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A Practical Approach: In-Situ Continuous Emission Monitoring Analysers

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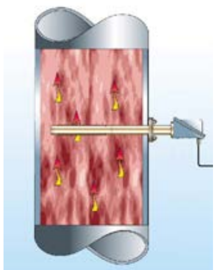
1 Introduction

Historically and for good reasons, Extractive gas Analysers have been widely used around the world for continuous emission monitoring duties. More recently, advances in design and construction of Stack Mounted analysers has resulted in a large and increasing demand for this technology in the market for Continuous Emission Monitors.

Definitions

Extractive	**Types** Cold Extractive Hot Extractive Dilution Extractive Main Advantage Automatic Zero & Cal Main Disadvantage High Maintenance Can Modify Sample

		On-Stack	
Across Stack	**Types** **Cross Stack** **Reflective Cross Stack** Main Advantage Monitors True Sample Main Disadvantage No facility for Zero & Cal gas challenging	**In-Situ** 	**Types** **Open Folded Beam** Main Advantage Monitors True Sample Low Maintenance **Enveloped Folded Beam** Main Advantage Monitors True Sample Low Maintenance Automatic Zero & Cal

2 On Stack CEMs

Initially the majority of CEM stack mounted analysers were cross stack, these systems did away with the need for sophisticated costly and often high maintenance extractive systems.

Unfortunately the open path nature of cross stack analysers results in problems with zero and calibration checks restricting many devices available in previous years, to use in non-compliant applications, such as CO monitoring.

With the introduction of the Enveloped Folded Beam system, the benefits of reduced sample handling, low maintenance and the capability of zero and calibration checks in accordance with European requirements and the American USEPA 40 CFR part 60 and 75, meant that the on stack gas analyser could challenge the dominant position of extractive systems.

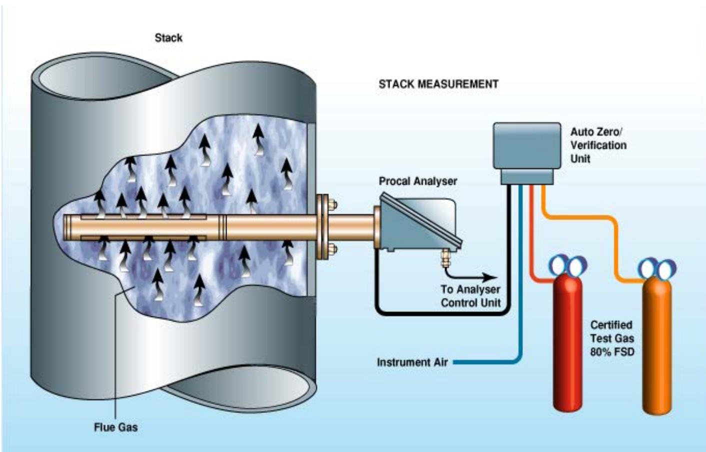
3 Disadvantages Associated with On Stack CEMs and their Solution

Multi component

Early stack mounted instruments, in common with extractive analysers, were single component, therefore if multiple components were require to be measured, the total number of sample ports needed, could make the use of on stack analysers impractical. Obviously, even if several extractive analysers were required, the extractive system would only need one take off. Another consideration is that stack gas components such as water vapour affect the readings of some gases, where on a cold extractive system water would be removed before the analysis takes place. With the introduction of multi component capability, one On Stack Analyser is capable of monitoring six or more stack gas components and doing any correction needed for cross sensitivity.

