Options for Calibrating Stack Flow to EN ISO 16911-2

Operators of combustion plant need to know the flue gas flow rate in order to calculate the mass release of pollutant emissions. The flue gas flow rate (m3/s) is multiplied by the concentration (mg/ m3) of pollutant, e.g., NOx, to give the mass release rate in mg/s. This information may be required for emissions trading, compliance or inventory reporting, or for air quality modelling purposes.

> *"E.ON Technologies offer an ISO 17025 accredited tracer dilution method for calibrating flow monitors or verifying flow calculations. The technique uses an inert tracer gas that is not affected by the process and can pass through combustion and abatement systems without losses"*

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A new standard on flue gas flow rate measurement was published in 2013: EN ISO 16911 'Stationary Source Emissions – Manual and automatic determination of velocity and volume flow rate in ducts. The scope of the standard, based on the original mandate from the European Union, is linked to the requirements of European Directives, including the Industrial Emissions Directive (IED) and the EU Emissions Trading System (EU ETS) which allows this alternative 'measurement' approach for CO_2 and requires it for emissions of N_2O and CH_4 from other sectors, all subject to defined uncertainty requirements. European Directives require the use of CEN standards when available.

The standard is divided into two parts. Part 1 defines manual Standard Reference Methods (SRM) to be used for the calibration of continuous stack flow monitors and for other compliance purposes, such as periodic testing. Part 2 of the standard applies to continuous monitoring and specifies the requirements for the certification, calibration and ongoing control of continuous flow monitors. Operators of large combustion plant are required to have stack flow monitors calibrated or flow calculations from fuel consumption verified based on EN 14181 and EN ISO 16911-2. For a QAL2 at least 15 parallel flow measurements are required (this can be reduced to 9 if a pre-investigation survey is performed to characterise the flow profile). The data should capture minimum and maximum load. Unlike EN 14181 there is no minimum time frame for completing the 15 tests.

When calibrating stack flow monitors or verifying calculated stack flow the standard allows the following SRM.

- Pitot tube traverse
- Vane anemometer traverse
- Tracer dilution technique
- Tracer transit time technique

Figure 1 - 3D pitot head

Figure 2 - S type pitot head

Operators should be aware of the pros and cons of each SRM method and the impact each may have on the final calibration result.

Pitot tubes and vane anemometers are used to obtain a representative flow measurement by traversing the duct at up to 20 positions, divided into centres of equal area, as shown if figure 3. This method is time consuming - taking around 90 minutes on large ducts where a minimum of 20 points is required. The accuracy of the volumetric flow is also dependent on an accurate measurement of the stack Cross Sectional Area (CSA). To confuse matters further, some monitoring locations are not ideal and may not allow a full traverse.

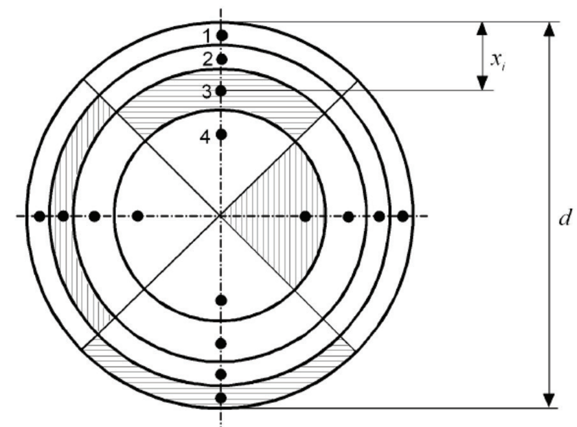

Figure 3 - Centres of equal area "Tangential Method"

"S" type pitot's are the most popular style of pitot; they are often used in manual iso-kinetic testing to match the sample flow rate with the velocity of the stack. Swirl (non-axial flow) can be identified but it is not automatically compensated for. They often over-estimate velocity and flow rate since the velocity profile close to the stack wall is too flat. The measured stack flow can then be much higher than the stack flow calculated from fuel consumption.

The 3D pitot measures velocity and automatically compensates for swirl. The method gives results close to calculated flow values but can also be slow and complex to operate. A traceable calibration in European countries is not currently offered.

The vane anemometer is easy to operate and gives reliable velocity measurements but it is not capable of measuring swirl making it unsuitable for ducts where swirl is present.

Tracer techniques are of short duration and have a low uncertainty. There are two methods available; tracer transit time and tracer dilution techniques.

The tracer transit time method determines the average velocity by recording the time taken for a tracer material to travel between two measurements stations. The distance between these two stations, situated in duct work of constant cross section, is divided by the measured time-of-flight to obtain the average velocity. This method gives accurate results with a low uncertainty. However the tracer material is radioactive. In some countries this can make the technique difficult to implement due to regulatory issues. As with pitot tube traverses, to obtain the volumetric flow rate, the average velocity must be multiplied by the duct CSA.

