Continuous Particulate Emission Monitoring in European Cement Plant: New requirements and Challenges, including implications of EN-14181

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New requirements for Continuous Particulate Monitoring on Cement Plant

Over the past 20 years, the cement industry across Western Europe has developed extensive experience in satisfying continuous monitoring requirements for cement kiln emissions. However, cement operators are now faced with new continuous emission monitoring requirements, as a result of significant changes in regulatory regime, the classification of cement kilns burning waste as a co-incineration process, proactive company environmental policies and changes in the particulate control technology. New solutions are required to satisfy these new and different types of monitoring requirements. Operators need to develop solutions to the following requirements:

1) Kiln stacks controlled under the Waste Incineration Directive (WID) must upgrade monitoring systems to meet the new standard EN14181

2) Cement, Clinker and Coal mill emission stacks (normally controlled with bag filters) require continuous monitoring to satisfy ISO-14000 programs and IPPC (Integrated Pollution Prevention and Control) regulatory authorisations
3) Large bag filters replacing Electrostatic precipitators to meet new tighter emission limits on cement kilns require emission management systems for efficient operation and control

This paper discusses these new particulate monitoring requirements, especially in relation to EN-14181 and summarises the main solutions provided by PCME, a leading manufacturer of particulate emission monitors.

Kilns covered by Waste Incineration Directive

The European Waste Incineration Directive 2000/76/EC (WID) applies to many cement facilities across Europe, since kilns using waste as a fuel source (eg tyres, plastics and municipal waste) are classified as co-incineration processes and are covered by the Directive.

The Directive has two major implications in relation to particulate control and measurement:

1. The Directive specifies a lower emission limit for particulate of 30mg/m^3 (at 10 % Oxygen conditions). The implication of this new lower emission limit is that many processes are already upgrading or planning to upgrade their existing particulate control equipment using Electrostatic Precipitators (ESP) to more efficient multi-compartment bag filter systems. Until 1st January 2008 regulators may specify a transitory emission limit of 50mg/m^3.
2. The Directive requires that emissions be continuously measured with a methodology that gives a total uncertainty of less than 30%. This new type of compliance monitoring is underpinned with two new European standards, EN-14181, which relates to the Quality Control of Automatic Monitoring Systems (covering dust and gas) and EN-13284-2 that is specifically relevant to particulate. EN-14181 and EN-13284-2 require monitoring that is more similar to compliance monitoring that is performed in the USA and is importantly different to that currently in place in most European Countries. All operators of cement kilns covered by the Directive will be required to assess their protocols to ensure it meets the new standard and many will need to change or upgrade their existing continuous monitoring systems to meet the standard. This requirement applies

from 28th December 2005 at the latest, in line with the provisions of the Directive.

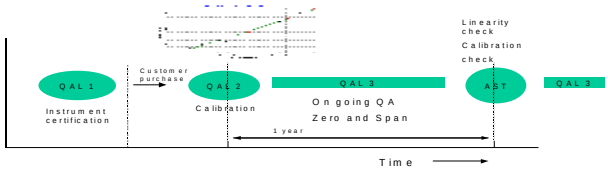
EN-14181/13284-2

These new standards (first published in the EU member states in 2004 and 2005) apply to cement kilns burning waste, as well as other Incineration Processes and plant falling under the Large Combustion Plant Directive (LCPD) to ensure that emissions are measured within the total uncertainty budget allowed within the relevant EU Directive. The standards focuses on the Quality Assurance of the Automatic Monitoring System (AMS) in four key areas referred to as Quality Assurance Levels (QAL):

1) QAL 1 (Instrument certification)
2) QAL 2 (Calibration)
3) QAL 3 (On-going Quality Assurance)
4) AST (Annual surveillance test)

The plant operator must use instruments with an appropriate QAL 1 (Instrument certification carried out by a certification body at the request of the instrument manufacturer), organise a team to calibrate the instrument according to the details of QAL 2, assess the instrument's on going operation with QAL 3 and organise an annual test on the calibration and instrument.

