Selective Catalytic Reduction – Ammonia Slip

Products: Tiger-i 2000

Tiger Optics Overview

Tiger Optics introduced the world's first commercial "Continuous Wave Cavity Ring-Down Spectroscopy" (CW-CRDS) analyzer in 2001. Today, our instruments monitor thousands of critical points for industrial and scientific applications. They also serve the world's national metrology institutes, where they function as transfer standards for the qualification of calibration and zero gases, as well as research tools for such critical issues as global warming and urban air quality.

CW-CRDS is ideally suited to the requirements of numerous environmental measurement applications, including process control for selective catalytic reduction (SCR) applications, where factors such as accuracy, sensitivity, low detection limits, speed of response, long-term stability, low maintenance, and interference free operation are all essential. This application note details the use of our Tiger-i 2000 NH_3 unit for SCR process control applications.

Tiger-i 2000 NH_3

SCR Ammonia Slip

Oxides of nitrogen, or NO_x, are formed in the combustion process via the reaction of nitrogen with oxygen at elevated temperatures. NO_x is a major by-product from a range of combustion sources and a key atmospheric pollutant.

Atmospheric NO_x is responsible for the formation of particulate matter and smog, acid rain, as well as the formation of tropospheric ozone. As such, emissions of NO_x to the atmosphere are strictly regulated, requiring the use of abatement technologies to reduce its concentration in the effluent stack gas.

Selective catalytic reduction by reaction with either ammonia (anhydrous or aqueous) or urea virtually eliminates NO_x from stack gases. The ammonia or urea is mixed with the stack gas prior to entry into a catalyst chamber, which facilitates the reactions as follows:

Ammonia:

$$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$$
$$NO + NO_2 + 2NH_3 \rightarrow 2N_2 + 3H_2O$$

Urea:

$$4NO + 2(NH_2)_2CO + O_2 \rightarrow 4N_2 + 4H_2O + 2CO_2$$

The schematic below shows a typical SCR system for a boiler application, in this case employing liquid ammonia as the reductant.

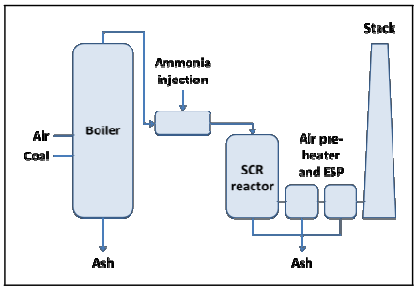

Figure 1. Example SCR schematic

Efficient operation of the system calls for tight control of the quantity of ammonia or, less often, urea introduced to optimize the conversion of NO_x. The key is to avoid the release of unreacted ammonia (so called ammonia slip) from the stack into the environment.

Ammonia is a critical atmospheric pollutant in its own right. As well as an odor nuisance at a local level, it is also a major contributor to the formation of airborne particulate matter. The transport of this secondary pollution, as well as ammonia itself, has a negative impact on air quality many miles from the source.

To prevent ammonia slip, you can control the amount of added reductant by accurately measuring the concentration of ammonia in the effluent gas and adjusting the input accordingly.

Current Analytical Technologies

Methods for monitoring ammonia include UV-VIS, *in situ* tunable diode laser absorption spectroscopy (TDLAS), and NDIR/FTIR. These options suffer from issues with both reliability and the accuracy requisite to measure at low ppm concentrations.

By contrast CW-CRDS offers the performance and range to contend with this demanding application, delivering accurate measurements at sufficiently low levels.

CW-CRDS for SCR Process Control

Tiger Optics Tiger-i range has been developed for the measurement of trace level gases in samples at ambient pressure, via the use of a vacuum pump. All Tiger Optics instruments are based on CW-CRDS, as shown in Figure 2 below.

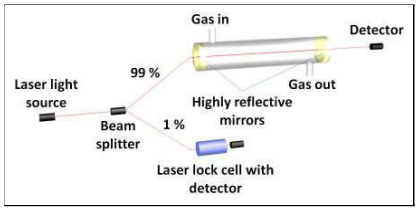

Figure 2. Schematic of CW-CRDS Analyzer

CW-CRDS works by tuning light rays to a unique molecular fingerprint of the sample species. By measuring the time it takes the light to expire or "ring-down", you receive an accurate molecular count in milliseconds. The time of light decay, in essence, provides an exact, non-invasive, and rapid means to detect contaminants.

CW-CRDS Sampling System and Operation

Tiger Optics CW-CRDS analyzers bring significant benefits to SCR monitoring applications:

- Accuracy traceable to the world's major national reference labs
- Freedom from interference
- No zero or span required
- No periodic sensor replacement/maintenance
- Nano-second speed of response
- Wide dynamic range

Coupled with a suitable dilution extractive sampling system – either a dedicated system or existing installation – the Tiger-i 2000 is capable of measuring ammonia at concentrations in the raw sample gas from low ppb to high ppm. Dilution enables the use of non-heated transfer lines to deliver a clean, cool gas with low particulate concentration to the analyzer. This simplifies the monitoring system, negating the need for costly heated lines and improving ammonia transport to the analyzer.

The maintenance-free and calibration-free nature of CW-CRDS also affords low cost of ownership and allows users to operate with confidence and ease in the field.

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Tiger Optics LLC, 250 Titus Ave, Warrington. PA 18976-2426, U.S.A ▪ Tel: +1-215-343-6600 ▪ Fax: +1-215-343-4194 ▪ sales@tigeroptics.com