SO_2 EMISSIONS MONITORING: EUROPEAN SURVEY OF OPINIONS ON MONITORING USING THE SRM (EN 14791) OR PORTABLE INSTRUMENTAL TECHNIQUES

With increasingly strict emissions limits being brought in across many industries, there is some debate over whether the existing Standard Reference Method for SO_2 (EN 14791) is capable of reliably detecting these lower levels. Some would advocate moving to longer EN 14791 sampling times to increase sensitivity whilst others would propose moving to portable instrumental techniques capable of providing the increased sensitivity without needing to increase sampling times, with the added benefit of real-time data. However, many of these portable instrumental techniques require the sample to be dried before measurement (conditioned sampling), and here more data is needed to better characterise conditioned sampling at low SO_2 levels so the community can fully understand this capability. A new European metrology project called 'Sulf-Norm' aims to address such sampling questions so that the emissions community have the data they need to make fully informed decisions on the future of SO_2 monitoring.

Here we report one of the first activities under Sulf-Norm which has been to conduct a survey to determine industry preferences and perception of the pros and cons of SO_2 monitoring using EN 14791 or portable instruments. Fifty seven questionnaires were completed online via the Source Testing Association (STA) server, with participation from across Europe. Overall, portable instrumentation was the preferred method in most countries, although concerns were raised regarding species cross-interference and losses within the conditioning system. Issues were raised across the survey regarding the logistics of glassware on site, the sample-train, and user-error in leak testing.

Introduction

With a growing global focus on the effects of air pollution and its environmental impact, there is an ongoing effort not only to reduce current emission limits, but also to ensure that decreased emissions are measured with continued confidence and accuracy.

The serious health risks associated with air pollution continue to impact heavily on the populations of all European countries, alongside the financial burden that this then transfers to their healthcare systems and governments. A recent United Nations report suggested that over 40,000 premature deaths in the UK per year were the direct result of poor air quality, with many of these in the country's largest and most densely populated cities[1].

The EU is tackling these issues in terms of emission limits that must be adopted and enforced by all member states. This is being supported at CEN by the publication of standards that provide emission measurement methods that are passed into, or referred to in member state legislation; by convention such methods are referred to as Standard Reference Methods (SRMs). The role of the SRM has become two-fold: to periodically demonstrate compliance with emission limits and to calibrate, via parallel measurements, in-situ permanently installed instrumentation (referred to as Automated Measurement Systems - AMSs). Alongside the regular compliance testing, these AMSs are then used for year-round, continuous monitoring of emissions, as is required on all plants with >100MW capacity. Fundamentally, whether by compliance or calibration, the monitoring framework is underpinned by the capability of the current suite of SRMs.

In 2013, the Industrial Emissions Directive (IED)[2] brought in stricter emission limits for key pollutants, and the European Commission estimated that successful implementation of the IED would reduce premature deaths in Europe by approximately 13 000 p.a. With Best Available Techniques Conclusions documents bringing in even stricter emission limits across a number of industrial processes the emission monitoring community has started to discuss whether the capability of the existing suite of SRMs is sufficient to enforce such limits.

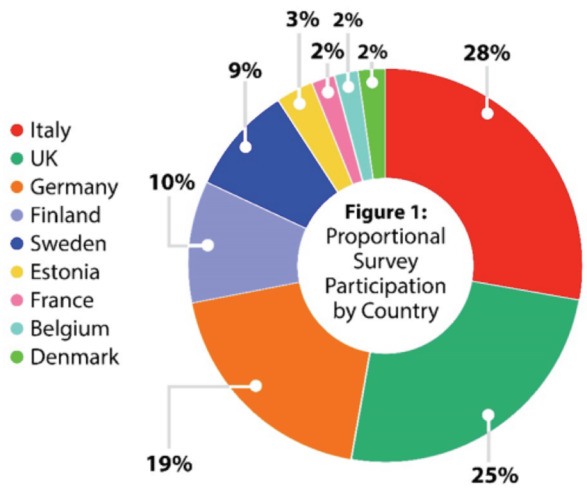
With respect to SO_2 the existing SRM - described in EN 14791[3] - is based on extracting a sample from the stack and passing it through impingers filled with $H_2O_{2(aq)}$, where the SO_2 is dissolved as sulphate for subsequent analysis off-line in an analytical laboratory, most commonly by ion chromatography. In principle, the sensitivity can be increased by sampling for longer periods of time (increasing the concentration of collected sulphate) and hence, this could be the solution to enforcing increasingly stringent emission limits. Alternatively, the community could move to using portable instrumental techniques (often optical in nature) that could provide increased sensitivity without increasing run times with the added advantage of real-time data. However, many of these techniques, in contrast to the SRM, require the extracted stack gas to be dried (conditioned) before being passed through the analyser.

