CleanAir

CASE STUDY

Using PEMs to Comply with EPA NOx Emissions Regulations

Background

Predictive Emission Monitoring Systems (PEMS) may be used to estimate emissions of NOx, SO2, CO and other gases from combustion sources regulated under 40 CFR Parts 60 and 75. A PEMS employs a mathematical model to correlate process inputs or other operating variables with emission rates. To comply with a designated emission limit, a facility normally installs a conventional continuous emission monitoring system (CEMS) on the combustion source. A facility could choose instead to monitor their emissions with PEMS for one of two reasons:

1) Lowering capital expenditures - PEMS are less expensive than CEMS

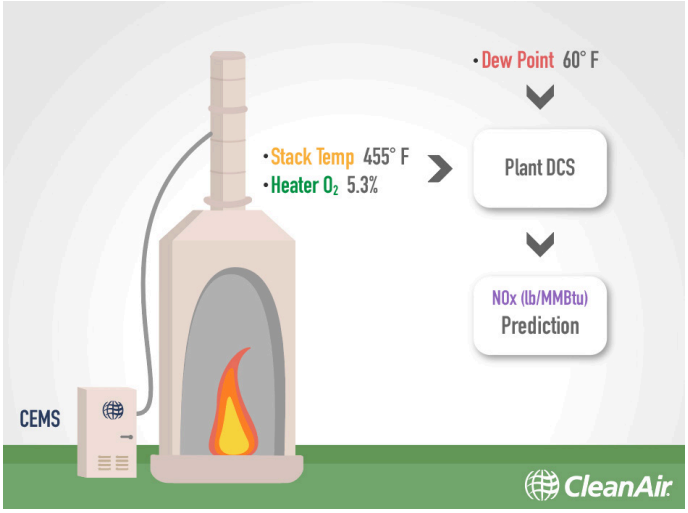
2) Reducing CEMS downtime - PEMS are a suitable backup to existing CEMS

Beginning in 2017, CleanAir started working on a PEMS project with an upstream oil and gas client to commission PEMS for some of their natural gas fired heaters. Instead of installing new CEMS, the client asked CleanAir to develop, certify, and audit several PEMS models. US EPA Performance Specification 16 (PS-16) outlines specifications and audit procedures for two types of PEMS: compliance and excess emissions. Compliance PEMS are used to demonstrate that emissions are maintained below limits set within the facility's Title V permit. Excess emission PEMS are used to quantify the emissions that may exceed Title V limits. CleanAir's client used PEMS to comply with excess emissions requirements.

CleanAir's Approach

Proof of Concept and Validation Testing

To build a working PEMS model, CleanAir collected continuous NOx (EPA Reference Method 7E) and O2 (EPA Reference Method 3A) data while the client operated their heaters over a wide range of operating conditions. The emissions profiles of the heaters varied depending on how the heaters were operated. Therefore, building a PEMS required recording emissions data during a range of normal operating scenarios. The PEMS were commissioned using data that captured variability in process parameters like heater excess air, process temperatures, fuel loads, and even ambient weather conditions.



The PEMS modeling periods were comprised of continuous emissions and process monitoring 24/7 and lasted up to 30-days in length. It was not cost effective for the client to hire contractors to perform conventional stack testing to obtain the data needed to build the PEMS model. Instead, CleanAir used its propriety Auto-CEMS system to automate the stack testing.

The Auto-CEMS consists of a complete continuous monitoring system packaged in a weatherproof and climate-controlled cabinet. Before arriving at each individual site, CleanAir pre-configured the test plan in the Auto-CEMS software. Once the Auto-CEMS cabinet was positioned, powered, and checked out, the software took over control of the testing. There was no need for on-site contractors to be present to collect data from the hardware, therefore reducing the labor cost. Throughout the testing programs, the CleanAir project team could access the Auto-CEMS data through its on-line CleanCloud portal, which also provided alerts anytime there was an issue with data collection or the CEMS hardware.

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Data Analysis and Modeling

CleanAir developed a PEMS algorithm that met the requirements of EPA Performance Specification 16 (PS-16). Data analysis and modeling were conducted in two general phases:

1) Data exploration and cleaning. Before any data could be used for modeling, it was organized in a single table and checked for errors, inconsistencies, outliers, etc. From here, it was possible to exclude extreme outliers, remove calibration periods, and perform other forms of exploratory data analysis – primarily graphing the data. As the old adage goes, a picture is worth a thousand words.

2) Building and Selecting Predictive Models. CleanAir used multilinear regression models to predict NOx emissions for the heaters. These simple models can be easily programmed into most DCS systems, and do not require a 'black box' or complicated explanation for approval. Although more complex and sophisticated predictive techniques could be used here, they are more expensive to build and prone to large overfitting errors.

Initial Certification

PS-16 requires a relative accuracy test audit (RATA) to certify that the PEMS accurately predicts the emissions. This certification test is similar to a conventional CEMS RATA, but with some notable differences. For a CEMS RATA, a stack tester would typically use its own independent gas analyzers and equipment to collect reference method data. The stack tester's audit data are then compared to the data collected during the same time by the plant CEMS. In the PEMS case, however, the audit data are compared to the PEMS algorithm predictions.

Another major difference is that the PEMS RATA requires testing at a range of process conditions. For example, CleanAir's client had to conduct testing at three different oxygen levels.

A conventional CEMS RATA normally requires that a minimum of nine audit runs be conducted at a single operating condition. The number of RATA runs required during a PEMS certification depends on whether the PEMS is used for continuous compliance or excess emissions. Continuous compliance PEMS require nine runs at each expected operating level, while excess emission PEMS require only three runs at each operating level. Compliance PEMS must also pass additional statistical tests (bias, variance, correlation coefficient) as part of the certification RATA.

Periodic Stack Testing

After initial certification, a PEMS requires two types of ongoing relative accuracy tests to stay in compliance with PS-16: an annual RATA and a quarterly relative accuracy audit (RAA). CleanAir conducts the annual RATAs using Auto-CEMS. One benefit of using Auto-CEMS for the annual RATA is that, if there is an issue with the PEMS passing the RATA, CleanAir can use the Auto-CEMS to immediately start collecting continuous reference method data (e.g., Methods 7E and 3A), thus avoiding down-time due to missing compliance data. Another benefit is that this is done without incurring the cost of an additional mobilization.

The RAAs can be conducted quarterly with a portable analyzer and test method ASTM D6522-00. After a PEMS passes the initial certification RATA, three successive quarterly RAAs, and one successive annual RATA, only one RAA per year will be required afterwards. However, if the audit testing indicates that the PEMS model needs to be modified, the compliance testing schedule restarts – beginning with the certification RATA.

Summary

A PEMS allows plants that operate combustion equipment to comply with Parts 60 and 75 continuous emissions monitoring requirements without installing conventional CEMS. CleanAir provided a turn-key PEMS solution that included proof-of-concept testing, predictive modeling, and stack testing. The Auto-CEMS system reduced the cost of data collection for CleanAir's client by limiting the amount of time on-site labor was needed for proof-of-concept and model development testing and eliminating mobilization costs when models needed to be refined.