Drift

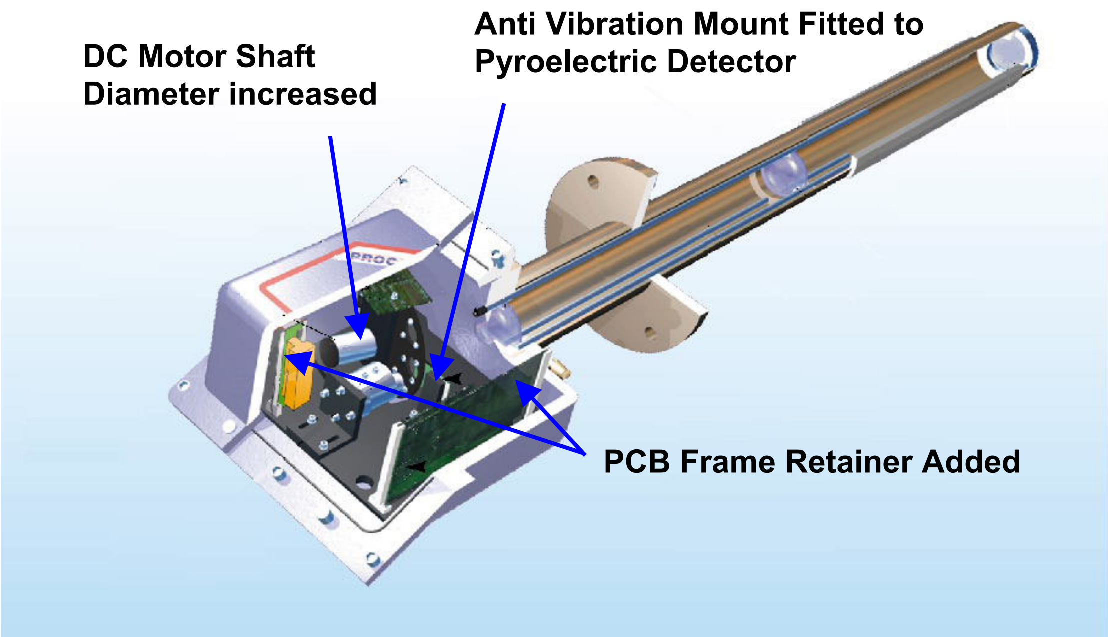
The major difficulty with cross stack analysis is associated with drift. Even if the manufacturer is confident that they have produced an instrument that has a low drift specification, this still has to be demonstrated by challenging the instrument with either test gases or certified gas filled cells. This problem was overcome with the introduction of the enveloped folded beam technology. This has, in common with Extractive Analysers the capability of flooding the sample cell with instrument air for zero or certified test gas for span, enabling the instrument to be challenged to ensure that it is in compliance.



Vibration and Stack Movement.

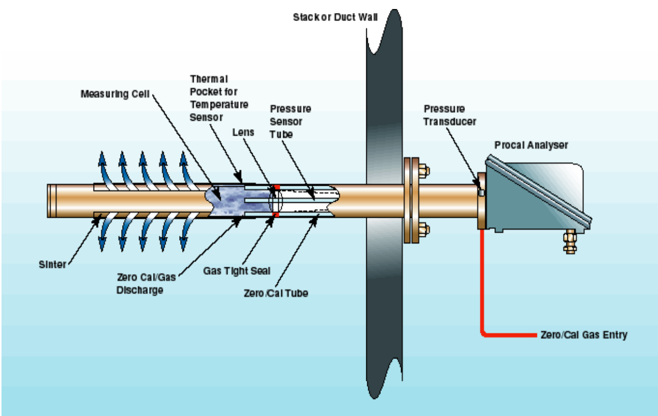
Depending on where the Insitu CEMS system has been installed it might be subject to vibration or in extreme conditions to significant duct movement. Obviously in a cross stack analyser, any significant movement could result in the Infrared or UV beam moving on and off the detector which would result in signal to noise problems. The enveloped folded beam which mounts on one side of the duct, is immune from this problem, however the analyser could be subjected to vibration which could either damage the analyser or induce noise sufficient to degrade the measurement. To overcome this under the recently introduced UK Stack gas analyser certification program MCERTS, it is necessary to have the instrument tested for many parameters including vibration. (Referenced to IEC 68-1/2 Basic Environmental

Testing Procedure) To comply with this standard it is now necessary take into account the effects of vibration when designing equipment for stack mounted Continuous Emission Monitoring, including extractive sampling probes. The example shown below indicates some changes which were necessary to achieve compliance with the vibration testing. On this model the changes are now standard.



