Analysis in DeNOx Process (SCR, SNCR)

Applied Analytics Application Note No. DS-001G

Application Summary

Analytes: **NO**, **NO_2**, **NO_x** (sum of NO + NO_2), **NH_3**

Detector: **OMA-300 Process Analyzer**

Process Stream: **$DeNO_x$ outlet stream**

Introduction

$DeNO_x$ is the conversion of NO and NO_2—two hazardous nitrogen oxides known generically as NO_x—to nitrogen and water. Plants are required to run this process in order to restrict NO_x emissions below allowable limits.

The efficiency and operational cost of this process hinge heavily on adequate process monitoring, specifically measurement of NO_x and ammonia slip downstream from the reaction.

The OMA continuously measures the concentrations of NH_3 and NO_x in the outlet gas downstream from $DeNO_x$ in order to keep a vigilant watch on NO_x reduction efficiency, catalyst problems, excess/insufficient ammonia injection, and potential maintenance issues from ammonium bisulfate formation.

OMA Benefits

- Continuously measures NO, NO_2, and NH_3 concentrations using dispersive UV-Vis absorbance spectroscopy
- Totally solid state build with no moving parts — modern design for low maintenance
- Ultra-safe fiber optic design with dedicated sample flow cell — no toxic/corrosive sample fluid in analyzer box
- Early indication of potential maintenance problems like ammonium bisulfate formation

Ammonia Slip Measurement

In selective catalytic reduction (SCR), ammonia is injected upstream from a catalyst to act as a reducing agent:

$$4NO + 4NH_3 + O_2 \longrightarrow 4N_2 + 6H_2O$$

The term *ammonia slip* refers to the unreacted ammonia found in the effluent stream from this reaction. Ammonia slip indicates excess NH_3 injection and, therefore, complete reduction of NO_X. However, using more ammonia than what the stoichiometry demands is a sign of a few glaring problems:

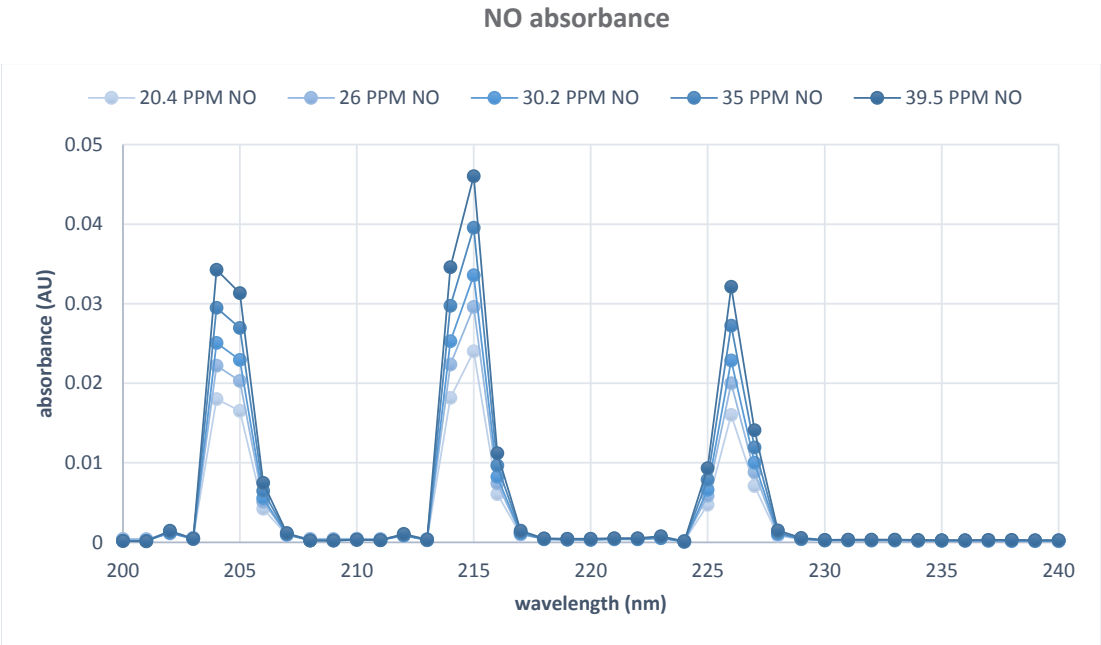
- NH_3 is an expensive utility to waste
- Downstream NH_3 will react with SO_3 to create ammonium bisulfate — a corrosive, tarlike solid notorious for plugging economizers and fouling surfaces
- Fly ash from NO_X reduction flue gas is often sold to manufacturers of concrete for added profitability, but fly ash contaminated with NH_3 makes concrete with unacceptable odor and is avoided by manufacturers
- NH_3 is a nonpoint source pollutant of water systems and contributes to particulate matter in the atmosphere

