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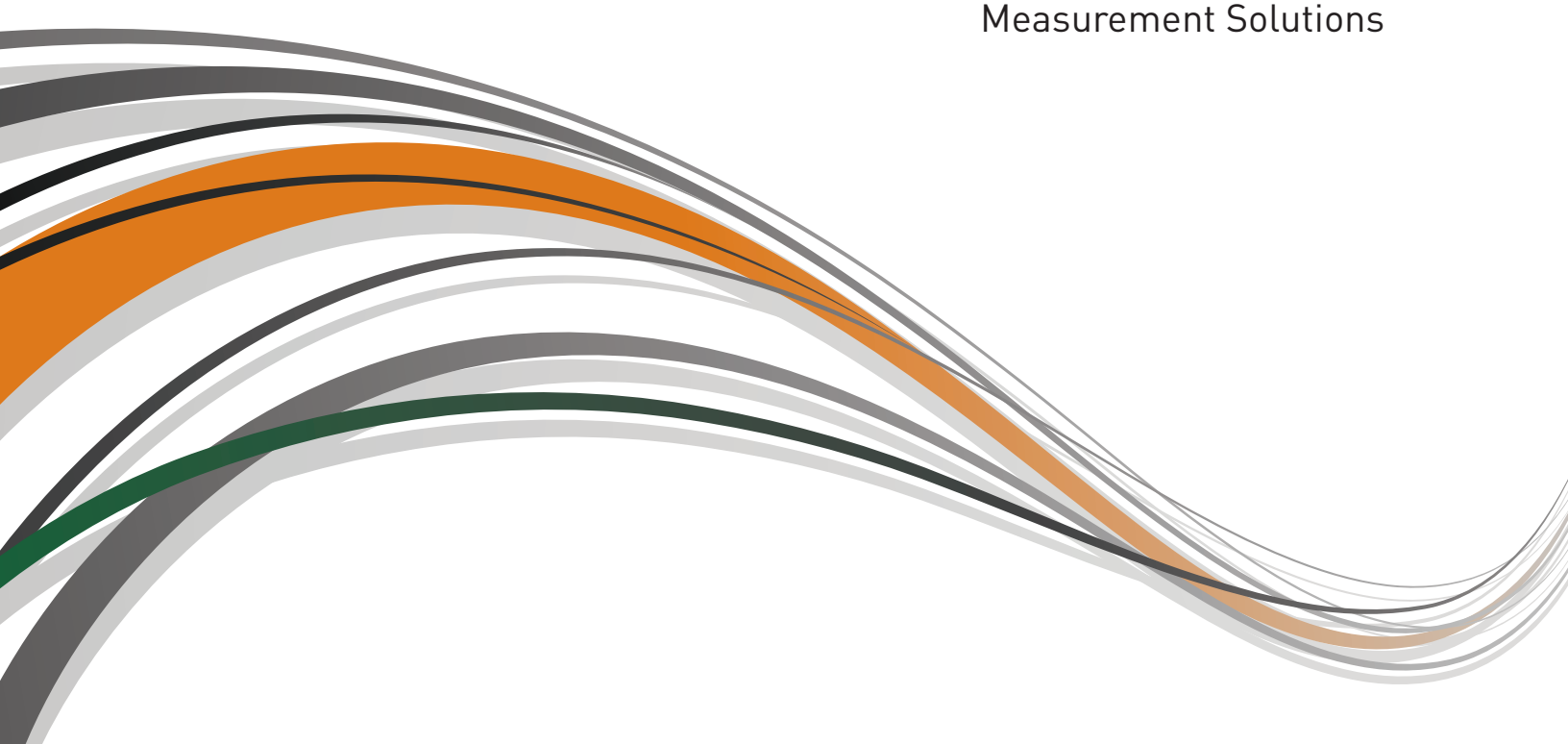
SMART SCIENCE • CLEANER ENERGY