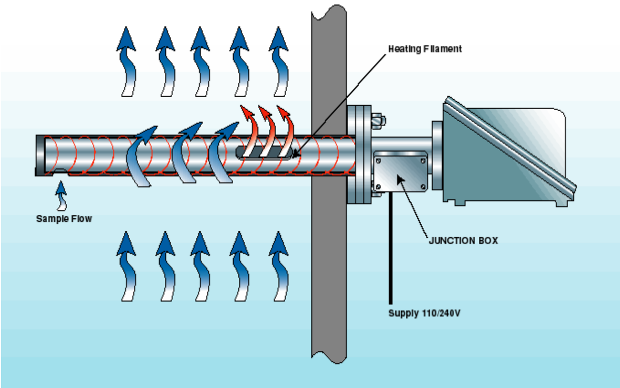
In Stack Filter

To achieve an optimum design for an enveloped folded beam cell it is necessary to not only protect the optical components in the process (mirror and lens) but also to design a cell which is capable of being emptied of flue gas and replaced by either instrument air for zero or calibration gas for span calibration. These functions can be made possible by fitting the insitu cell with filters, thereby removing the possibility of ingress of particulates into the cell and enabling, during calibration, a slight over pressure forcing the flue gas out of the cell and replacing it with either Zero or Calibration gas.



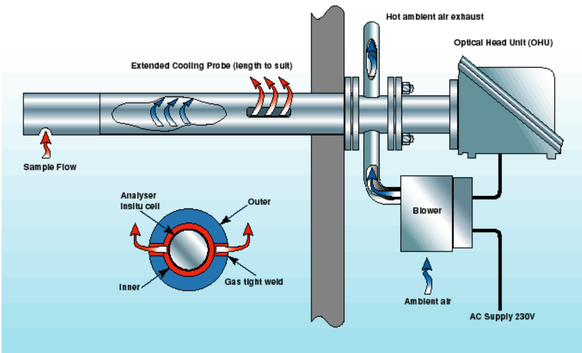
In the model below this has been achieved by using sintered material, Stainless Steel 316, Inconel or Hastelloy depending on application. Unlike conventional Extractive Probes a sample gas is not continuously drawn through the filter, but permeates through them. It has been shown that the effect of the stack flow keeps the in stack filters relatively clean. In addition this model continually monitors the pressure within the cell, which enables the condition of the sintered material to be automatically verified. That is, if the pressure during auto zero / calibration increases over time, then this would indicate that the sinter material has deteriorated. In reality with many hundreds of installations, this is a very unusual occurrence.

Potential Corrosion Damage



A frequently voiced concern with in-Situ analysers is that the probe, which is subject to the stack sample conditions, may suffer from corrosion. If the temperature is low, there can be a possibility of condensation forming on the surfaces of the probe. In certain applications, especially when gas scrubbing systems such as SCR & FGD are employed, the sample temperature can come close to flue gas dew point. Therefore the possibility of acid condensation forming resulting in its damage, could occur. This problem has been eliminated on modern insitu stack gas analysers, with the introduction of probe heaters, ensuring that the measurement cell is at an elevated temperature, therefore removing the risk of condensation. In the event of the failure of the heater then, in addition to the activation of a low temperature alarm, a purge is applied which protects the in stack mirror, lens and sinters.

