THE UNCERTAINTY OF EQUIVALENCY

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ABSTRACT

Throughout Europe, more and more legislation is being introduced, through European Directives, which either requires or refers to methods for the measurement of air pollution. Quite often these methods are not available as European standards (ie CEN methods), although member countries may have their own national standards. These may be used in the interim, but would need to be revoked once a CEN method was introduced, because CEN standards are mandatory in Europe. There may also be other standards available from ISO or the US EPA, but it is not a requirement that these be used by the European Union Member States. Standards exist in many forms, and often the accuracy (sic) is quoted. Unfortunately, this only provides a very rough estimation of the precision of the standard. Rarely does it explain the true accuracy (uncertainty). If they are to be used to demonstrate compliance with European legislation, then this is far from satisfactory.

Where member countries have in the past relied on their own National standards, and have put a lot of time, effort and money into their development, they may find it difficult to change their networks or instrumentation. To ensure future consistency throughout Europe, it is fundamental that a CEN Reference Method exists. Where the Reference method is based on a laboratory technique, is very precisely described or legislation is approved before a CEN method is available, it may not be possible for member countries to make the necessary changes, especially where extensive networks have been introduced. In these instances it would be necessary to be able to demonstrate equivalency with the CEN Reference Method, or the specific requirements of the EU Directive. However, no such methodology or guidance exists at present, for this to be done on a consistent basis.

This paper discusses the need to move to standard methods of known uncertainty, which are drafted more as performance standards, so that equivalency can be easily demonstrated, if required. In this way we not only encourage better standards, but we do not stifle innovation in measurement techniques.

LEGISLATION IN THE EU.

The EU approves a wide range of legislation every year, on environmental issues, covering topics as diverse as protection of habitats to industrial pollution. This legislation becomes increasingly more detailed and complex, and in many instances will even specify test methods and how calibration shall be approached, before standards are in place.

Member States have to implement this legislation, and if there are no European standards (ie CEN), they have to resort to their own national standards or international or American standards. This is a far from satisfactory situation, if, for no other reason, than that this leads to inconsistency. Also more often than not, existing non-CEN emission standards, have very little in the standard that covers accuracy, precision or uncertainty. Whereas this was acceptable in the past, it is now totally unacceptable. Both ISO and CEN are planning to ensure that in future, standards will be produced with such information. Unfortunately, to obtain data on uncertainty can cost a great deal of money in field trials, and this is not always readily available.

The EC has the power to issue mandates to CEN to produce standards to support and compliment legislation, and in particular this has been done for the Large Combustion Plant and the Hazardous Waste Incineration Directive, which contain emission limit values. To support this legislation there was a need for both manual extractive standards and standards for the continuous monitoring of releases to air. Also depending on the averaging periods for limit values prescribed, there may be the need to develop new standards. The CEN committee, which handles this work, is TC 264, Committee for the production of Air Quality Measurement Methods. To ensure that these standards are produced as quickly as possible the EC will issue such mandates.

Where the EC is also keen to ensure that these standards have the necessary uncertainty data available when the standards are published, they are prepared to pay for the field validation work to be carried out. Therefore alongside the mandates they will often sign contracts for this work to be undertaken, in a controlled , auditable and speedy fashion. Unfortunately this is often done after the event, that is, after Directives have been approved and published. This is far too late. These standards should be produced at the same time that the legislation is being promulgated. CEN is now encouraging the EC to allow them to get involved at the earliest possible stage, so that standards can be available, before or soon after legislation is approved.

Also it is not always certain that the EC will have all the funds available that are required. Only a certain amount will be available in any one year. It has been necessary therefore to seek funds from elsewhere. Research funds have been considered, but these are often only available for a short period, say a year or two. Most standards take at least five years to complete, so this form of funding is not always very helpful. It had been suggested that working group members contribute to the costs of the field work, but this would depend further on the goodwill of companies providing the experts for the working groups. The sums involved, even if split four or five ways, can run into hundreds of thousands of Euros-rather a large sum for companies to find. The other source, but of only limited funds, is the Environment Institute, part of the Joint Research Council (JRC), situated in Ispra, Italy. If identified well in advance, and if the standard is of high priority to the Commission, then certain limited funds and staff can be made available. So it can be seen that the funding of this field work is not straightforward, and relies heavily on the European Commission, and its desire to see appropriate CEN standards available to member States, in support of European legislation.

UNCERTAINTY.