NO_X Measurement

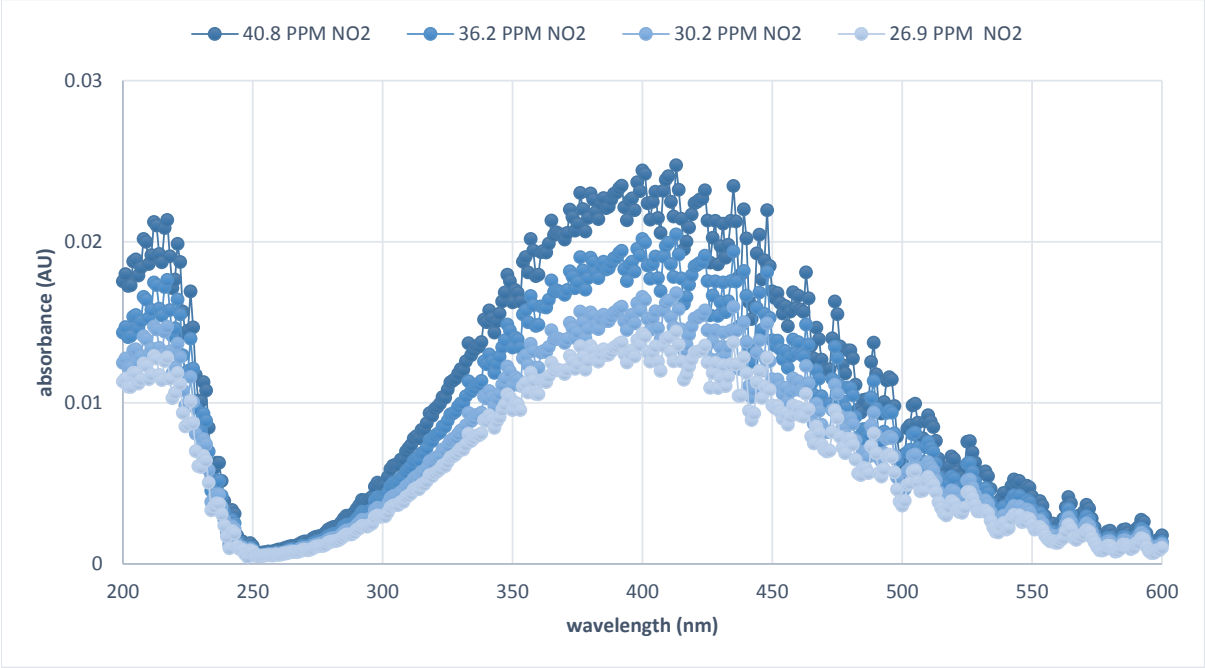
Monitoring the SCR effluent for the presence of NO and NO_2 is the most dependable method for verifying efficent NO_X reduction. Furthermore, a sudden spike in NO_X concentration downstream from the reaction is a good indication of catalyst bed failure.

