LEHIGH ENERGY UPDATE

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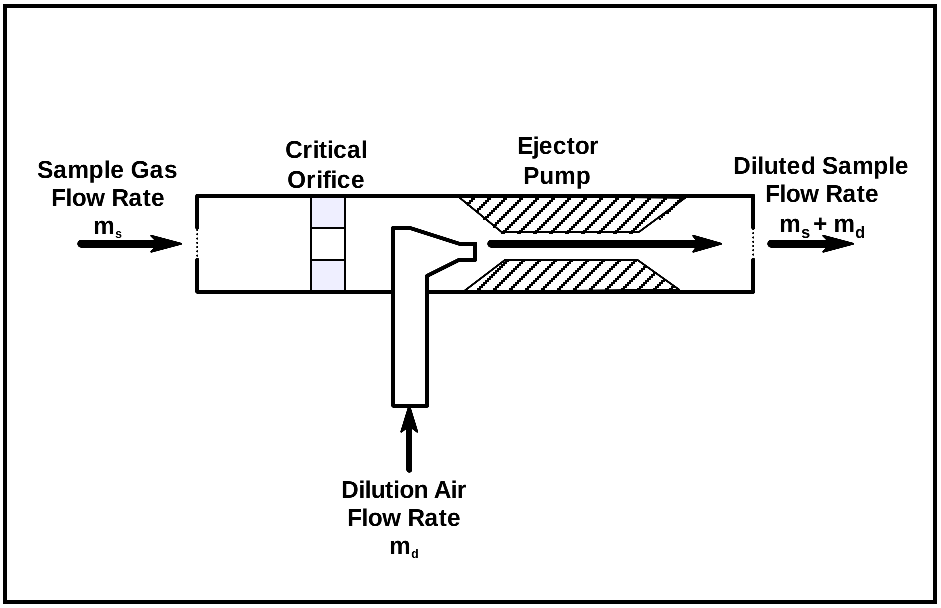
MODIFIED DILUTION EXTRACTIVE PROBE REDUCES NO_x MEASUREMENT BIAS ERROR



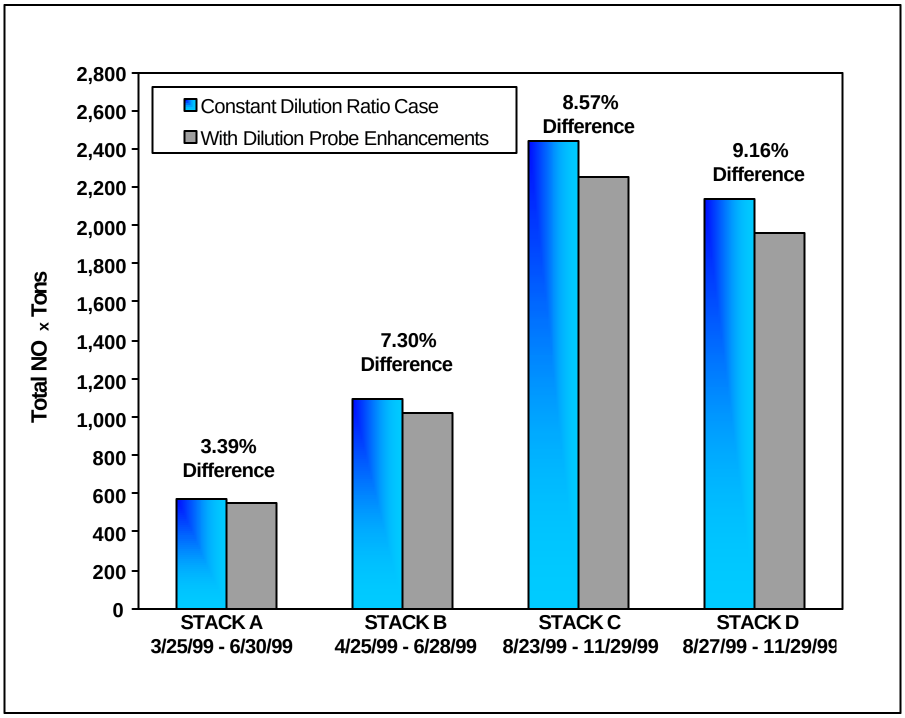
Schematic of dilution probe. Sample gas from the stack is drawn into the dilution probe, mixed with clean, dry air, and then sent to gas analyzers in a diluted form.

Utilities with fossil-fired power plants are required by EPA to use continuous emissions monitoring systems (CEM) to measure quantities such as SO_2 and NO_x emissions. A typical CEM system consists of an instrument to measure flue gas flow rate, instruments to measure concentrations of SO_2, NO_x and CO_2 in the flue gas, and a device referred to as a dilution extractive probe for removing a small sample of flue gas from the stack. The dilution probe conditions the sample and transports it to the gas analyzers for measurement of flue gas composition.