But it could be asked, why is there a need to include data in standards that explains the uncertainty of the method? Unfortunately there are no 100% accurate methods. All measurement techniques are inaccurate, and depending on the technique used, may incur inaccuracies at different steps of the procedure. Unfortunately in the past, information on uncertainty was scarce, and if we were lucky there may have been reference to accuracy, and/or precision in a grudging , take it or leave it sort of way. In some more recent standards, there may be reference to standard deviation, or even repeatability (Interval Variance) and reproducibility (External Variance). But these are only part of the story. To work out the overall uncertainty of any method it is necessary to know and understand the individual uncertainties, and how they may be minimised. Only in this way can we be sure that different methods are equivalent to one another. Fortunately advice is available in the form of a document known as GUM, the Guide to the Expression of Uncertainty in Measurement, published both by ISO, and CEN (ENV 13005).
The overall uncertainty of methods can be influenced by many factors, and may in a typical manual extractive method fall into the following areas.

Use of Materials. Are reference materials available to undertake validation work; Is their source traceable? Are other materials available to a verified purity?

Representativeness – Is the sampler seeing or collecting a representative sample of the emission to be evaluated?

Sampling nozzle – Are there any obstructions in the sample line; Is damage possible from repeated use; How does temperature, pressure, moisture and interferents affect the result; Does the nozzle ensure 100% collection, etc?

Sample collection – what are the losses in the sampling line; Are the gases reactive with the sample line; Will particulate matter adhere to sample line wall; Does the collector trap all the pollutant in the exhaust stream, Will other institutes collect the sample in the same way, and can the sample and stack flow be measured accurately, etc?

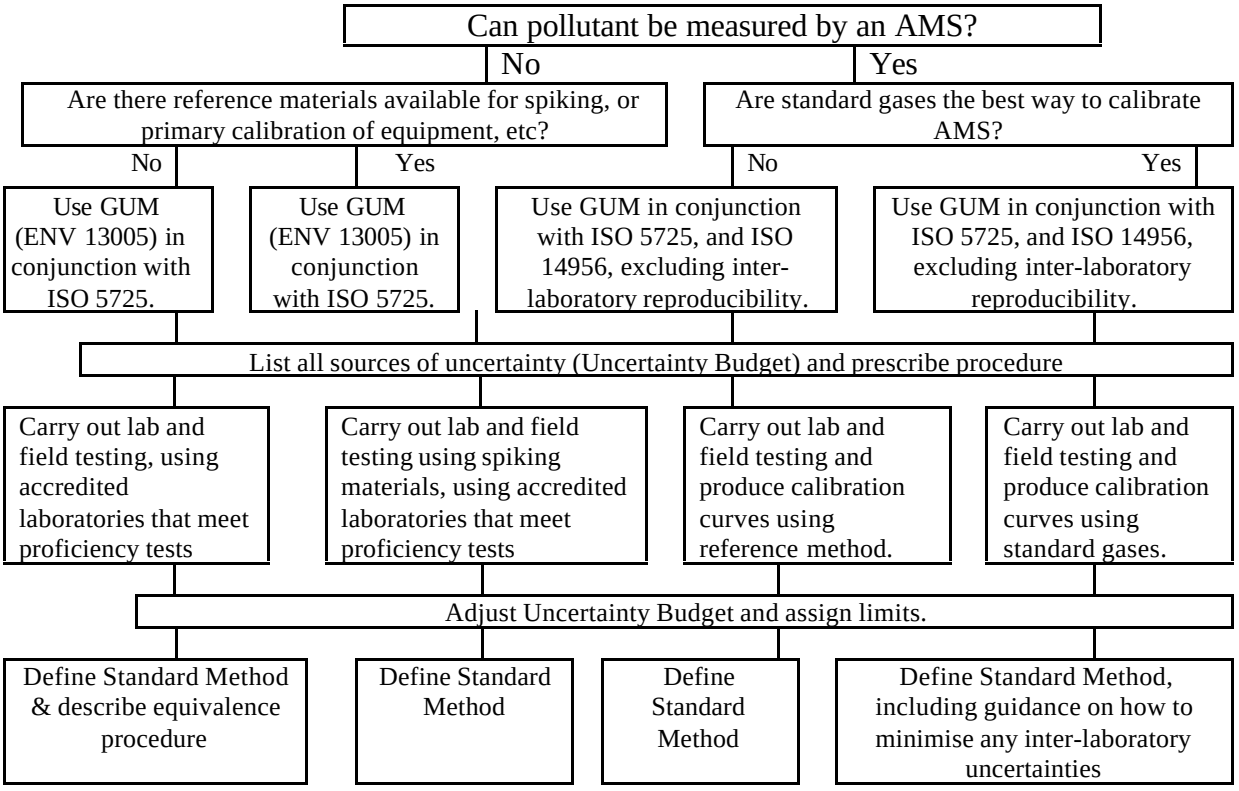
Sample integrity – Can all of the sample be removed from the sampling train, without loss or damage; Can the sample remain in the same state on transfer to the laboratory, etc?

