World-leading supplier

Your partner for gas monitoring solutions

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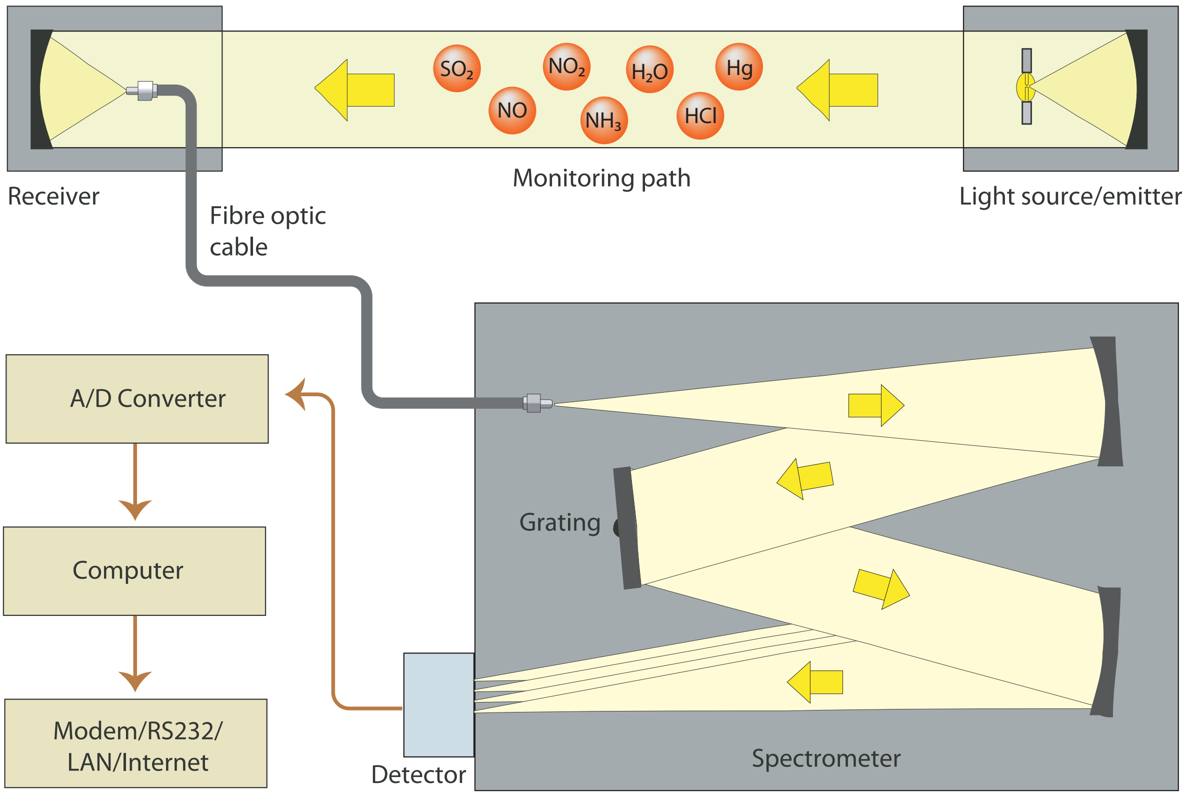
UV DOAS • FTIR DOAS • TDL

OPSIS Monitoring Techniques

OPSIS UV DOAS Technique



The basis of the principle used by OPSIS to identify and measure concentrations of different gases is scientifically well established: Differential Optical Absorption Spectroscopy (DOAS), which is based on Beer-Lambert's absorption law. It states the relationship between the quantity of light absorbed and the number of molecules in the lightpath.

Because every type of molecule, every gas, has its own unique absorption spectrum properties, or "fingerprint", it is possible to identify and determine the concentrations of several different gases in the lightpath at the same time.

DOAS is based on transferring a beam of light from a special source – a high-pressure xenon lamp – over a chosen path and then using advanced computer calculations to evaluate and analyse the light losses from molecular absorption along the path. The light from the xenon lamp is very intense, and includes both the visible spectrum and ultraviolet and infrared wavelengths.

The light is captured by a receiver and conducted through an optical fibre to the analyser. The fibre allows the analyser to be installed away from potentially aggressive environments.

