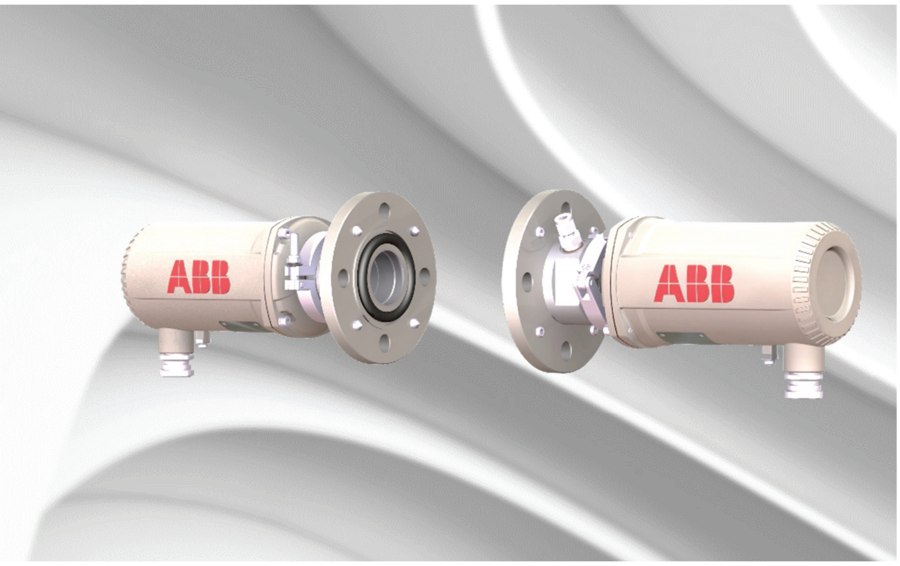
ABB MEASUREMENT & ANALYTICS | APPLICATION NOTE

Diode laser analyser LS4000

Ammonia slip measurement for DeNOx process



Optimize efficiency of denitrification process in DeNOx unit.
Reduce downstream problems, related costs and maintenance work.

Measurement made easy

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Diode laser analyser LS4000
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Introduction

During combustion – one of the most wide-spread industrial process across all industry sectors – the chemical energy present in fuels, such as coal, natural gas or oil, is converted into heat by oxidization.
The heat is needed for a wide range of production processes such as generation of electricity in coal fired power plants.
The flue gas contains various air pollutants, which are harmful to the environment and people.

With a growing sensibility for environment protection, the reduction of air pollutants has globally attracted the attention of governments. Besides others, nitrogen oxides (NOx), which comprise nitrogen oxide (NO) and nitrogen dioxide (NO_2), is considered to be a major cause for environmental damage. Hence, its emissions are strictly restricted by national and supranational regulations.

In order to comply with the emission limits, various measures are applied, which can generally be categorized into primary and secondary measures.

- Primary measures aim to avoid the formation of NOx during the combustion process itself.
- In contrast, secondary measures remove the pollutant before the flue gas is released to the environment.

Since primary measures tend to have insufficient efficiency levels, often secondary measures such as flue gas treatment systems play a major role for achieving the emission limits.

The part of the flue gas treatment system, in which the abatement of nitrogen oxides takes place is the denitrification unit, in short DeNOx unit (refer fig. 01 on page 3).

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Ammonia slip measurement for DeNOx process

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01 DeNOx unit as part of flue gas treatment on the example of a coal-fired plant

Measuring task – Ammonia slip measurement
As shown in Fig. 01, the exhaust gas from the boiler enters the DeNOx unit where nitrogen oxides are removed by a chemical reaction.

For this chemical removal of NO and NO_2, a reducing agent, for example ammonia (NH_3), is injected into the flue gas in the headspace or upstream of the unit.

The concentration of the injected ammonia is constantly regulated depending on the NO/NO_2 concentration in the exhaust gas. Even if the basic principle is identical, secondary measures can be divided into two types.

An often used technology is the selective catalytic reduction (SCR), which applies catalysts to accelerate the reduction of nitrogen oxides.

In contrast, the alternative selective non catalytic reduction (SNCR) does not uses catalysts, but requires higher process gas temperatures.

Due to the lower required process temperatures and higher reduction rates of more than 95 %, SCR is often the preferred technology.

In case of SCR, the mixture of ammonia and flue gas passes the catalysts where the nitrogen oxides are reduced on the SCR catalyst to produce elementary nitrogen and water vapor. Downstream to the SCR unit, only very few NOx and NH_3 molecules are present.