For the emissions community to take informed decisions regarding the future approach to emissions monitoring, data are needed that show how far the SO_2 SRM can go in enforcing increasingly stringent emissions limits and if portable instrumental techniques offer a viable alternative. With respect to the latter, the European

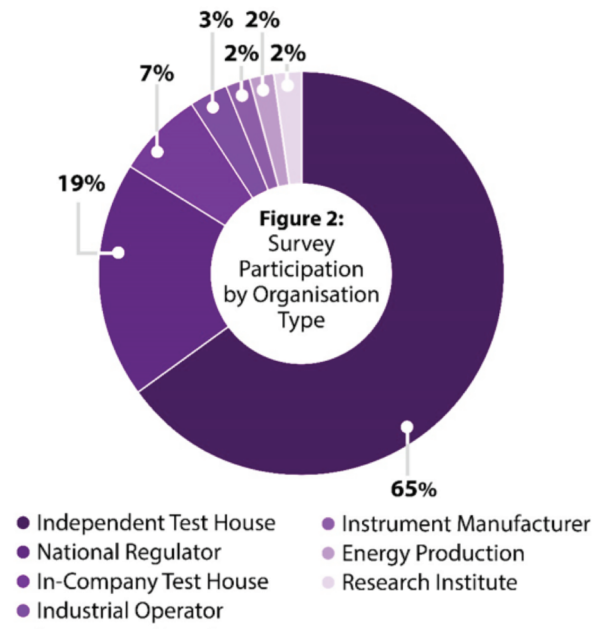
Metrology Programme for Innovation and Research (EMPIR) project 'Sulf-Norm' is aimed at addressing some of the issues. Work is being undertaken in this project to better understand the performance of different conditioning technologies at low SO_2 levels applicable to a range of different industrial processes. As a starting point for the project a survey was carried out to exploit the experience the community has to date with conditioned (portable instruments) and unconditioned (SRM) sampling in order to gauge current perception of capability. Here we summarise the results of this survey and discuss the reported experiences, providing trends where possible.

Survey Respondents

This survey was made available online and hosted through the Source Testing Association (STA) servers, with the aim of being available to a range of organisations and relevant parties across Europe. A link was circulated to the STA membership and also by Sulf-Norm project partners to members of the emissions monitoring community within their respective nations, and in some cases beyond. A total of 57 questionnaires were completed online with the highest numbers of participation from Germany, Italy and the UK (Figure 1).



A broad range of institutions took part, with full-time staff numbers ranging from 10s to 1000s. The breakdown in Figure 2 shows that the majority of organisations who responded were independent test houses (65%). National regulators and in-company test houses also responded in high numbers, with other participants ranging from instrument manufacturers to energy producers.



Trends Observed

Of the organisations surveyed it is seen that 24% offered only testing to EN 14791, 21% offered only portable instrumentation techniques and the remaining 55% offered both. In Figure 3 the results are broken down by country: Belgium, Denmark, Estonia and France are excluded as there were too few respondents from these countries to draw any meaningful national comparisons. Of those remaining Finland had a high proportion of organisations offering only portable methods, Germany and Italy showed a high proportion of organisations offering only EN 14791, and Sweden and the UK showed a high proportion of organisations who offer both. None of the respondents from Germany or Sweden offered only portable. Of course, not every organisation in each nation is included in the survey, however, these trends are likely to be representative.

