A Review of Methodologies Used to Continuously Monitor Particulate Emissions In Wet Stacks

Industrial plant operators in Europe, US and other industrialised countries are increasingly interested to continuously monitor stack emissions. This serves the double purpose of proving that a plant's emissions are below agreed emission limits and also giving the plant operator feedback on the performance of arrestment plant, so that fault conditions can be quickly detected and hence emissions minimised.

Wet stacks, which are categorised as those in which there are water droplets or mist in the flue gas, are more challenging to continuously monitor than 'dry or non condensing' stack conditions since there are the additional problems of overcoming interference from water droplets and the increased likelihood of instrument fouling causing errors in measurement.

However, a number of methodologies have emerged over the past 15 years which are now more widely available to provide a choice of reliable compliance measurement or pragmatic arrestment plant control for wet stack applications.

Typical Processes with Wet Stacks

Wet stack applications are most commonly found in processes using wet scrubbing as a pollution control technique. Wet collectors are typically used in processes where acid gases need to be 'scrubbed' as well as particulates reduced meaning they can be found in the chemical, metals, incineration, wood and power industries. While the advent of high efficiency bagfilters has replaced wet collection in certain processes, the uptake of wet Flue Gas Desulphurisation (FGD) technology in the power industry has recently seen the increase in the number of large wet stacks. In addition, wet stack conditions may also exist in processes where the stack temperature falls below dew point:

Typical applications with wet stacks are hence:

1) After FGD plant in the power industry where the stack is not fitted with reheat

2) After lime kilns in the pulp and paper industry

3) After Titanium Dioxide plant

4) Older municipal incinerators and small incineration plant

5) Metal furnace applications

6) Biomass boilers where the fuel has high moisture content

7) Drying processes (eg sugar beat and detergent dryers)

Types of Monitoring Required

In Europe, processes falling under the Waste Incineration Directive (WID) and Large Combustion Plant Directive (LCPD) must continuously monitor particulate emissions in mg/m^3. This type of compliance measurement is one in which the calibration of the instrument reading in mg/m^3 may be relied upon within defined uncertainty limits and is defined in European Standard EN 14181. For these types of processes it is essential to use measurement techniques in which the interference effects of water droplets are negligible or eliminated.

For steel, chemical, pulp and paper and mineral processes falling under the European Integrated Pollution Prevention and Control Directive (IPPC) it is sometimes acceptable to monitor for changes in wet collector efficiency by use of a surrogate or indicative method. This type of monitoring is not required to report emissions in mg/m^3 but to provide a reliable indication should the wet collector performance change adversely hence enabling emission events to be detected early.

Compliance Monitoring Techniques

There are essentially two core techniques for monitoring particulate emissions with high accuracy in wet stacks and both are extractive in nature (ie a sample is drawn continuously from the stack in a representative fashion) and passed through the analyser before return to the stack).

1) Beta Attenuation

In these instruments, a sample is collected on a filter tape for a fixed period of time (typically 15 mins). Once the sample is collected the tape is rotated such that the sample collected is inserted in a radioactive beta source and detector instrument. The amount of beta particles absorbed is directly proportional to the total weight of particulate. This process is repeated for a semi-continuous measurement.

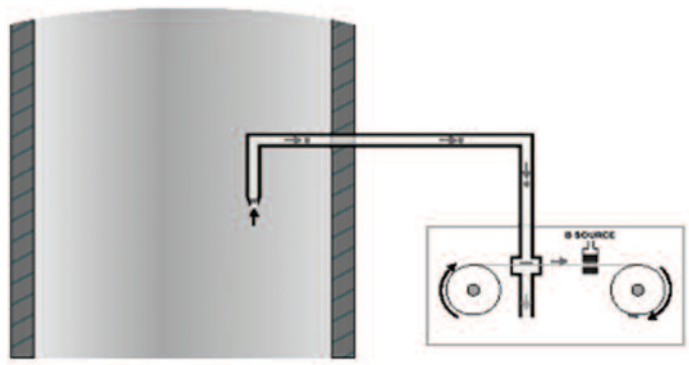


Diagram of Beta Attenuation instrument

2) Extractive Light Scatter

In these instruments, the extracted stack sample is heated to evaporate any residual water droplets. Thus the sample may be analysed by a standard light scattering technique.

There are a number of heating mechanisms used by the core instrument manufacturers focused on wet stack measurement:

1) The sample pipe wall is heated over an extended length so that sufficient heat may be added to the sample to evaporate water and there is sufficient contact time between sample air and the heating surface. This was the original approach pioneered over 15 years ago.

2) The sampled gas stream passes into a chamber where it follows a spiral path around the inner heated wall. This approach ensures efficient heat transfer to the gas stream and to the water droplets which are thrown against the wall.