The residual NH_3 concentration at the outlet is called ammonia slip, which is continuously monitored (refer fig. 01).

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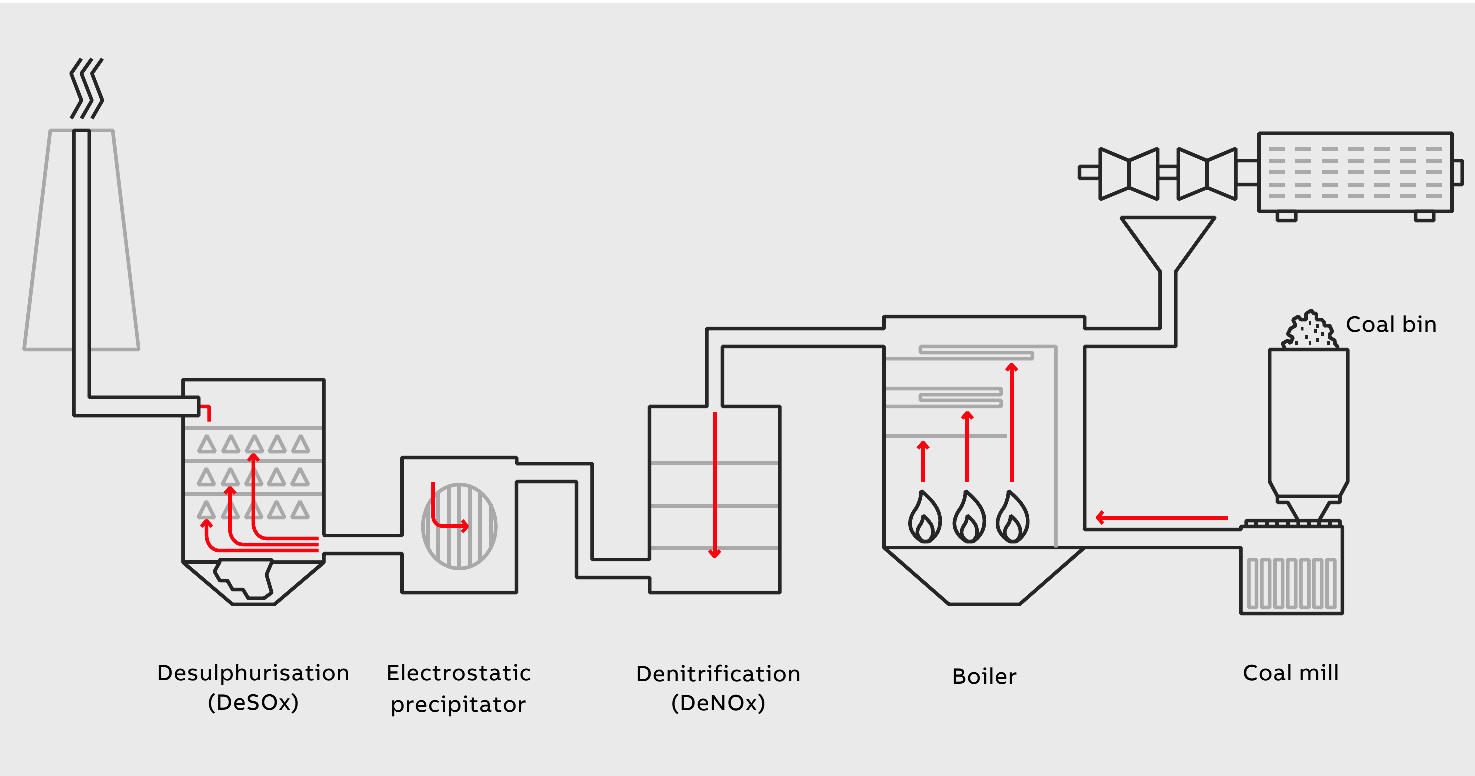

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01 Ammonia slip measurement in DeNOx units

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02 Schematic diagram of SCR process

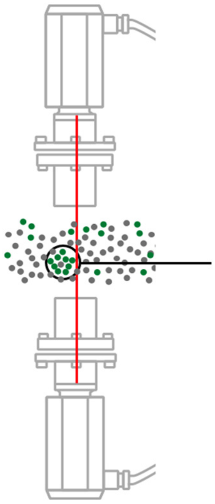
Why is this measurement important to plant operators?

In general, the motivation for the ammonia slip measurement after SCR and SNCR DeNOx units is manifold.