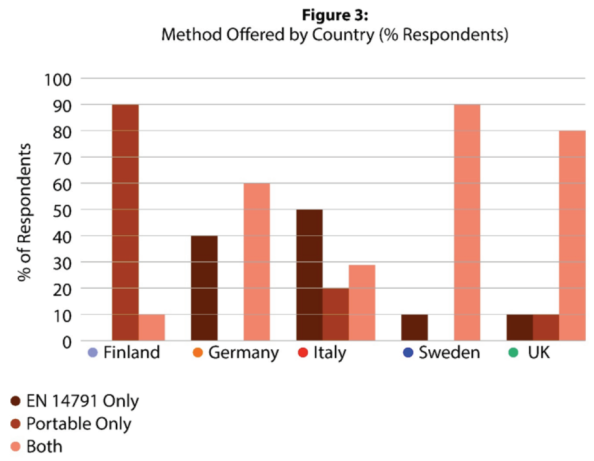


Figure 3: Method Offered by Country (% Respondents)

Much of this divide might be explained by the approaches of the national regulators in each country. For example, in the UK, Finland and other Scandinavian countries, alternative methods (AMs), such as those based on portable instrumental techniques, tend to be accepted by the national regulators whereas this generally is not the case in Germany and Italy where only the use of the SRM is permitted for regulatory purposes.

To gain an insight into the methods being used in the field, survey participants were asked to list the types of process plants on which they sample SO_2, and the types of testing they commonly undertake in these circumstances (i.e. compliance and QAL2 calibrations). These EN 14181 QAL2 calibrations are carried out after the installation of an AMS, taking parallel measurements and testing the range of validity of the calibration functions in order to ensure continued suitable operation. Under the Medium Combustion Plant Directive periodic measurement is required on small to medium combustion plants at least every three years (1MW-20MW thermal input), or every year (>20MW), but certain member states may require continuous measurement by means of AMSs[4]. The feedback below would suggest that AMSs are indeed in use on many medium combustion plants, with QAL2s being undertaken on these sites.

For medium combustion plants, as listed in Figure 4, portable instrumentation is most used when compliance testing, but less so for QAL2 testing. EN 14791 is used least at medium combustion plants, but it can also be seen that there are a high number of participants using both methods for compliance. EN 14791 is the most popular method for all types of medium combustion plant testing under QAL2, being used most commonly at single fuel waste incineration plants.

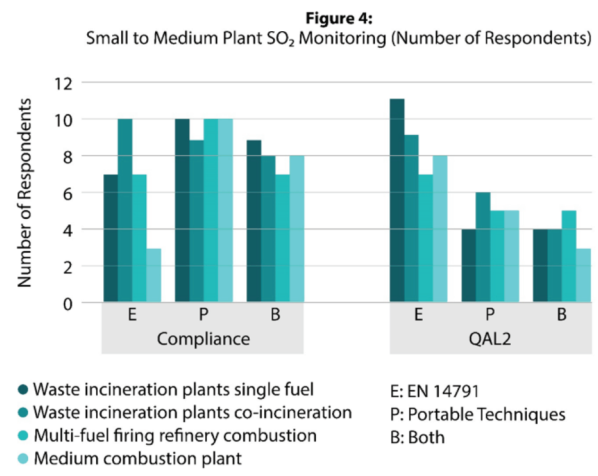


Figure 4: Medium Plant SO_2 Monitoring (Number of respondents)

When considering large combustion plants in Figure 5 it is seen that portable instrumentation is used more often than EN 14791 in most cases. These numbers are significantly higher for coal and lignite, peat, and co-fired biomass combustion plants. Biomass and liquefied gas combustion plants have results which are much closer in number, but it must also be noted that many participants recorded using both methods for compliance testing.

The number using both methods is significantly lower for QAL2 testing, and in contrast to medium plants, portable instrumentation appears to be used more commonly than EN 14791. Two notably higher examples of portable instrumentation testing are on liquefied gas plants and co-fired biomass combustion plants. Alternatively, for biomass combustion the use of EN 14791 is significantly more popular.