Stages of EN-14181 (13284-2)

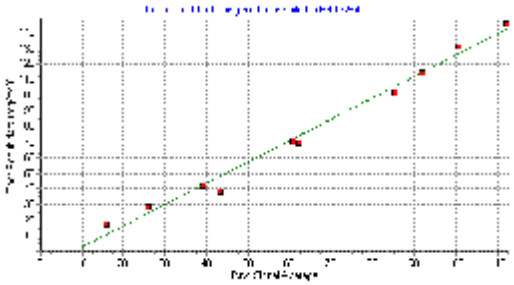


The key parts of the quality assurance levels are as follows:

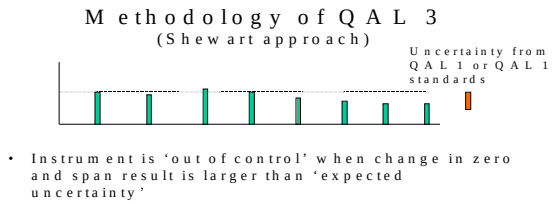
- Suitability of instrument for intended use (QAL 1):
  - The QAL 1 approval is similar to existing type approval schemes (e.g. BImSchV 17 in Germany and MCERTS in the UK but importantly different is that the uncertainty of an instrument is also assessed. The features which permit the instrument to perform a QAL 3 test (on- going quality assurance) may also be assessed.
- Calibration (QAL 2)
  - A rigorous calibration of the AMS is performed over at least 3 days and must include at least 15 data sets. In the calibration, the AMS is correlated against the results of a standard Reference Method (SRM i.e. Iso-kinetic sampling standard for particulate) defined in

EN-13284-1. The calibration is defined as valid only if the data points pass a variability test, a statistical test which compares the uncertainty in the data points against the uncertainty allowed in the European Directive.

  - It is crucial to plan that the calibration covers a truly representative emission cycle of the plant including high emissions to avoid additional calibration time and costs. This is to satisfy the standard, which states that the valid calibration range of the AMS can be interpolated to include emissions of 110% of the maximum during calibration, but no higher without additional calibration work.



- On going Quality Assurance (QAL 3)
  - A process for detecting any adverse change in the performance of the instrument is implemented using either automatic or manual zero and span checks. The readings associated with the zero and span checks are compared against the known uncertainty of the analyser and drift and changes in precision are detected using a choice of statistical approaches (referred to as CUSUM or Shewart charts). Therefore, key to the QAL 3 are the provision of suitable zero and span materials, which 'challenge' the analyser in a representative fashion and the recording of the zero and span results to allow the statistics to be calculated.



  - It should be noted that with particulate monitors Zero and Span materials check for change in instrument operation rather than change in calibration. A reference material is introduced into the analyser as a surrogate to the 'standard particulate', however it cannot account for changes in the process (e.g. change in particle size) which will change an instrument calibration
- Annual surveillance test (AST)
  - This test is performed annually to check the linearity of the instrument (using surrogates) and to ensure that the calibration has not shifted. The calibration check is done with a 5-point SRM comparison and variability test statistics.

Kilns not covered by Waste Incineration Directive

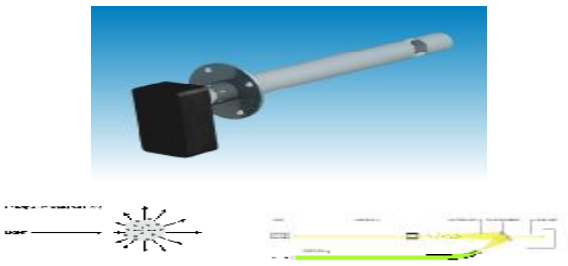
Kiln processes not falling under Co-Incineration Directive are unlikely to adopt the new standards EN-14181/13284-2 due to the higher costs of monitoring. The costs of monitoring to satisfy EN-14181 are significantly higher than current monitoring practice in Europe, due to three key issues:

1) The calibration must cover at least 3 days and the data traceability and analysis requirement are also quite extensive. In the UK this has increased costs from £1-2K to £5- £10K
2) Calibrations not passing the variability test must be repeated
3) Instruments must be upgraded to have appropriate zero and span materials and statistical features to satisfy QAL 3

In such processes, continuous monitoring is likely to continue with instruments approved to meet existing regulatory standards (e.g. BImSchV 17 and MCERTS standards of April 2003) and with calibration regimes using 3 or 5 Iso-kinetic tests).