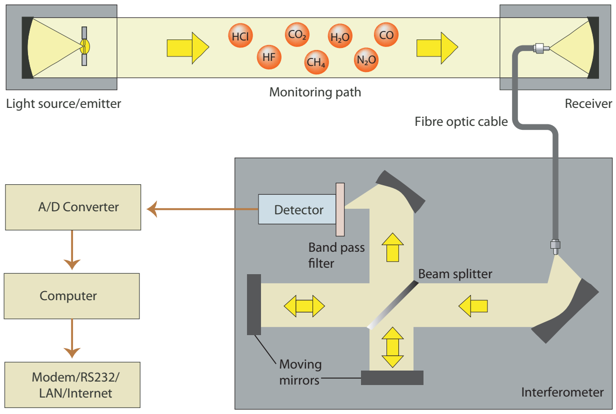
The analyser includes a high-quality spectrometer, a computer and associated control circuits. The spectrometer splits the light into narrow wavelength bands using an optical grating. This can be adjusted so that an optimum range of wavelengths is detected.

The light is transformed into electrical signals. A narrow slit sweeps past the detector at high speed, and a large number of instantaneous values are built up to form a picture of the spectrum in the relevant wavelength range. This scan is repeated a hundred times a second, and the registered spectra are accumulated in the computer's memory while awaiting evaluation.

The absorption spectrum just registered from the light path is compared with one calculated by the computer. The calculated spectrum consists of a well-balanced summation of the reference spectra for the analysis concerned.

The computer proceeds by varying the size factors for each reference spectrum until it reaches the best possible match. From this the different gas concentrations can be calculated with high accuracy.

OPSIS IR DOAS Technique



OPSIS has developed an analyser for monitoring compounds specifically in the infra-red wavelength range area. The OPSIS IR technique is based on the same method for identifying and measuring concentrations of various compounds as the comprehensive OPSIS spectrometer technique, described on the previous page.

The IR technique is based on Beer-Lambert's absoption law, which states the relationship between the quantity of light absorbed and the number of molecules in the light path. A light source projects a light beam onto a receiver which transfers the light via an optical fibre to the analyser.

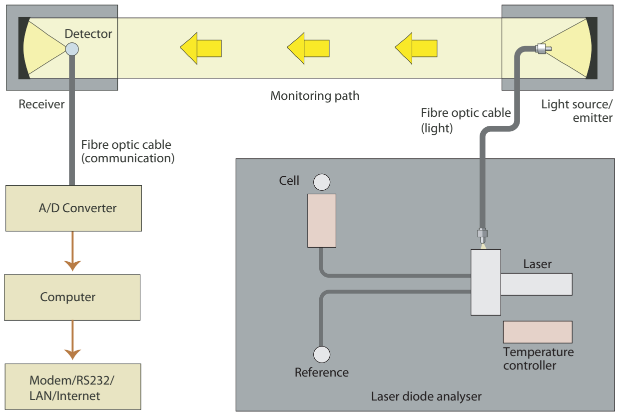
The analyser includes an interferometer, a computer and control circuit cards. The interferometer consists of a beam splitter which divides the light towards two moving mirrors. An interference pattern is formed.

By using advanced computer calculations, the interference pattern is transformed into a wavelength spectrum, corresponding to the spectrum which is measured in the OPSIS spectrometer.

The interferometer gives higher spectral resolution in the infra-red wavelength range than the spectrometer does.

The computer proceeds by varying the size factors for each reference spectrum until it reaches the best possible match. From this the different gas concentrations can be calculated with high accuracy.

OPSIS TDL Technique



OPSIS LD500 laser diode gas analyser, based on the TDL (Tuneable Diode Laser) technique, emits laser light in the near infra-red section of the wavelength spectrum. The measurement is made by rapidly scanning the laser over the absorption line in the gas absorption spectrum.

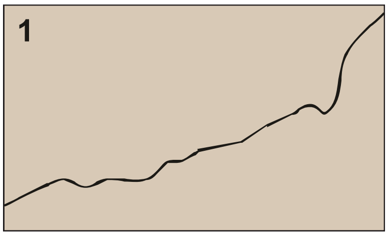
The laser operates continuously, and it is tunable, so the laser wavelength can be slightly changed. This is achieved by applying an electric voltage across the semiconductor diode. The voltage applied is precisely controlled, and varies according to a ramp function during a scan.

During a measurement, the LD500 averages a large quantity of scans. The measurement interval is in the order of 1-20 seconds, and the scanning rate is in the kilohertz range.