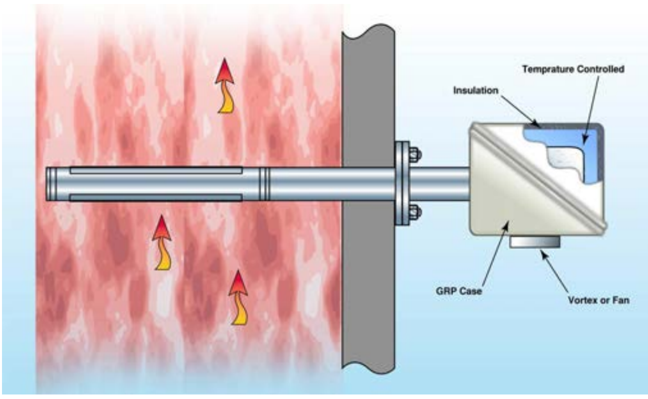
High temperatures

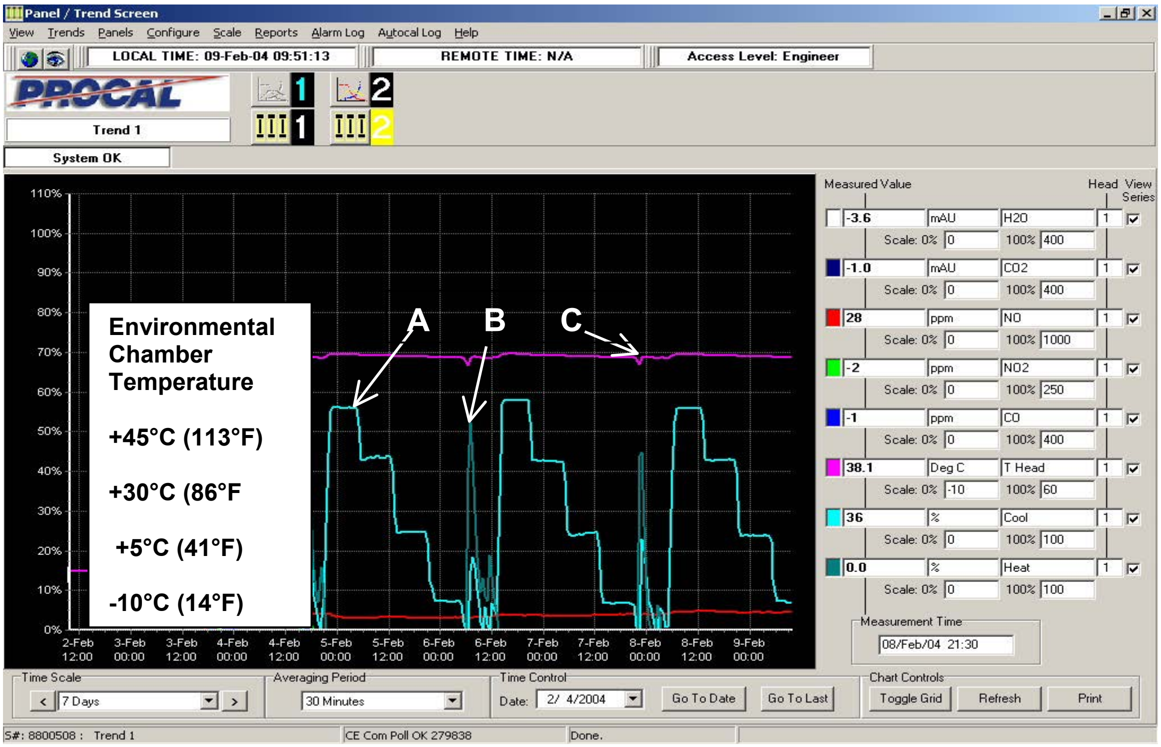


If the stack gas temperature is high and infrared analysers are being used, back ground Infrared can introduce noise resulting in deterioration to the measurement. In some typical applications, especially on measurements prior to the bag house or precipitators where the stack gas is above 300°C (572°F), then background infrared can be present. This problem can be eliminated by the use of cooling probes, which ensure that the probe temperature is controlled at approximately 200°C (392°F)

Ambient Temperature

In some applications especially when Infrared analysers are being used, ambient temperature swings could effect the measurement. Indeed on certain installations in the United States ambient temperatures changes where seen to affect the measurement, this problem was overcome by fitting temperature covers, as can be seen from the test results.