Analyte Absorbance Curves

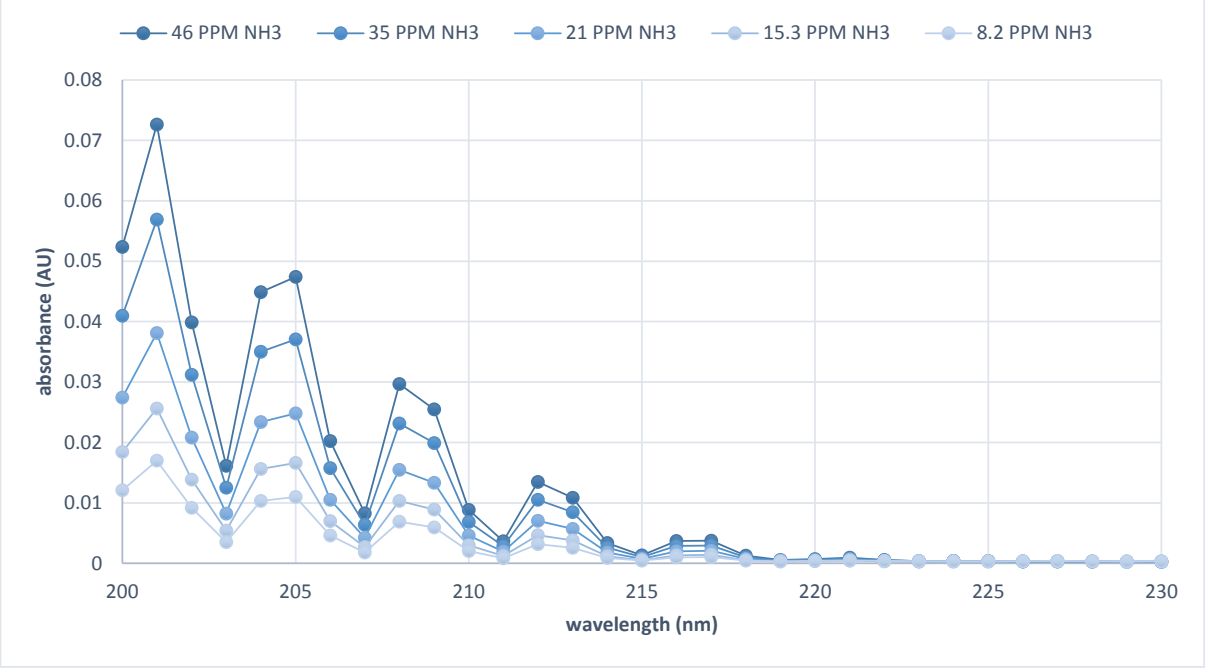
The OMA uses a high-resolution UV-Vis spectrophotometer to detect the complete absorbance curve of each analyte.