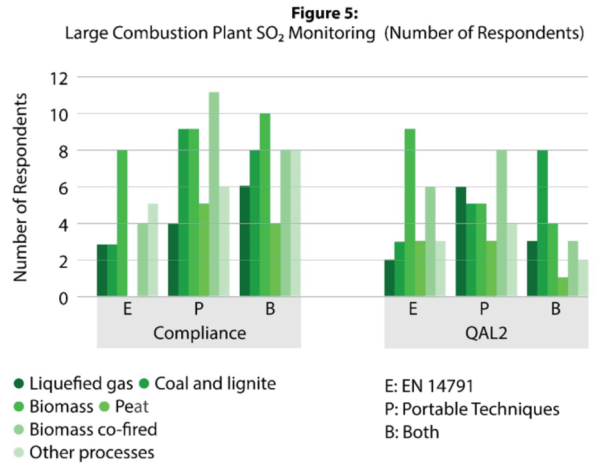


Figure 5: Large Combustion Plant SO_2 Monitoring (Number of respondents) E: EN 14791, P: Portable Techniques, B: Both

Respondents were asked which monitoring methods they would rather use if they had a free choice in the absence of any regulatory requirements. 59% of respondents selected portable techniques, with 24% preferring the SRM and 17% with no opinion. It was postulated that perhaps those without an in-house capability for analysing collected sulphate samples would inevitably have a preference for portable (in many member states the same organisation is not required to carry out both sampling and analysis under EN 14791). However, the data showed that, of those who had a preference for portable, sixteen (46%) had an in-house analytical capability whilst out of those who had a preference for EN 14791 only one (7%) used external analysis.

Trends in portable instrumentation varied across participants, the two most popular type of analyser were the Horiba NDIR (67% of respondents) and the Gasmet FTIR (44% of respondents). There were few notable trends by country, but every company from Italy who responded included the Horiba PG250/PG350 in their equipment list, with these models also proving popular in Finland. Germany, and the UK.

General Comments Returned

Respondents were asked for general comments on the application of both the SRM and portable techniques.

Asked what their preference would be in the absence of any regulator or national constraints it was found that 79% of Italian respondents and 66% of UK respondents preferred portable whilst 73% of German respondents preferred EN 14791. Interestingly, although all Swedish companies responded in favour of portable methods, the tests they reported offering are mainly in the use of both methods or EN 14791 alone (Figure 3).

It terms of commenting on the issues associated with each approach the most common responses were as follows. For EN 14791 44% reported issues in terms of handling glassware on-site listing contamination, quality of solutions, and space and logistics of setting up the sample train. 22% complained that data were not available in real-time and of sample train uncertainties in terms of frequency of user error in leak testing. Also, issues over freezing sample lines and solutions were listed, as might be expected from respondents residing in the cooler climates in the north of Europe.

With respect to portable methods, concerns due to bias caused by cross-interference from other species was mentioned by 44% of respondents, whilst 33% mentioned issues regarding losses in conditioning systems. Logistical issues of using gas cylinders on-site and permits to transport on the road were listed by 22% of respondents, whilst a small number complained about the time it takes to condition sampling systems on-site.

Conclusions

Respondents from 9 nations have highlighted a variety of issues from their experiences in using EN 14791 and portable instrumental techniques. With respect to the former, concerns expressed revolved mainly around contamination, quality of solutions and space / logistical requirements for setting up sampling trains on-site. With respect to the latter concerns were raised over cross-interference, losses in sampling systems and logistic issues with use / transport of gas cylinders. In terms of application we have seen that portable techniques are more commonly used for compliance measurements than QAL2, this perhaps being rationalised by differing regulatory approaches that in some member states would preclude the use of portable techniques, particularly for the latter.

There were some strong national preferences, no doubt driven in part by different regulatory environments. For example, it was seen that given a free choice 73% of German respondents would favour the use of EN 14791, whilst 79% of Italian respondents would favour portable instrumental techniques. Across all 57 respondents the preference fell on the side of portable techniques with 59% saying they would prefer to use this approach if free to choose. However, it should be noted that even if the industry preference is for portable techniques as this survey suggests – perhaps due to increased sensitivities being possible without extending run times and data being provided in real-time – as a community there must be confidence that the data such techniques provide are of sufficient quality. The highest response relating to portable techniques was on the issue of poor data quality due to cross-interferences, so this is clearly an area that needs further work if user-confidence is to be improved. Another key issue identified by the respondents relates to sampling (drying) of extracted stack gas. This highlights why the Sulf-Norm project was first proposed, which aims to provide important data into the debate over the future of SO_2 emissions monitoring.

