CEM 2004

COMPARISON OF METHODOLOGIES FOR CONTINUOUS, AUTOMATIC EMISSION DUST MONITORING

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Introduction

Automatic monitoring for particulates in gaseous medias is a special challenge, as the required answer from the monitors is a signal of Concentration, however, the matter to be detected is a mixture of two phases (stack gas = gaseous phase, particulates = solid phase), and such a mixture never can be ideal. Therefore in-situ methods avoiding the extraction of sample gas for measurement have a significant advantage over extractive methods. For extractive methods (including the reference method Isokinetic Gravimetric Sampling) the position of the extraction point (= representative point) is of vital importance for the accuracy of the measurement.

For automatic monitoring various methodologies are available. In general they can be grouped into several, partially also overlapping, groups:

Qualitative and Quantitative Methods

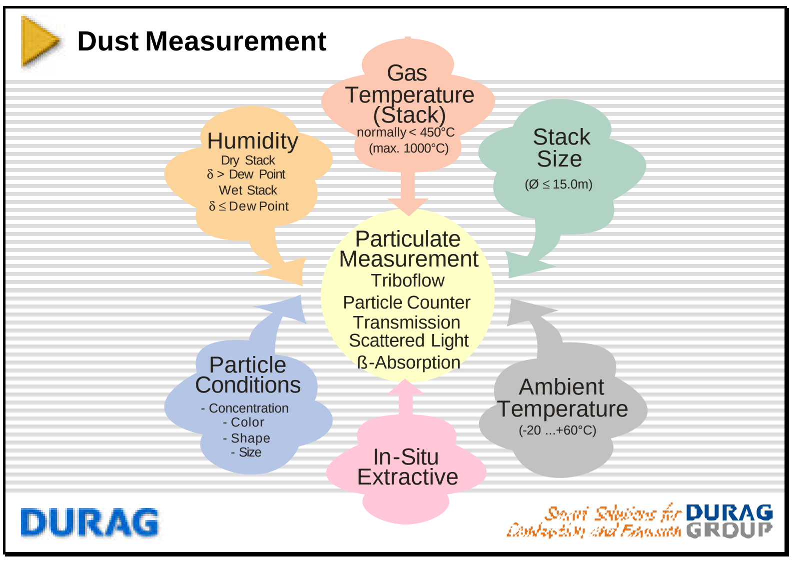
In-situ and Extractive Methods

Electrical and Optical Methods

Optical methods can be sub-grouped into Light-Transmission and Light-Scattering Methods.

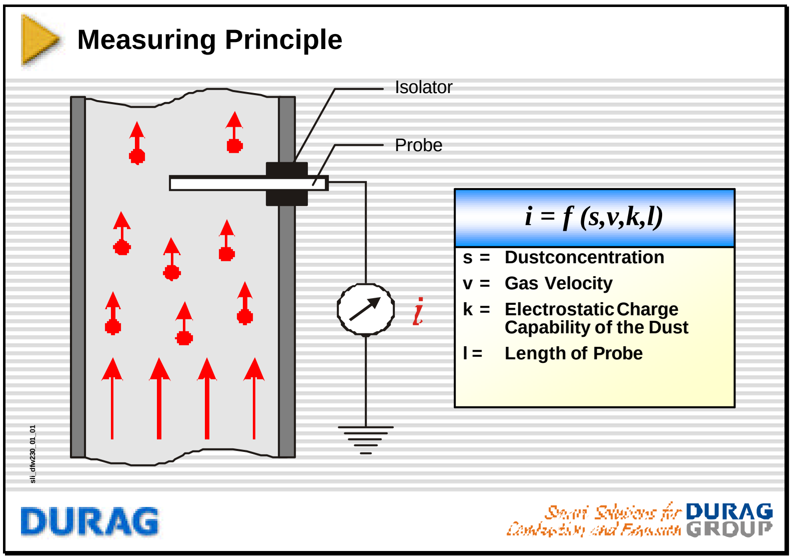
Main Subject

The decision, which methodology turns-out to be the most suitable one to solve a specific task of dust/particulate monitoring is based on various aspects:

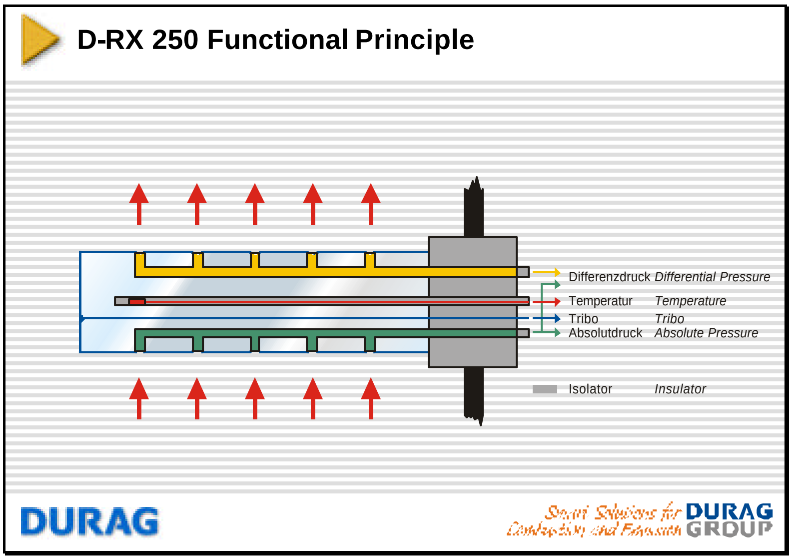


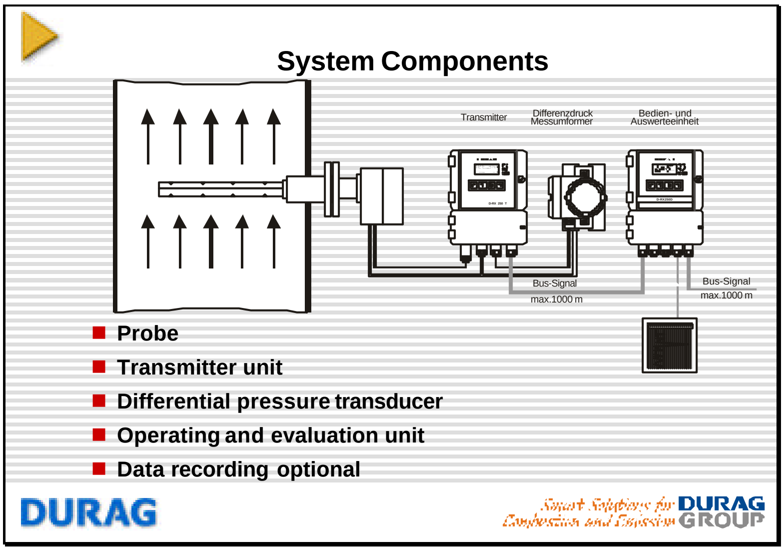
Electrical Methods

Tribo-Electric Methods (Triboflow) are either qualitative or quantitative methods. The detection principle is based on the electrostatic charge of particles once they are transported in a gas stream. The amount of electrostatic charge is mainly based on the mass and the velocity of the particles. Therefore changes in gas velocity show influences in the reading and triboelectric probes are used as qualitative filter monitors to detect the development of cracks in bag filters.



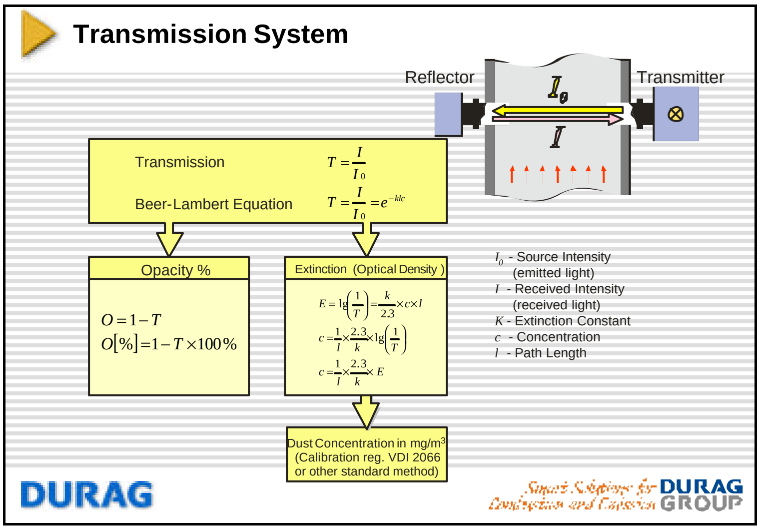
However, if the gas velocity is measured in parallel and the triboelectric reading automatically corrected for velocity changes this methodology can also be used for quantitative dust concentration measurement and can be calibrated using the standard method.





Optical Methods

Optical Methods are the most widely used detection methods for automatic and continuous measurement of dust concentration in stack gas. These methods are divided into Light Transmission and Light Scattering. Light Transmission can give two different results: Opacity or Optical Density. The measurement itself (emitted light and received light) is the same, only the calculation of the result is different. Opacity is the quotient of received light over emitted light (which is transmission), whereas for Optical Density / Dust Concentration the concentration of the absorbing matter (= dust particles) is calculated according to the Beer-Lambert Equation.