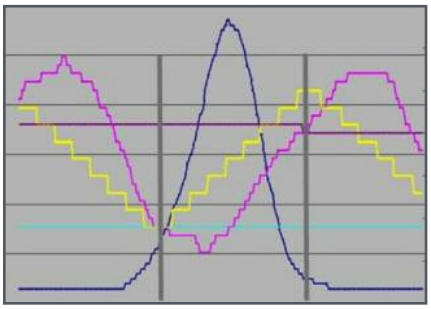
Acid Gas (SO_3 and HCL)
Measurement Solutions



SO_3 Measurement – AbSensor SO_3 condensables system

INTRODUCTION

Sulfur in the fossil fuel combustion process oxidizes to form SO_3 in the Boiler and convective pass region with additional SO_3 being generated in the SCR, if present. SO_3 exists in various forms throughout the flue gas time-temperature history and therefore it is difficult to accurately measure SO_3 unless you can define which form of SO_3 is to be measured.



AbSensor-SO_3 measurement Cycle

Forms of SO_3

- **SO_3 Gas** – Exists above 800 DegF and in reducing quantity between 800 DegF to 400 DegF
- **H_2SO_4 Vapor** – SO_3 combines with H_2O to form Sulfuric Acid Vapor. Starting at 800 DegF until it is all converted by 400 DegF.
- **H_2SO_4 Aerosol** – Typically below 400 DegF. When H_2SO_4 Vapor goes through rapid cooling which can occur in the Air Heater, the vapor condenses out in the gas phase and forms an aerosol. This is also called Sulfuric Acid Mist or SAM. Post Wet-Scrubber, all H_2SO_4 is SAM.
- **Ammonium Bisulfate** – As SO_3 combines with H_2O to form H_2SO_4 vapor, it can further combine with free Ammonia and form Ammonium Bisulfate, which is a condensable gas. Typically exists between 330 DegF to 550 DegF. The Ammonia to SO_3/H_2SO_4 ratio is typically in the 1:1 range at equilibrium to form Ammonium Bisulfate.
- **Ammonium Sulfate** – When the Ammonia to SO_3 ratio gets closer to 2:1 Ammonium Sulfate is formed. However, kinetically, Ammonium Bisulfate forms first. Ammonium sulfate is not condensable but it is too small to be captured by the ESP and escapes up the stack providing nucleation sites for water. Ammonia then off-gases and a Sulfuric Acid plume results.
- **Sodium Bisulfate** – If Sodium is present along with SO_3 at the right temperature, Sodium Bisulfate can form which is a high temperature, 350 to 600 DegF, condensable.

Define the problem

Sulfur condensables, which include all the species above result in one of the following balance of plant (BOP) impacts:

- Backpass Slagging
- SCR performance and Mimimum Operating Temperature (MOT)
- Air heater fouling, ID Fan capacity, Unit derate
- ESP Performance
- Baghouse Bag blinding
- Duct corrosion
- Visible (Blue) Plume

Measure the condensable

SO_3 gas itself is never the root cause of the problem. One of the condensable species defined above is the root cause. Therefore, it makes the most sense to measure the condensables rather than focusing on SO_3 gas ppm.

AbSensor – SO3 Condensables System

The Breen AbSensor – SO_3 condensables system is the only commercially proven product in the marketplace that can measure all the SO_3 condensables species defined above. Based on the location of the measurement point, one or more of these species can be measured. With over 125 systems installed commercially and in closed loop control, the AbSensor device is the clear choice for SO_3 measurement in the industry. The output of the device includes, as applicable, SO_3 ppm, Formation Temp (temp at which material will condense), Evaporation Temp (temp at which material will self-vaporize), Equilibrium dewpoint and fouling state and intensity.

HCL Measurement – Infrared Absorbance Spectroscopy

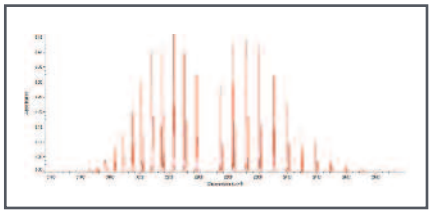
INTRODUCTION

HCL is a very difficult measurement to make in power plant flue gases due to its low concentration, high reactivity, water solubility and low temp dewpoint in the water range.