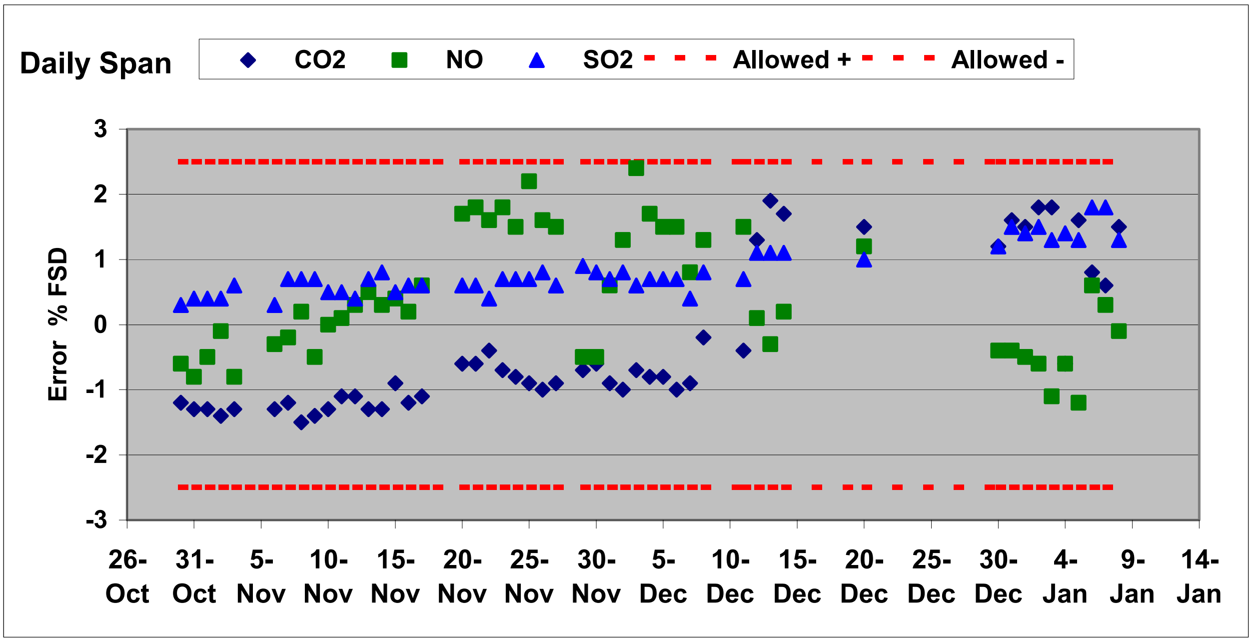
Temperature Testing

A Pulsi 200 was placed in an environmental chamber and the temperature cycled in 15°C (59°F) steps between –10°C (14°F) to +45°C (113°F). The screen dump shows three complete cycles.

Trace A	Cooling maximum 56% on
Trace B	Heating maximum 52% on
Trace C	Controlled analyser temperature set at 38°C (100°F), achieved 38°C ±1°C (100°F ±2°F)

US EPA 40 CFR part 60 and 75

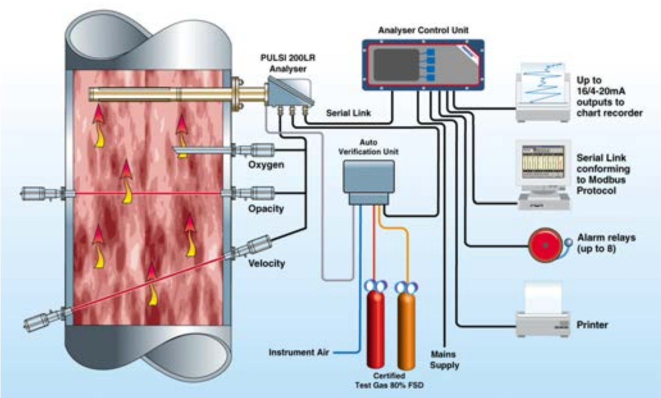
To comply with the requirements of the US EPA it is necessary to demonstrate that the instrument is in compliance on a daily basis. From work carried out by Brian Yeager on South Carolina Electric & Gas McMeekin Power Station, this can be seen from the graph



which demonstrates that an In-Situ analyser, without any maintenance or adjustments, has achieved compliance over a three-month period.

