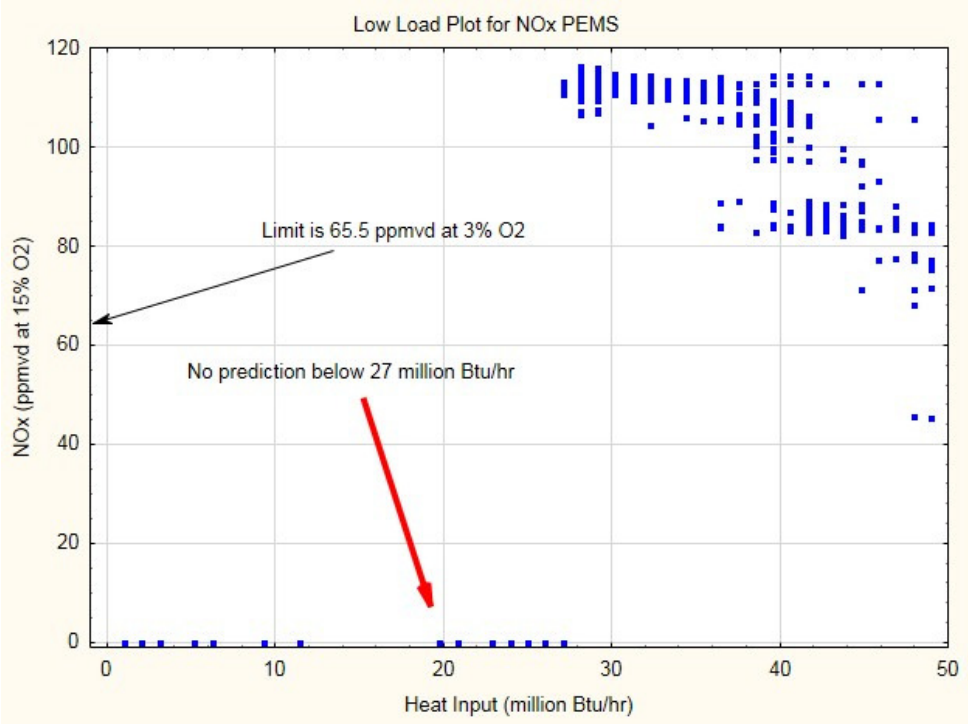
Avoiding Pitfalls - 2

- 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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