Typical measurement techniques are based on Infrared Absorbance Spectroscopy and may be based on Laser sources (Tunable Diode Laser or Quantum Cascade laser) or Fourier Transform Infrared Systems (FTIR).

Infrared Absorbance Spectroscopy

This is a spectroscopic technique that measures the absorption of radiation in the Infrared Region as a function of wavelength, due to its interaction with the sample. A material's absorption spectrum is the fraction of the incident radiation that is absorbed by the material over a range of frequencies. Radiation can only be absorbed at frequencies that match the energy difference between two Quantum Mechanical states of the molecule being measured.



HCL Absorption Spectrum

This technique can employ a narrow band radiation source such as a Tunable Diode Laser or a stronger, slightly wider band radiation source such as a Quantum Cascade Laser or a full IR band system as typically employed in FTIRs.

TDLAS (Tuneable Diode Laser Absorption Spectroscopy) is a more cost-effective method but has lower power and a narrower analysis band. Typically the analysis region is chosen to avoid absorption from other compounds. But if this is not possible it will be susceptible to interference

QCLAS (Quantum Cascade Laser Absorption Spectroscopy) has more power and a wider scanning region than TDLAS and is therefore able to penetrate through more opaque paths and can use a wider analysis region to avoid interferences. However, it is specifically designed to measure a particular compound, such as HCL.

FTIR (Fourier Transform Infrared Spectroscopy) uses an interferometer and either an absorption cell or a cross-duct configuration to generate an absorption spectrum through the entire IR region. As a result it can be easily used for multi-component measurement and analysis.

Gas Sampling

Measurement can be made across the duct or a sample gas may be extracted into a cell through which the incident radiation source is passed to produce an absorbance spectrum. In-duct measurements are susceptible to dust loading, positive pressure, fouling issues and therefore are limited by duct dimensions, power of the incident source and alignment.

Extractive methods require appropriate sample line material and conditioning to ensure that the material to be measured is not effected by the sample line. Therefore temperature control and sample line length is critical. Further, the incident source must be bounced off mirrors within the cell to obtain a path length suitable for the accuracy and minimum concentrationsrequired for the material being measured. PPM level measurements of HCL may be obtained with relatively short path lengths in the order of 3 to 6 feet. Close-coupled extractive methods minimize the need for sample line conditioning thereby greatly improving reliability of the system and reducing maintenance.

AbSensor – HCL Measurement System

The Breen HCL monitor is based on an FTIR measurement methodology using sample lines and providing the capability for multi-component measurement including, but not limited to, SO_2, NOX, NH_3, CO_2, CO etc. Built in the format of a CEMs device, various mechanical, data analysis and software improvements have been made to take into account typical drawbacks and issues associated with FTIR techniques. A dynamic mirror alignment system, auto-shift and heuristic software techniques make the measurement reliable and maintenance free.

Future direction

Breen is working on across the duct and close-coupled extractive techniques to minimize sample line related issues and maintenance as well as improve accuracy and reliability of the system. New products based on these sampling techniques and QCLAS and FTIR techniques are expected to be released in 2012.

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ACID GAS MEASUREMENT SOLUTIONS

AbSensor – SO_3 condensables measurement system

- In-Duct, in-situ measurement
- Dewpoint based device
- Directly measures the condensables species
- Provides SO3 ppm data where applicable
- Provides Formation, Evaporation and Dewpoint Temperatures
- Over 125 Commercial installations in the power industry
- Ideal for closed-loop control of DSI systems

AbSensor – HCL measurement system

- FTIR or QCLAS based measurement
- Minimum measurement threshold 0.5 ppm
- CEMS design
- Rugged, Reliable with minimum maintenance
- Coming soon – Across the duct and Close-coupled extractive