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HVAC air flow transmitter with digital interface

The EE650 air flow transmitter from **E+E Elektronik** is dedicated for building automation and process control. The highly accurate device allows for reliable control of the air velocity in ventilation ducts and air conditioning systems. Besides the version with analogue output, the transmitter offers now RS485 interface and Modbus or BACnet protocol.

The EE650, available for duct mount as well as with remote sensing probe, measures air velocity up to 20 m/s (4000 ft/min). The new version features RS485 interface with Modbus RTU or BACnet MS/TP protocol, which facilitates the integration into a bus system. The EE650 with analogue output provides the measured data either as current or voltage signal. The measuring range, the output signal and the response time are user selectable.

The E+E air flow sensing element employed in EE650 operates on the hot-film anemometer principle. The state-of-the-art transfer molding technology gives the thin-film sensor a high mechanical stability. Due to its innovative flow profile, the sensing element is particularly resistant to contamination, which leads to excellent measurement accuracy and long-term stability.

The functional IP65 / NEMA 4 enclosure and the mounting flange included in the scope of supply facilitate the installation of the transmitter.

With an optional adapter cable and the free EE-PCS product configuration software, the user can adjust the EE650, set the output scale and select the interface parameters.

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Increasingly sophisticated use of Triton data reflects growing confidence in remote sensing for wind profiling

The diverse range of applications by European wind operators and developers spans wind resource assessment, bankable due diligence and noise studies.

The European wind energy industry is increasingly adopting data collected by remote sensors for a wider range of applications. In doing so, developers and operators have benefitted from reduced assessment times, lower development and permitting costs, and an improved understanding of on-site wind conditions.

To date, Vaisala's Triton Wind Profiler has been deployed on almost 5,000 wind measurement campaigns, and is increasingly being used in a diversity of ways by European firms both domestically and overseas, from wind resource assessment through to bankable due diligence and noise studies. The development comes as wind energy firms continue to reduce their reliance on meteorological (met) masts and embrace the use of remote sensing units across their project portfolios and operations.

Particularly across the mature European wind markets, Triton is increasingly being used to support project financing. While met masts have long served as the industry standard in this respect, a growing evidence base demonstrating the accuracy of remote sensing data has led to greater acceptance of this data to demonstrate projects' financial viability.

In France, for instance, a leading developer has successfully used Triton data to secure financing for a five-turbine wind farm. The unit measured wind conditions at the site at a hub height of 120 meters, with the developer also installing an 80-meter met mast and extrapolating measurements for the additional 40 meters. The two sets of data were together submitted to the bank and formed the basis of the successful financing proposal, with the Triton data in particular being used to reduce the degree of uncertainty in resource calculations.

Remote sensing has also enabled developers to overcome unique market challenges, such as strict noise regulations in France, the United Kingdom, and elsewhere. Here prospective developers are required to carry out detailed analysis of the potential noise impacts of new wind farms under a series of different conditions. This requires brief campaigns to capture wind speed measurements.

Given this short time period, erecting a met mast to undertake this analysis would be prohibitively expensive. However, the Triton's versatility and ease of deployment makes it well suited to the task, and it is frequently deployed for this purpose by leading developers in France and the United Kingdom.

The industry's growing confidence in remote sensing is equally reflected in the Triton's increasing use in a number of new markets throughout Europe, the Middle East and Asia. Developers and operators in those markets are using Triton for applications as diverse as shear validation, performance analysis of operating wind farms, reducing uncertainty derived from complex terrain and acting as a permanent on-site met station.

"As we approach the Triton's 5,000th deployment, it's clear one of its greatest assets is an ability to serve a wide range of uses throughout site prospecting, development and project financing," said Nihat Hünerli, EMEA Regional Manager for Vaisala's energy business unit. "In Europe, we've seen how the sophisticated range of data provided by the Triton has given financiers a greater understanding of site conditions, and this increased confidence in the data has been instrumental in ultimately securing financing for those projects. Similarly, in the emerging wind markets, the unit's versatility and the quality of data it provides is leading to it rapidly becoming the resource assessment tool of choice."

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