Light Transmission Instruments increase their sensitivity with increasing path length. As longer the path length as lower the detection limit. Therefore this methodology is mainly used for medium to large stacks and for medium to high concentration. A major interference for the Light Transmission Principle is the particle size of the to-be-measured dust particles. However, under normal conditions in emissions the particle size (as well as the density and specific weight of the fly ash) are fairly constant; therefore the interference is more theoretical than practical. Nevertheless it is important to keep this interference in mind.

Dust Particulate Diameter

- Bag Filter < 2 µm
- Power Plant, Incinerator ~ 4 µm
- Older Electrical Precipitator 10 – 30 µm
- Cyclone Dust Separator 40 – 50 µm

Measuring Range of Transmission Monitors:

	2	4	10	30	40 µm diam.
LDL	5	10	25	75	100 mg/m³
Low Range	150	300	750	2,250	3,000 mg/m³
High Range	2,400	4,800	12,000	36,000	48,000 mg/m³

Data based on fly ash, per meter effective measuring length; Ref. VDI 2066

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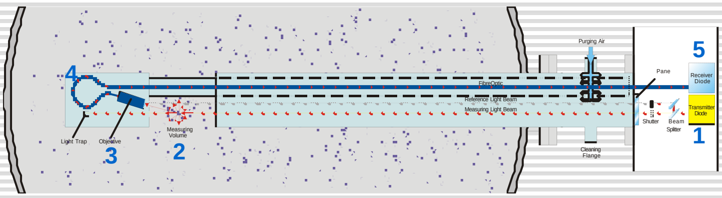
Light Scattering Methods can be separated into Forward-Scattering and Backward-Scattering. For both methods the detection limit is not path length sensitive and these methods are typically used for small stacks and/or low concentrations.

An example for Forward-Scattering:

D-R 800: Measuring Principle

- The collimated and modulated light beam of a laser **Emitting Diode (1)** crosses the **Measuring Volume (2)**; the dust particles are scattering light mostly in the forward direction
- This "stray light" is proportional to the dust concentration and is collected by an **Objective (3)** and transferred via a **Fiber Optic (4)** to the **Receiver Diode (5)**.
- The signal is processed by a highly sensitive circuit which calculates the final measurement value. The result can be calibrated according to the German regulation VDI 2066 (or any other standard method) into dust concentration [mg / m³]



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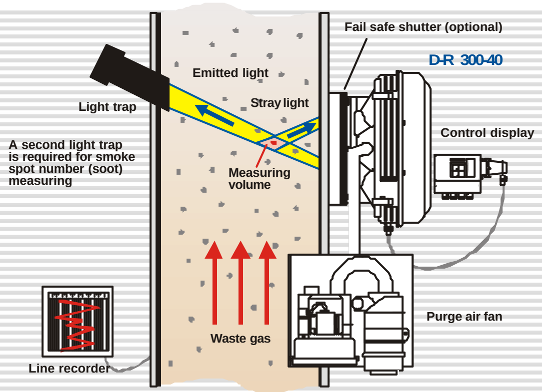
An example for Backward-Scattering:

D-R 300 System Components



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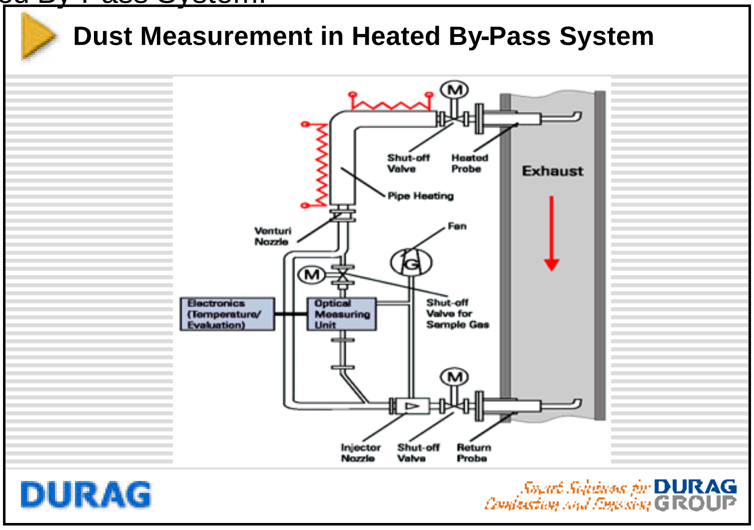
Extractive Methods

