WHITE PAPER

GUIDANCE FOR SAMPLING OF NO$_X$ CONCENTRATIONS FOR SCR SYSTEM CONTROL IN COAL-FIRED APPLICATIONS

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The Institute of Clean Air Companies, the nonprofit national association of companies that supply stationary source air pollution monitoring and control systems, equipment and services, was formed in 1960 to promote the industry and encourage improvement of engineering and technical standards.

The Institute's mission is to assure a strong and workable air quality policy that promotes public health, environmental quality and industrial progress. As the representative of the air pollution control industry, the Institute seeks to evaluate and respond to regulatory initiatives and establish technical guidelines to the benefit of all.

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SAMPLING OF NO$_x$ CONCENTRATIONS FOR SCR SYSTEM CONTROL IN COAL-FIRED APPLICATIONS

Guidelines for Accuracy and Reliability

SUMMARY: *This document provides guidelines for the design and operation of Selective Catalytic Reduction (SCR) system sampling and monitoring systems. The SCR system inlet/outlet data is important to the overall control system in order to maintain system reliability in the operation and control of the SCR system.*

BACKGROUND

In the United States, the number of SCR systems in operation on coal-fired boilers will dramatically increase over the next few years. This increase is due to the Title IV requirements of the Clean Air Act Amendments and compliance with federal, state and regional clean air initiatives designed to reduce emissions of nitrogen oxides (NO$_x$).

Proper operation of a SCR depends on the ability of the control system to reliably monitor NO$_x$ concentrations in the flue gas at the inlet and the outlet of the SCR catalytic reactor. These measurements are important because of the requirements for high NO$_x$ (NO + NO$_2$) emission control efficiency and low ammonia slip from the process. Improper control of the system will lead to poor NO$_x$ emission control and potential problems due to the resultant ammonia slip.

In several cases involving coal-fired boiler installations, the monitoring systems have experienced various problems with reliability and accuracy. Some of these systems have been removed from service due to the high maintenance required. As a result, SCR system performance has suffered from poor control, overinjection of ammonia and related balance of plant problems.

The purpose of these guidelines is to provide recommendations for the proper design, installation and operation of NO$_x$ emission sampling and monitoring systems for SCR applications on coal-fired boilers.

SAMPLING ENVIRONMENT

The SCR control system must be capable of performing in a flue gas environment with a wide range of conditions. The general characteristics of coal-fired boiler flue gas that the SCR system can be exposed to can range as follows:

- Gas temperatures up to 800° F
- Inlet NO$_x$ concentrations ranging from 100 to 1500 ppmvd
- Outlet NO$_x$ emissions as low as 20 ppmvd
- SO$_2$ concentrations between 300 and 3,000 ppmvd
- Dust concentrations from 2 to 12 gr/dscf

Specific system designs will require particular attention to unique operating characteristics and flue gas composition.

REPRESENTATIVE SAMPLES

Coal-fired plants that will require SCR controls generally have a large cross-sectional flue gas duct arrangement. This tends to generate unique flow profiles in the ductwork, which create a situation where a single point probe will not necessarily provide a representative sample. The sampling system must be designed to provide an average sample over the entire duct cross-sectional profile. This has to be accomplished by the use of multiple probes in the ductwork. The best way to determine the actual duct profile at the point of measurement is to have a testing company perform a load profile "map". This will provide the best sampling locations, as well as the number of points required.

If a profile "map" cannot be developed, and the point of measurement is located in a straight run with little disturbance before or after the measuring point, a profile based on standard wind-tunnel testing can be used (see figure below). If a profile is generated by a testing company over various loads, then the number of probes as well as the position and length of the probes may be different than the diagram provided.