The tracer dilution system directly determines the flue gas flow rate and does not, therefore, require the CSA to be known. A tracer is injected into the flue gas, for a short period of time, upstream of the flue, such that the tracer is well mixed with the flue gas. The concentration of tracer in the flue gas is then measured. A one-off EN 15259 concentration traverse must be performed to demonstrate that the tracer is well mixed for the given injection configuration. Simple dilution relationships are then used to calculate the flue gas flow rate from the tracer injection flow rate and concentration.

E.ON Technologies offer an ISO 17025 accredited tracer dilution method for calibrating flow monitors or verifying flow calculations. The technique uses an inert tracer gas that is not affected by the process and can pass through combustion and abatement systems without losses. The diluted tracer gas is dried and analysed using a mass spectrometer. A tracer gas injection of around 1-2 minutes is required to obtain a spot volumetric flow measurement. Trials and commercial projects have shown the technique is very accurate giving results closest to the calculated flow rate, and the 3D pitot result, with a typical uncertainty of <2% at 95% confidence.

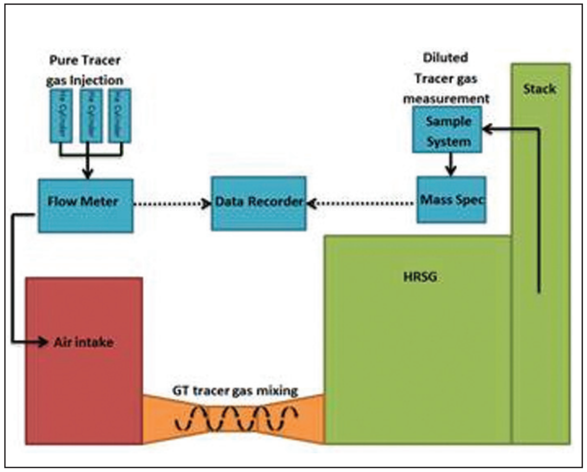

Figure 4 - Tracer dilution schematic

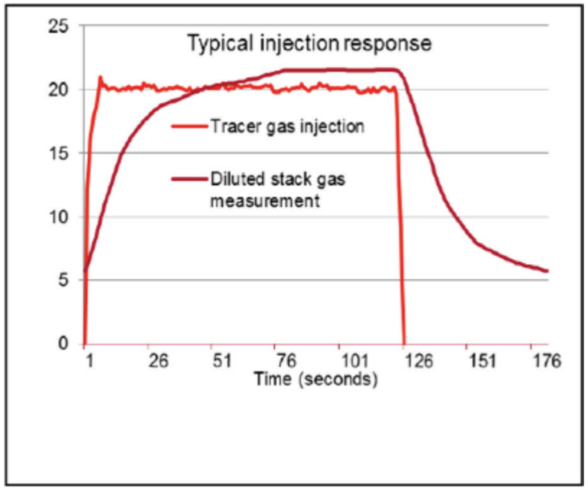

Figure 5 - Tracer dilution injection/detection response

A recent comparison was made verifying a flow rate calculation on the same stack using the tracer dilution system and an "S" type pitot. Figure 6 shows a comparison of the calibration determined using the tracer dilution and "S" type pitot vs calculated flow. The tracer dilution technique gave better agreement with the calculated flow and was carried out in a matter of hours rather than days. The tracer dilution system was also beneficial to the process operator as the low load period was only required for around 30 minutes. For comparison the "S" type pitot needed low load for a minimum of 3 hours to complete 2 traverses.

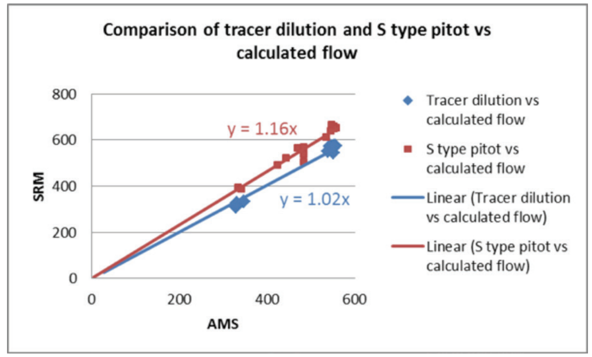

Figure 6 – Comparison of tracer dilution and S type pitot vs calculated flow

Process operators have a choice of approaches to select from when calibrating flow monitors or verifying flow rate calculations. Pitot tube traverses are widely available and will be offered by most test laboratories. A typical QAL2 will take around 3 days and may over-estimate the flow rate. Tracer techniques are quicker, typically taking ½ a day to complete a calibration. They have proven to be more accurate than traditional Pitot velocity techniques giving good agreement with flow rate calculations based on fuel consumption. The tracer transit time method is known to have a low uncertainty with regards to velocity measurement. However, the tracer dilution method has two advantages; volumetric flow is directly measured and the tracer material is not radioactive.