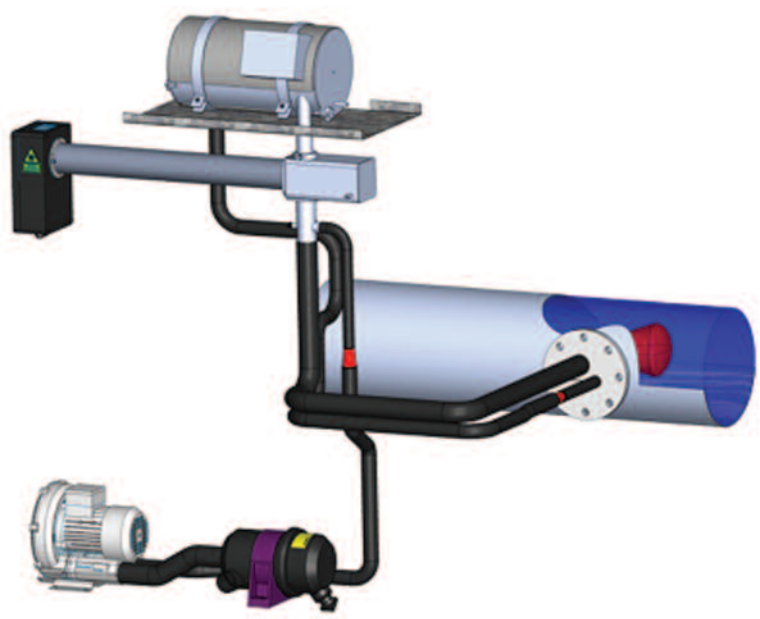
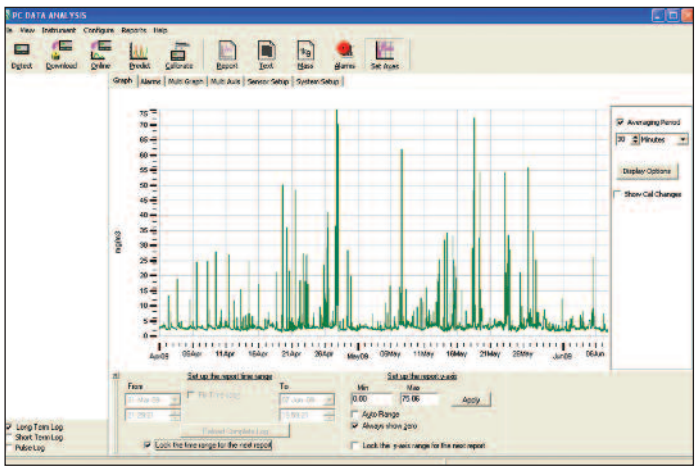


Diagram of wet stack monitor

3) Heated dilution air is added to the sample to evaporate any surplus water. The dilution air volume is carefully controlled relative to the sample volume to ensure a known dilution on dust concentration. Typically this method uses a small sample volume.

Instruments using both Beta and extractive light scatter methodologies are accepted as methods to monitor wet stacks and there are a choice of instruments which carry QAL1 approvals (required for EN 14181 monitoring). These approvals cover the analysers used for measurement and in certain cases the complete extraction and heating system as well.

Extractive systems are more complex than standard in-situ techniques (such as opacity and probe electrification) and require careful location to ensure representative measurement as well as maintenance to keep the sampling system free from cont-amination over extended periods of time. As such, in dry industrial stacks where there are alternative approaches, they are rarely used. However, for wet stack applications, they provide a proven method to monitor particulate levels according to legislative compliance requirements.



Graph 1

The spikes in Graph 1 are due to bursts of particulate matter generated by the monitored process, evident only because an interfering and overwhelming signal from water droplets has been removed by droplet evaporation in the heated chamber.

Indicative Monitoring Approaches

The other approach to wet collector monitoring is to implement a simpler pragmatic method to detect changes in wet collector efficiency. Indicative monitors are used in processes where it is not necessary to report emissions in mg/m³ but simply to provide a reliable indication and warning should the wet collector efficiency change significantly. Two common techniques used are:

1) pH and level of water

In this approach the pH of the collected water from the wet collector is monitored along with the level of the discharge water reservoir. Should either of these change dramatically this is an indication that the wet collector efficiency is changing. This technique is often suggested in the US as a solution for Compliance Assurance Monitoring of Wet Collector efficiency as required in many Title V plant.

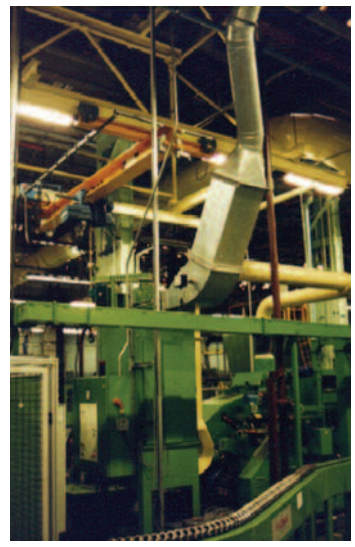
2) Increase in charge activity

ElectroDynamic™ Probe Electrification sensors may be installed in the discharge of wet collectors where the 'knock out plates' reduce the water droplet levels so that there is no water running down the stack walls. This type of instrument responds to both particles and water droplets (since both carry charge) and hence a condition which results in an increase in water or particles can be reliably detected. This technique is applicable to the aggressive conditions in a wet stack since provided the rod insulator is kept clean (with air purge) the condition and contamination of the rod surface does not affect instrument response.

In cases where the water content is very low and the gas stream is just at the dew point (ie after process driers, users have found that the results of the instrument with an insulated sensor, may be correlated to mg/m³ emissions from the process in a cost effective manner.

Summary

With the increasing environmental pressure to continuously monitor emissions from industrial stacks and the recent resurgence of wet collector technology associated with FGD plant, the need for effective wet stack particle monitoring has increasing importance. Extractive techniques using Beta and Light scattering sensors are proven for high accuracy compliance requirements and other methodologies may be used for indicative monitoring or changing wet collector efficiency.



ElectroDynamic™ sensor installed in Engine Plant wet collector

AUTHOR DETAILS

William Averdieck
Managing Director
PCME Ltd
Clearview Building
60 Edison Road
St Ives, Cambs
PE27 3GH
Tel: +44 (0) 1480 468200
Fax: +44 (0) 1480 463400
Email: williama@pcme.co.uk
Web: www.pcme.co.uk