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EMISSION MONITOR CALIBRATION AND TESTING

Introduction

This document discusses the credibility of the results returned by Triboelectric Emsission Monitor products, and in so doing, addresses such issues as testing, calibration and validation.

Credibility Criteria

To verify the correct operation of any emission monitoring system, it is usually necessary to demonstrate one or more of the following:

- That the principle on which the monitor works produces consistent, repeatable results with respect to an absolute "gravimetric" or "dead weight" measurement. If the triboelectric emission monitor is applied carefully with knowledge of the factors which can affect it's accuracy, measurement of particulate emissions by triboelectric principles has been shown to be consistent and repeatable, so this criterion is satisfied.
- That the instrument has maintained it's state of calibration without drift. The circuitry in AC coupled emission monitors is by nature stable. Most faults produce an output of zero, which is easily detected by a LowLow alarm (eg, in the CONNECT software). To absolutely test for drift, and to guarantee that the probe has suffered no damage, an Electronic Dust Signature (an artificial emission signal) can be mounted near the probe, and periodically energised to verify calibration. Emission Monitors from EMS6 onwards include a built-in independent EDS signal for this purpose. The built-in EDS signal cannot identify a broken or disconnected probe, but it can identify more subtle problems such as a leaky probe insulator.
- That the instrument is calibrated to produce a quantitative output in preferred engineering units, which can be compared directly with criteria set down by regulatory bodies. To achieve this, it is currently necessary to carefully execute an in-situ test of the instrument while also accumulating dead-weight data, typically by an "isokinetic" test (see below). It is sometimes possible to deliberately introduce dust into the process gas stream from a precision feeder, however this is only useful if the dust has the same physical, chemical and distribution characteristics as would be present in normal plant operation.

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Triboelectric Emission Monitor Calibration

Quantitative Measurements

A Triboelectric Emission Monitor produces an unscaled total emission signal which is highly repeatable (under the same conditions). While many applications are served adequately by such relative (percentage) measurements, legislation increasingly requires quantitative mass density or mass flow rate measurements (eg mg/m3 or mg/s). The currently preferred way to achieve quantitative results is "isokinetic testing", in which a gravimetric sample is taken from the duct at the same time as the emission monitor's output is accumulated. The emission monitor can be calibrated by comparing the two results.

Velocity Problems With Mass Density

As both isokinetic testing and integrated triboelectric emission monitoring produce outputs in terms of total mass, calibration will always be valid in terms of mass flow rate or total accumulated mass, regardless of velocity variations during the test. However if there are substantial velocity variations during the tests, it is mathematically meaningless to calibrate with an instrument which measures mass density, or in terms of average mass density (mg/m3), regardless of the technology used (many competitive products fall into this category). For example, taking an extreme case, if the plant were off-line for part of the test (zero particulates and zero velocity), even a high emission level during the remainder of the test would be wrongly averaged downwards.

While dust particles in most industrial processes have reached a state of charge equilibrium before passing the Emission Monor, this is not the case in a typical short wind tunnel at high velocities. In that case the flight time of the particle is far too short to achieve charge equilibrium. Reducing the velocity will increase the flight time, the charge accumulated during the flight time, and the sensitivity. Thus an industrial mass flow instrument will appear to measure mass density. Some instruments are characterised solely on the basis of tests in short wind tunnels, and because of this phenomenon, are therefore incorrectly presumed to measure mass density.

Reducing Electrostatic Interference

Where the emission monitor and isokinetic sampling point are mounted within 10 diameters or 20m of each other (and preferably in all other cases too), the sampling probe and it's fittings must be grounded reliably to the same ground connection to which the emission monitor is connected. Check the connection with a multimeter, in case of oxidised threads. For hand-held sampling probes, a light flexible single core flying lead with a quick-connector will be suitable (eg, the earthing straps used at electronic assembly workstations). Reliable earthing reduces electrostatic interference from the sampling process, which would otherwise invalidate the emission monitor results.

Calibration By Isokinetic Sampling

To calibrate an emission monitor using an isokinetic test, the output of the monitor must be accumulated while the test is performed. Eg by a chart recorder, SCADA system, PLC or CONNECT software, or even by observing on an EMP5 or EMS4 the reading on the bargraph, or on a milliammeter or multimeter connected to it's analog output. It is important that the output from the monitor is totalised or averaged over exactly the same time periods as the isokinetic sampling occurs. CONNECT software makes this easy, but it is still possible using any of the other methods. After the test, the average results from both the isokinetic test and the emission monitor will be known, so calculate K = IsoValue / EmisMonValue. K can then be used to process subsequent data into the units of choice, in one of these ways:

- For analog emission monitors like EMP5 and EMS4, future readings can be multiplied by K to calculate a result in the units of the isokinetic test (eg mg/m3). The emission monitor values can be in any convenient units, such as bargraph segments, percent, or Volts, as long as the same units are always used. or...
- For networked emission monitors like EMS6, the EngineeringRangeHigh in the polling software (eg CONNECT) can be modified once only (multiplied by K), so that all future readings will already be in the units of choice. or...
- For Connect 3.0 or later, or for the AUD1 Numeric Display, this calculation is done automatically on command, providing full automatic calibration.

Isokinetic Sampling

Definition

The sampling process involves the extraction of a sample from a process gas stream via a nozzle or tube open to the oncoming gas flow direction. The process is called ISOKINETIC if the sampling is continuous and gas extraction velocity matches the nearby gas stream, so there is no tendency for particles of different sizes to be falsely 'sucked into' or deflected away from the nozzle. The gas stream velocity is commonly monitored using a pitot tube, and from that measurement the correct sampling flow-rate is calculated and set. After measuring the gas volume and total particulate mass collected on a filter medium (an alumdum thimble of filter paper), the average dust burden level is calculated over the test period, typically an hour or more.

Flow Rate Control

To obtain a reasonable representation of dust burden across the whole of the duct in spite of stratification or uneven distribution of particles across the cross section, the nozzle is moved sequentially across the duct to specified points known as traverse points. The number and location of the traverse points can be determined from knowledge of the duct cross-sectional dimensions and the relevant standard for sampling of particulate matter in ducts or stacks (eg Australian Standard's AS 4323.1 and AS 4323.2).

Accuracy

Isokinetic sampling is the most accurate method available to measure total suspended particulates, with an overall accuracy of better than +/-10% for large particles of inert material in relatively high concentrations, under constant velocity. Under the same process conditions, repeatability is even better. Accuracy can be degraded as far as +/-50% when the material tends to adhere to the sampling tube walls.

Particle Size Fractions

The grade of filter paper nominally determines the smallest particle size which will be trapped. It is possible to arrange a seies of filters with successively smaller pores, and thus to trap a series of fractions of the total dust burden corresponding to different particle sizes. While less accurate than a basic isokinetic test, this method can provide useful information on particle size distribution.