- First of all, the measurement helps plant operators with the trade-off between having sufficient ammonia present for the target conversion of NOx and the minimization of the ammonia consumption and ammonia slip at the same time. This allows to minimize the related operation costs for the reducing agent, but still to be compliant with emission limits.
- Secondly, the ammonia slip helps to determine the best point in time for catalyst regeneration in SCR units. If there is a trend of increasing ammonia slip at unchanged conditions, this is an indicator that the catalyst activity is decreasing.
- Thirdly, it is important to monitor the ammonia slip since it can have severe impacts on the downstream equipment. After the DeNOx outlet, unused ammonia reacts with acidic gas components present in the flue gas. This results in formation of ammonia salts, of which especially ammonium bisulphate causes problems. Due to the lower temperature downstream to the DeNOx unit, ammonium bisulphate accumulates on surfaces of downstream equipment (e.g. air preheater) leading to an increased pressure drop or in worst-case plugging of the equipment. Additionally, ammonia bisulphate in combination with water from the flue gas can also causes corrosion of downstream equipment.
- Finally, excess ammonia can contaminate fly ash, which is often sold as by-product to the cement industry. If the quality limits are exceeded, the ash can no longer be sold. This equals a financial loss impacting the overall profitability of operation.

To sum up, this measurement helps the operator to

- optimize efficiency of denitrification process and
- reduce downstream problems, related costs and maintenance work caused by an excess of ammonia.



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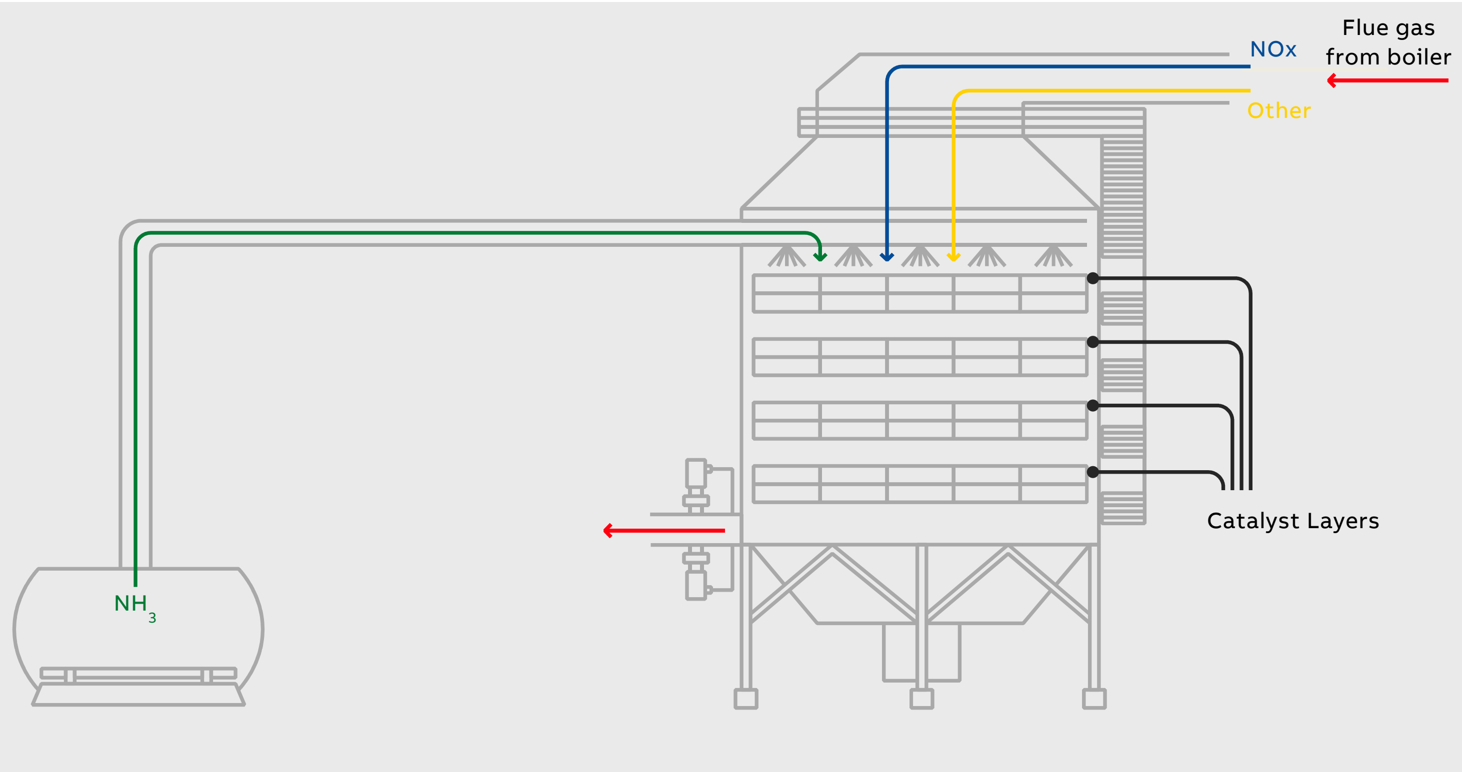