4 Installations

Analysers used for compliance monitoring are generally mounted on the stack or the duct leading into the stack and will simultaneously monitor five to six gases for example: NOx, SO_2, CO, CO_2 and Water vapour. In addition the analyser can act as a hub for other stack mounted analysers including opacity (dust), Oxygen and velocity. The data can then be transmitted over a four wire RS 485 link in a MODBUS format to a display/data logging PC system. This makes wiring relatively simple and in applications where more than one analyser is installed, then the analysers can be daisy chained to reduce installation costs. The analyser is normally mounted on the stack using a 3” to 5” 150lb flange.



Although the analyser requires very little maintenance it is necessary to have access typically on a 6-month interval to carry out inspection to ensure there’s been no physical deterioration or damage to the instrument.

5 Examples of Installation Utilising Insitu CEMS Systems

Drax PowerStation United Kingdom recently operated by AES but now by Drax Power.

Drax is a coal-fired PowerStation with a capacity of 4,000 MW. In December 2000, after intense testing, a program to install 18 insitu analysers to replace existing extractive systems was undertaken. The main reason for making the change was to reduce the high maintenance cost of the Extractive Systems.
The Flue Gas Desulphurisation (FGD) analysers where calibrated as follows:

Inlet (12) Analysers		Outlet (6) Analysers	
0-3000ppm	SO_2	0-300ppm	SO_2
0-300ppm	CO	0-800ppm	NO
0-20%	H20	0-20%	H20

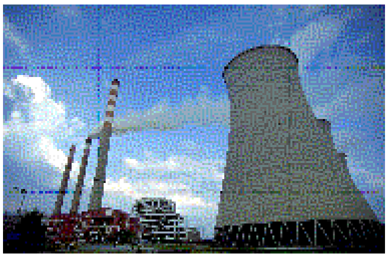
Powerton operated by Mid West Gen,
A coal fired PowerStation approximately 1,538 MW. The station installed two In-situ stack analysers in March 03. The instruments calibrated to the following ranges:

0 - 20 %	CO2
0 - 600ppm	NO,
0 - 250ppm	NO_2,
0 –200ppm	CO.

The analysers have been installed for control and on line data will form part of neural network controlled system. To ensure confidence in the data the instruments have run for a year without any maintenance.

The analysers were amounted on the horizontal duct leading to the main stack, the first unit is installed already, the port for the second unit is being prepared. Each analyser was supplied with a panel containing a Auto Verification Units and Local Power Supply. In subsequent deliveries to Mid West Gen, to ensure reliable operation under extremes of low ambient temperature, the panels were mounted in heated cabinets.

TVA Paradise PowerStation operated by Tennessee Valley Authority



The installation is a coal-fired PowerStation. With capacity of approximately 2,266 MW. In July 1997 the insitu stack gas analyser was installed on the inlet to the FGD Plant. The instruments calibrated to the following ranges:

0-10% H_20

0- 3000 ppm SO_2

The instrument has been functioning for seven years the only maintenance carried out in that period has been the replacement of the insitu lens and mirror.

6 Conclusion

Where In-Situ analysis cannot claim to be the answer to all stack gas applications, as has been shown, they can now compete very favourably with extractive systems. The main benefits are that the maintenance requirements are generally lower than extractive systems, installation costs can be lower as costly sample lines are eliminated. The need for analyser shelters is removed, and because the sample cell is in the gas flow, response time is suitable not only for CEM but also combustion, FGD and SCR control. In-Situ instruments are available with MCERTS approval, complying with the requirements of QAL1 of prEN14181, the (draft) European Standard for Quality Assurance of Automated Measuring Systems, awarded under the British Environment Agency's Monitoring Certification Scheme.