PCME Solution to EN-14181

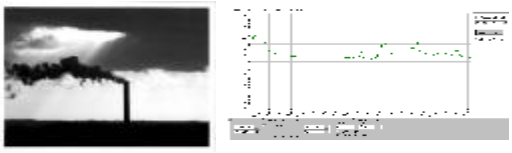
The LMS-181 has been specifically developed by PCME to satisfy the new requirements of EN-14181. The instrument comprises a sensor probe with an in-situ measurement volume at the tip of the probe which is inserted in the stack. The instrument uses pro-scatter technology, a form of light scattering technique, to measure the particle concentration and is calibrated by reference to an SRM to EN13284-2. The cone of light scattered from particles in a low angle to the incident laser beam is collected by a concave mirror and collected on a quartz rod.



The LMS-181 instrument is specifically relevant to monitoring to satisfy to EN-14181 for the following reasons:

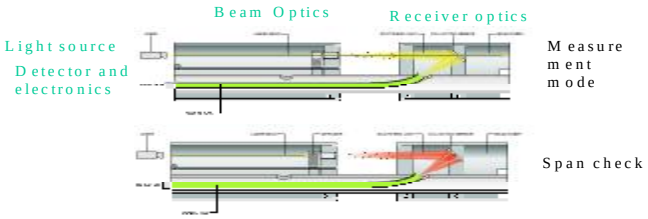
- The instrument is designed to meet QAL 1 and has the resolution and sensitivity to monitor emissions from below $1mg/m^3$ to in excess of $50mg/m^3$. Unlike traditional Opacity instruments, it is therefore suitable for the lower levels of particulate found after processes meeting the new WID emission limits.
- The inherent calibration of the instrument is less effected by changes in particle size than light scattering instruments using larger scattering angles. This has the significant advantage that the plant conditions can be varied more dramatically during the QAL 2 process to increase the valid calibration range while still maintaining a single calibration line.
- The instrument comes complete with control unit for configuration and includes data acquisition and graphics trend screens to assist the QAL 2 calibration and instrument usability.

Results from LMS-181 in Cement Kiln application



- The instrument includes automatic zero and span checks that means the responsibilities to conduct manual QAL 3 are eliminated for the end user. During the span check a scattering element is automatically inserted in the laser path to provide a reliable measure of instrument drift including any effects of contamination. The results of the QAL 3 are stored within the instrument for analysis and reporting via 'QAL 3 reporter PC software'

Span and zero check on LMS-181

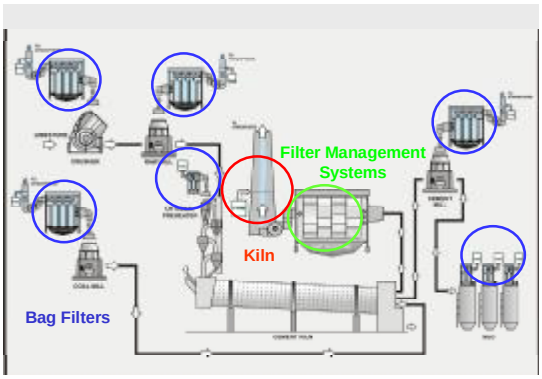


Diffuser creates scatter in span check

- External reference materials are available to conduct the five-point linearity test during the annual AST audit.

Bag house management systems and emissions monitoring for mills

There are a growing number of other emission sources on a modern cement plant where continuous monitoring can provide real process benefit to the process operator as well as provide information to satisfy growing environmental pressures.