Over the last several years, considerable attention has been given to the accuracy of CEM measurements, with particular emphasis placed on bias errors in the flue gas flow rate measurement. These typically result in over-reporting the amount of SO_2, NO_x and CO_2 emitted. Several investigations have shown the dilution extractive probe can also be a source of measurement error that contributes to the over-reporting problem, although the magnitude of that error and the means of eliminating it have not been well understood by the utility industry. Working with investigators from PP&L, Inc., the Energy Research Center recently completed a study of the operation of dilution extractive CEM probes. This investigation has resulted in a new technique for operating a dilution probe such that a significant part of the sampling error is eliminated.

The internal components of a dilution extractive probe consist of a complex arrangement of a filter, sonic flow nozzles, a heat exchanger and an ejector. During normal operation, gas from the stack is drawn into the probe, mixed with clean, dry air and then sent to the gas analyzers in a diluted form. Dilution ratios of air-to-gas flow rate of 50 to 200 are typically used. The relationship between the actual pollutant concentration at the stack and the pollutant level measured at the analyzers is constant if the dilution ratio does not change over time. In practice, however, the dilution ratio does change; and thus the dilution ratio determined at calibration conditions will differ from the value when the dilution probe is sampling flue gas. There are many factors that affect dilution air flow rate and sample gas flow rate. These include, for example, stack temperature and absolute pressure, flue gas molecular weight and dilution air supply pressure. Thus, in practice, the dilution ratio varies with stack conditions and probe operating conditions, resulting in errors in concentration measurements as large as 10 percent in some situations.

Working with engineers from PP&L, Inc., the Energy Research Center carried out a series of analyses and experiments to quantify the effects of probe operating conditions on dilution ratio. The project team consisted



Enhancements to dilution probe have reduced overreporting of measured concentrations of NO_x and SO_2 at PP&L power plants. The results in this graph compare NO_x emissions using the dilution probe enhancements to those that would be reported assuming a constant dilution ratio.

of Carlos Romero and Ali Yilmaz, Research Engineers with the Energy Research Center, and Jim Batug and Noel Moyer of PP&L, Inc.

The investigation began with computer simulations of the fluid flow and heat transfer processes occurring within the probe. The computer simulations looked at the factors that affect the flow rates of dilution air, sample gas flow rate and the flow rate of calibration gas.

Experiments were then run at controlled conditions in a PP&L test facility to measure the dependence of dilution ratio on parameters such as sample gas molecular weight and dilution air supply pressure. Comparisons were also made to laboratory test data that had been published by EPRI several years earlier.

The results of the computer simulations and experiments showed some of the factors that affect dilution ratio can be calculated from theory quite accurately. However, there are other effects that are difficult to pin down with much precision, due to uncertainties in internal probe dimensions caused by manufacturing tolerances.

The approach ultimately used by the project team to obtain accurate information on dilution ratio consists of a combination of direct measurements of probe-operating conditions and theoretically derived algorithms. Additional laboratory tests performed at PP&L showed the improved method resulted in excellent agreement between measured sample gas composition and actual values of gas composition.

Based on these results, PP&L implemented the dilution probe improvements in the stacks at its fossil-fired units. In doing so, PP&L took the steps necessary to ensure that the modifications meet the quality assurance requirements of the CEMS regulations.

Evaluation of the results showed a 3.4 to 9.2 percent reduction in tons of NO_x and SO_2, compared to those that would be reported assuming a constant dilution ratio. In addition, the modifications made it much easier for PP&L technicians to pass RATA tests, and calibration and linearity error tests.

All of PP&L's CEMS use unheated dilution extraction probes; however, the approach will also work with heated dilution probes. In this case, however, the expected percentage reduction in measurement errors will be lower than those found in the PP&L field trials.

According to Jim Batug, "PP&L has achieved reductions of positive bias in its reported emissions of NO_x and SO_2 as a result of the improvements we've made to our dilution probes. We have more than 5,000 MW of installed fossil-fired capacity monitored by CEMS with the dilution probe modifications. The reductions in reported NO_x and SO_2 are quite substantial, so much so that we've been able to recover the cost of the modifications to our probes in just a month or two. But just as important, the probe improvements have made life much easier for our CEM technicians. The gas pollutant monitors now routinely pass RATA, calibration, and linearity error tests on the first try and this has also resulted in a reduction in operating costs." •

For more information on ***Dilution- Extraction Probes***, please contact John Sale at the Energy Research Center at (610) 758-4545 or at jws3@lehigh.edu.