Measurement Profile Across Rectangular Duct
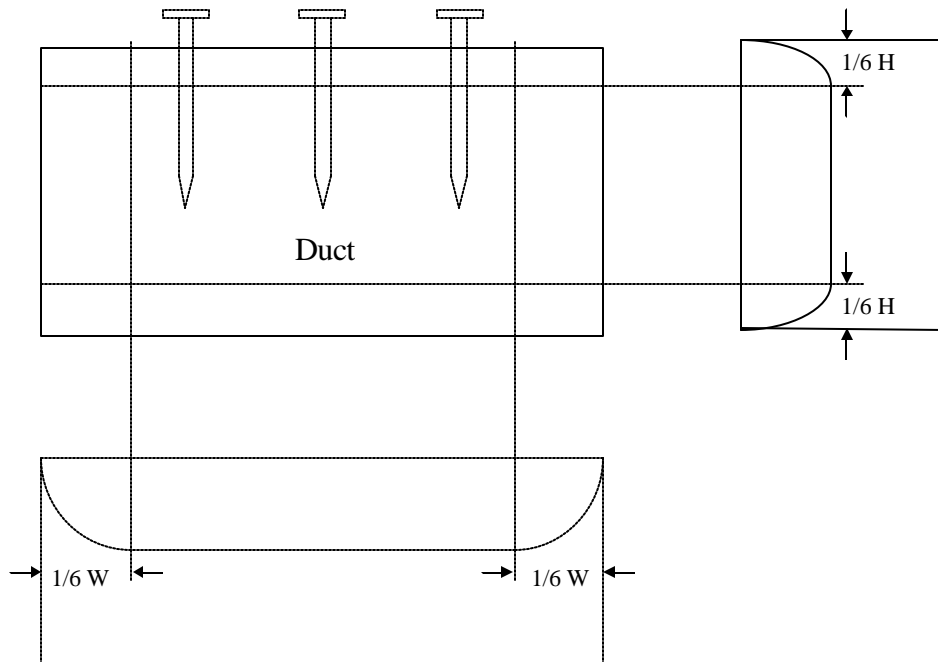
In addition to obtaining a representative flue gas sample, the user must account for the presence of SO_3, NH_3, and high particulate loading. If the sample temperature drops below 550° F, sulfuric acid, ammonium bisulfate and condensed SO_3 can form and create significant problems within the sampling system. Also, as the flue gas NO_x levels decrease during the reactions across the SCR catalyst, the ratio of the NO_2 to NO increases making traditional NO_x monitors less accurate due to the NO_2 loss in the oxidizer.

SAMPLE INTEGRITY

A very important design consideration is the ability to maintain the quality of the sample from the sample point to the analyzer. Particular attention must be given to removing dust from the sample and keeping the sample well above the sulfur-related dewpoint (such as SO_3/H_2SO_4) prior to the analyzer.

At the SCR outlet, the sampled gas will contain ammonia of varying concentrations. This ammonia is a by-product of the SCR process and will gradually increase as the catalyst ages. For reliable performance of the control system, the temperature of the sample must be well above the calculated dewpoint of ammonium bisulfate as well as SO_3 and H_2SO_4. Formation of these compounds will plug sample lines and possibly analyzers.

RECOMMENDATIONS

In order to establish a NO_x monitoring system that provides the reliability and accuracy necessary for proper control system input, the following guidelines are recommended:

Number of Sample Points – The optimum number and location of sampling points should be established through load profile "mapping". If this mapping is not performed, a minimum of three inlet and outlet sampling points should be specified for large ducts (coal-fired plants).

Location of Inlet Sampling Points – Locate the inlet sampling points sufficiently upstream of the reagent injection grid to avoid possible reagent (ammonia) interference.

Type of Sample Measurement – Either an extractive or dilution system can be used. It is critical, however, with either system that the sample must be maintained above the acid dewpoint at all times. Blowback air, dilution air, and all components that are in contact with the sample gas must also be maintained above the dewpoint prior to removal of sulfur and ammonium sulfate/bisulfate compounds.

Loss of NO_x compounds must be maintained at a minimum.

Temperature of Sample - Flue gas samples must be maintained above 550° F prior to conditioning in order to maintain the integrity of the sample and prevent corrosion and plugging of the sampling and analyzer systems.

Maximum Sample Line Length - Sample line length is directly proportional to monitoring system response. The longer the sample line, the longer the system response. The sampling system should be designed to minimize the length of sample lines. Also, the inlet and outlet sample lines for the SCR system should be of equal length. This reduces the number of components and the calculations required in the PID control system for the SCR (i.e., lagtime for the flow through the SCR will only need be accounted for and not monitoring lagtime differences).

Dust Filtration – The flue gas sample must be filtered at temperatures above the acid dewpoint. Filter porosity should be no greater then 2 microns prior to the analyzer. Probe filters must have site adjustable timers for blowback and the blowback air must be maintained above 550° F. This prevents corrosion and solids buildup.

Analyzer Response – The system should be designed such that the actual system response from probe tip through analyzer should be 30 seconds or less.

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