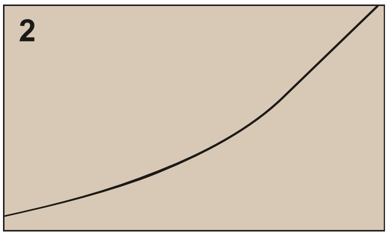
In the end of the measurement interval, the averaged spectrum enters an evaluation procedure. The result is compared through a least squares fitting procedure with the known absorbance cross section of the gas.

The cross section relates to the strength of absorption in the gas, at specific wavelengths. Knowing the monitoring path length, the concentration of the gas can then be evaluated.

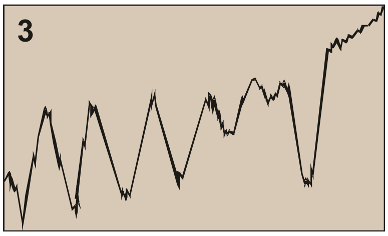
What happens in the computer?



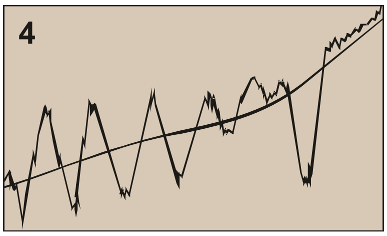
1. Once the data has been collected, the raw spectrum is stored in the computer's memory.



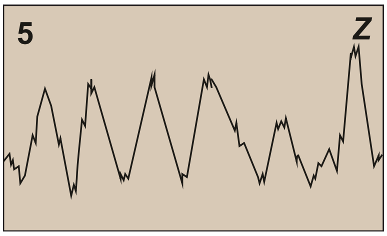
2. First the raw spectrum is compared with a zero-gas spectrum. This has previously been registered with no absorption gases present and is used as a system reference.



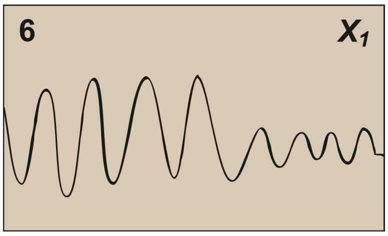
3. After division by the zero-gas spectrum, the total light absorption between the transmitter and the receiver is obtained. This result is caused not just by the gases that are present but also by e.g. dust in the atmosphere or dirty optics. The task now is to separate the light absorption of the gases from other influence.

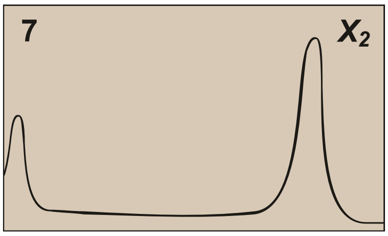


4. To do this, the system takes advantage of the fact that only gas molecules will cause rapid variations in the absorption spectrum. The slow variations, which give rise to the gradient on the absorption curve, result from a large number of known and unknown factors. Their influence can be eliminated completely by matematically matching a curve which does not follow the rapid variations in the spectrum.



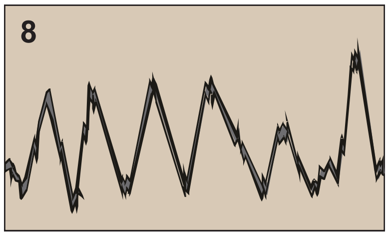
5. After a new division, all that remains are the rapid variations. For the remaining calculations, the logarithm of the curve is taken, which turns the curve upside down. A differential absorption spectrum has now been obtained. This spectrum is a combination of the various gases present between the transmitter and the receiver at the moment of detection. In the example this is called Z.





6-7. The gases that absorb light in this wavelength range are already known, and a pre-recorded reference spectrum for each gas is stored in the computer's memory. In this example there are only two gases, called X_1 and X_2. The task is to determine the proportions of X_1 and X_2 that combine to give the best match for Z. The system achieves this by very rapidly creating a new curve out of the sum of the two reference spectra, varying values until the best correspondence is achieved.

The equation the computer uses can be expressed as $C_1X_1 + C_2X_2 = Z$, where C_1 and C_2 are the proportions of each gas. From C_1 and C_2 it is then possible to calculate the current concentrations.



8. Finally, the result is checked by determining the difference between the measured and the calculated curves (the shaded area). This means that every measurement result can be stated with a standard deviation.

The more reference curves stored in the computer's memory, the more accurate the result of the calculation will be. However, even if there should be some unknown interference, i.e. when the measurements are affected by a gas whose reference spectrum is not stored in the computer's memory, the computer nevertheless evaluates the gases it is programmed for. The influence of the unknown gas is presented as an increase in the standard deviation in the measurement result.

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