Applied denitrification technology
The typical process conditions as well as the measuring range depend on the applied denitrification technology (i.e. SCR or SNCR).
In case of SCR, the measurement range is typically in the low parts per million (ppm) range and the typical conditions for SCR are shown in Table 01 on Page 6.
For SNCR, the ammonia slip and also the related measuring range are usually higher. In addition to NH_3, an optional H_2O measurement is often conducted additionally.

Traditionally used Technology
Historically, extractive analyzers – often with indirect, differential methods – have been applied for this measuring task. However, ammonia is difficult to measure extractive due to its sticky and reactive behavior. It might be lost in the sample handling system or leads to plugging of the tubes due to the formation of ammonia salts. Since the typical measuring range is a few [ppm], a measurement technology with higher sensitivity is needed.

ABB's solution
ABB's LS4000 is an in-situ cross-stack analyzer applying the highly selective, optical measuring principle of tunable diode laser absorption spectroscopy (TDLAS). The device consists of a transmitter unit with a laser light source and a receiver unit with a photo detector, connected via a junction box which includes all interfaces such as power supply and analog outputs.

Highly selective measurement is virtually cross interference free
The optical measuring principle of tunable diode laser absorption spectroscopy (TDLAS) allows a direct, virtually cross-interference free measurement. Due to the narrow spectral line width of the laser beam and the narrow scan window, only the absorption line of the target measuring component is scanned.
Consequently, a high selectivity and accuracy of the measurement is achieved, which fulfills the requirements of the low ppm-level NH_3 measurement.

Fast and direct
A sample transport and conditioning, like used in extractive systems, is not required since the LS4000 is directly installed at the process (in-situ). This precludes the loss of ammonia in the sample system and reduces the maintenance efforts for sample handling components.
Moreover, the LS4000 ensures more representative measurement since local concentration spots (e.g. due to inhomogeneity's of catalyst efficiency) can be detected by measuring across the duct.

Safe, compact and easy
Additionally, LS4000's compact and light-weight housing makes LS4000 insensitive to vibrations and makes LS4000 is easier to handle. Due to its long term stability maintenance efforts for calibration are minimized.

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01 Clean coal power plant

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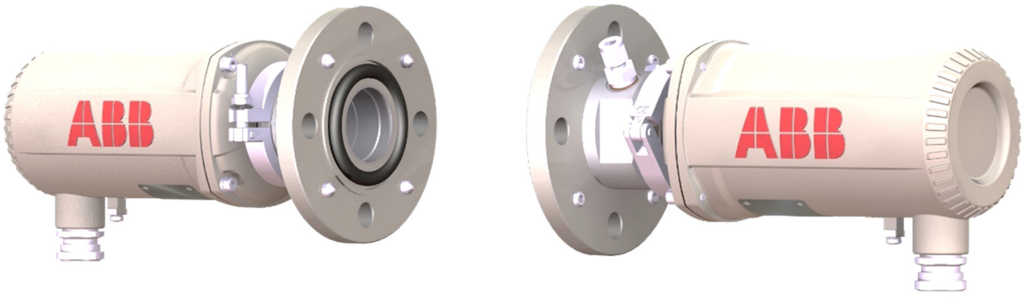
01 Diode laser analyser LS4000



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	Diode laser analyzer LS4000
Measuring ranges	NH_3: 0 ... 10 to 0 ... 50 ppm H_2O: 0 ... 30 to 0 .... 40 Vol%
Process temperature	250 ... 400 °C (482 ... 752 °F)
Process pressure	980 ... 1040 mbar abs.
Dust load	< 5 g/m^3
Typical open path length	2 ... 5 m (6.6 ... 16.5 ft)

Table 01: Typical process conditions for NH_3 slip (SCR)

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AN/ANALYTICAL/LS4000/101-EN Rev. B 08.2017