Emissions from bag filters fitted to coal, clinker and cement mills and storage silos are highly abated and under normal circumstances are well below emission limits of 50mg/m^3. However, there is a growing need for continuous monitoring, since the issue is to understand that the arrestment plant is working correctly and provide information to maintenance personnel to help locate and replace leaking and miss-sealed bags early on before failures create contagious failure in other bags. Hence monitors are often required for these types of process as part of IPPC permits, although some plant have already fitted instruments as part of their own ISO-14000 program and to assist filter maintenance.

With the advent of new lower emission limits of 30mg/m^3, cement kilns and a growing number of processes will use high temperature bag filters to abate emissions. Due to the large volumes of emission gas, multi-compartment designs are preferred since a single compartment can be isolated for bag maintenance without the need to stop the complete plant. These plant, while discharging into a common stack have individual emissions outlets from each compartment that should be individually monitored for appropriate process control.

PCME solutions for mill emissions monitoring and bag filter management

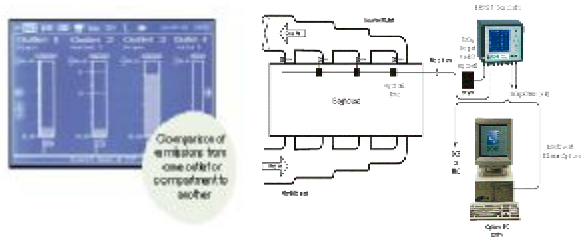
PCME has a range of Electrodynamic instruments suitable for multi-compartment filter management systems and for single compartment emission measurement.

The DT-990 instrument is for continuous emissions measurement on coal, clinker and cement as well as emissions from silos and drying processes controlled by bag filters. The instrument comprises an Electrodynamic sensor inserted directly in the stack connected to a central control unit for user interface and data acquisition. The sensor operates by monitoring the natural charge signature induced as particles pass the probe with the key advantage of being unaffected by contamination on the sensor rod surface and being able to operate reliably and without cross interference from water vapour. This rugged performance is critical in cement processes where there can be high levels of accumulating dust and high levels of humidity from drying processes.

The DT-990 also provides the following capability:

1) Up to 32 sensors can be networked to the same control unit and onwards via Ethernet to a LAN. This is of value in large integrated cement plant.
2) The instrument can be synchronised with the filter bag cleaning sequence to permit the row of a failed bag to be easily identified and isolated by a review of the pattern of dust displayed on the graphics screen.
3) The instrument carries BImSchV 17 and MCERTS approvals for emission measurement specifically for bag filter applications. It is suitable for measuring dust from below 0.1 mg/m^3 as well as operating in conditions where a bag failure has occurred and dust exceeds over 1000mg/m^3.
4) The instrument can easily be fitted to a stack with single side mounting and rod lengths to cover stack sizes from below 200mm to over 4m.

For the new large multi-compartment bag filters being retro-fitted to cement kilns to meet lower emission limits, the BBS-220 provides on-line monitoring of the condition of each individual bag compartment. A sensor is installed in the plenum from each bag compartment and is connected to a central control unit, so that the emission condition can be compared between compartments and against selectable alarm conditions. Maintenance personnel use this information to isolate any compartments with failing bags, so that emissions from the total bag house can be kept below emission limits and the plant can continue to operate.



Summary of new requirements for continuous monitoring

A significant challenge affecting the cement industry in the next few years in relation to emission monitoring is to upgrade continuous emission monitoring systems to meet the new standard EN-14181. This standard introduces a new type of compliance monitoring where the uncertainty of measurement is assessed for the process and defines new levels of quality assurance associated with the certification (QAL1), calibration (QAL2), and on going operation (QAL3).

For those cement kiln processes where new multi-compartment bag filters are being fitted to replace electrostatic precipitators in order to meet the new 30mg/m^3 emission limit, the issue of bag filter management will be of new relevance. Multi-compartment failure detection systems can reduce running costs and improve emissions performance. Continuous monitoring is also of relevance to mill and silo emissions where the resulting data is used to better schedule and control the maintenance of bag filters, as well as satisfy new IPPC requirements and IS0-14000 policies.

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