NO_2 absorbance

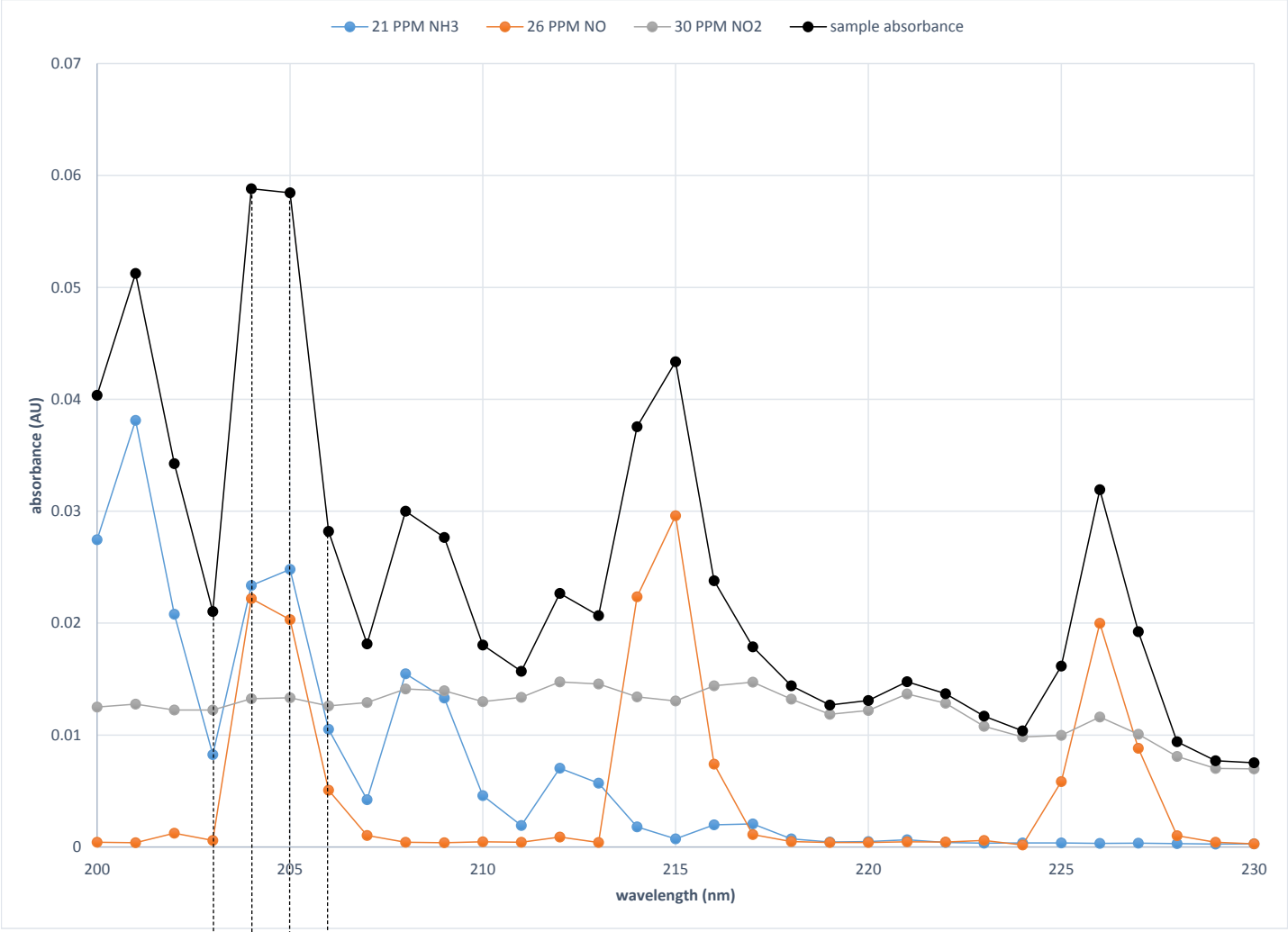


NH_3 absorbance



Multi-Component Analysis for DeNO$_x$ Stream

The OMA uses a proprietary multi-component analysis algorithm which harvests the rich data from the full-spectrum spectrophotometer in order to measure multiple chemicals with overlapping absorbance curves.



$$A^{206'}_{(NO + NO2 + NH3)} = e^{206'}_{NO}bc_{NO} + e^{206'}_{NO2}bc_{NO2} + e^{206'}_{NH3}bc_{NH3}$$

$$A^{205'}_{(NO + NO2 + NH3)} = e^{205'}_{NO}bc_{NO} + e^{205'}_{NO2}bc_{NO2} + e^{205'}_{NH3}bc_{NH3}$$

$$A^{204'}_{(NO + NO2 + NH3)} = e^{204'}_{NO}bc_{NO} + e^{204'}_{NO2}bc_{NO2} + e^{204'}_{NH3}bc_{NH3}$$

$$A^{203'}_{(NO + NO2 + NH3)} = e^{203'}_{NO}bc_{NO} + e^{203'}_{NO2}bc_{NO2} + e^{203'}_{NH3}bc_{NH3}$$

Each data point supplies an equation to the matrix which the OMA continuously solves in order to de-convolute the absorbance curves of multiple overlapping analytes. Using one data point at each integer wavelength, this method provides excellent signal:noise by eradicating the effect of erroneous results at any single wavelength.

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The specifications below represent performance of the OMA-300 Process Analyzer in a typical $DeNO_x$ application.

For technical details about the OMA-300 Process Analyzer, see the data sheet:
http://www.a-a-inc.com/documents/AA_DS001A_OMA300.pdf

All performance specifications are subject to the assumption that the sample conditioning system and unit installation are approved by Applied Analytics. For any other arrangement, please inquire directly with Sales.

Application Data		
Performance Specifications		
Accuracy	*Custom measurement ranges available; example ranges below.*	
	NO	0-100 ppm: ±1% of reading, full scale 0-500 ppm: ±1% of reading, full scale
	NO_2	0-100 ppm: ±1% of reading, full scale 0-500 ppm: ±1% of reading, full scale
	NH_3	0-10 ppm (if NO_x < 100 ppm): ±0.5 ppm 0-10 ppm (if NO_x > 100 ppm): ±1 ppm 0-1,000 ppm: ±1% of reading, full scale 0-1%: ±1% of reading, full scale 0-50%: ±1% of reading, full scale
	Notes: *1. NO_x measurement specification assumes sample SO_2 concentration < 400 ppm. NH_3 measurement specification assumes sample SO_2 concentration < 100 ppm. These conditions can be ensured by optional SO_2 removal in sample conditioner.*	

Further Reading

Subject	Location
OMA-300 Process Analyzer Data sheet	http://www.a-a-inc.com/documents/AA_DS001A_OMA300.pdf
Advantage of Collateral Data Technical Note	http://www.a-a-inc.com/documents/AA_TN-202_CollateralData.pdf
Multi-Component Analysis Technical Note	http://www.a-a-inc.com/documents/AA_TN-203_MultiComponentAnalysis.pdf

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