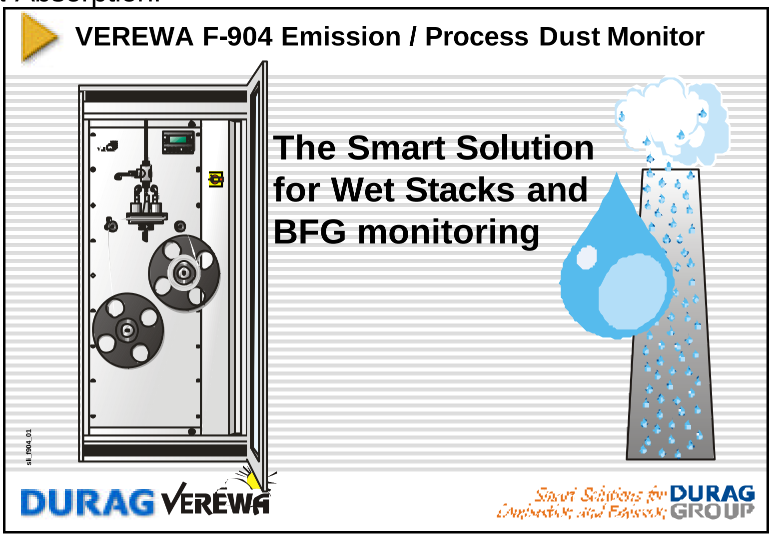
All previously described methodologies work very well in all kinds of stack gas environments with one major limitation: The stack gas temperature needs to be well above the dew point of the stack gas to avoid condensation of water. None of these methodologies is able to discriminate between solid particles (= dust to be measured) and liquid droplets or fog (= condensation). Wet stack gas conditions (below the dew point) are present mainly at stacks with low outlet temperature, as well as in stacks after wet scrubbers.

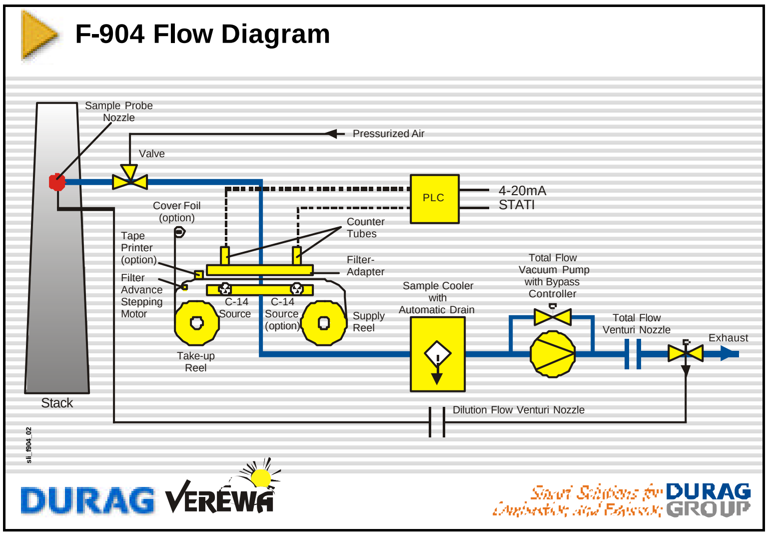
Dust measurements in these stack gas environments are typically carried-out using extractive methods. The two most commonly used extractive methods are Heated By-Pass and Beta-Absorption. The Heated By-Pass uses for detection of particles Light Scattering Instruments, whereas Beta Absorption Analyzers work very similar to the reference method with the only difference, that the difference between two beta-electron emissions (before and after the sampling) is measured, whereas the Reference Method uses a balance to determine the increase in collected particle mass before and after sampling.

Example for Heated By-Pass System:



Example for Beta-Absorption:





Conclusion

The various methodologies for monitoring of particulates in gaseous medias serve different applications. A brief overview is given as last slide:

Comparison of Emission Particulate Monitoring Methods

Condition	b-GAUGE (904)	Opacity	Scattered Light
Concentration High (> 100 mg/m ³)	ok	good	ok
Concentration Low (< 100 mg/m³)	good	bad	good
Dry Stack (above dew point)	good	good	good
Wet Stack (below dew point)	excellent	very bad	very bad
Humidity(non-condensing) constant	good	good	good
Humidity(non-condensing) varying	good	bad	very bad
Stack Diameter Large (> 3 m)	ok	good	bad
Stack Diameter Small (< 3 m)	good	ok	good
Particle Size constant	good	good	good
Particle Size varying	good	not ok	bad
Particle Color constant	good	good	good
Particle Color varying	good	not ok	very bad
Particle Density constant	good	good	good
Particle Density varying	good	not ok	bad
Gas Velocity constant	good	good	good
Gas Velocity varying (> ± 10 m/s)	not ok	good	good

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