Sample analysis – Can all the sample be retrieved from the collector; Is the analysis specific to the pollutant in question; Do other substances interfere; Would different institutes analyse in the same way, Are the instruments of the same specification and produce the same detection limits, etc? Is humidity in the lab a factor?

Although it is possible to make certain assumptions on some of these topics, it is necessary to evaluate each of these areas, if one wants to properly quantify the level of uncertainty associated with a particular method. To undertake this work on one method is going to be quite costly, even if one assumes that some of this can be done in the laboratory. As soon as you have to go into the field to carry out investigations, or where several different methods are involved, the costs mount dramatically. However, if we want robust consistent standards that can be repeated anywhere within Europe, with a known degree of certainty, then this work must done. And funds must be found to do it.

This of course reflects how one might approach manual extractive testing, but this will not be the same for all substances or continuous emission monitoring (automated measurement systems - AMS). Some simplification may be possible, but where it is necessary to rely on manual extractive methods, it is possible that the exercise may be prolonged and more complex. It is necessary therefore, to have a strategy, which enables you to follow the correct course of action. The following is an attempt to logically access all options.

Options for the preparation of CEN standards for the measurement of pollution in Stacks.



Typical for metals, particulates.	Typical for: Dioxins, HCl.	Typical for: SO2, NOX, Flow, TOC.	Typical for: CO, Oxygen, CO2.

It can be seen from the chart above, that the strategy allows four courses of action to be followed for the determination of uncertainty of particular methods, depending on the type of pollutant to be measured, and the method of measurement. In the majority of cases, and especially where it is possible to produce a standard on more performance based criteria, it should not be necessary to provide guidance on equivalency. However in some instances it may be necessary to produce more prescriptive standards. (nb. A performance based standard means one which does not describe or prescribe the equipment to be used, but does list how the performance of each stage of the monitoring must be met; sampling, integrity of sample, recovery of sample and analysis. A prescriptive standard is one which describes in detail each piece of equipment used, and the procedures to be followed.).

Equivalency.

From the outset it has been assumed that to ensure consistency and equivalency, there is a need to produce a CEN Reference Method, and that following the Standstill Agreement, that all other conflicting standards must be withdrawn. However, there may be circumstances as illustrated above, where it has been necessary to produce an over-prescriptive method, and therefore there is the need to demonstrate how other methods/instruments might be shown to be equivalent. Although generally, it is not advisable to formulate prescriptive standards, in the past, there has been little alternative. However, now that we have guidance on how to determine the individual components of uncertainty, it is now possible to move to more performance standards rather than prescriptive standards.

But, where it is necessary to consider equivalency, there needs to be a strategy to allow this to be carried out in a consistent manner. The following are proposals for principles, which might be the foundation for such a strategy.

Basic principle.

Any non-reference method (NRM) used for the measurement of air pollutants in stacks, shall meet the uncertainty specified in the CEN Reference Method.

Guiding Principles.

1. The uncertainty of any NRM, shall be evaluated using the principles laid down in a Technical Report on Uncertainty , to be published by CEN/TC 264. The evaluation shall take into account, at least those uncertainties identified for the Reference Method (RM), where applicable. Any uncertainties not covered in the RM shall be recorded and evaluated.

2. The evaluation shall be performed by an accredited body for such work, for which some form of authentication will be required. The accredited body shall be able to demonstrate that it has the necessary proficiency in the area concerned.

3. A series of multiple parallel measurements shall be undertaken using recognised statistical methodology, in accordance with GUM, to generate a series of comparable results between the RM and the NRM.

4. Where the NRM differs from the RM, each area of uncertainty, which has not already been covered in the RM, shall be evaluated by taking a series of measurements. (eg where the efficiency/uncertainty of membrane filters has already been evaluated then no further validation is required, but that area of uncertainty must be included to calculate the overall uncertainty of the NRM).

5. All reference materials used in evaluations shall be traceable. Where traceable standards are not available then equivalence with the Reference Method may have to be demonstrated in some other way, (eg using multiple parallel measurements and recognised statistical methodology).

6. The procedures stated in the RM shall be used, where applicable, over a range of conditions applicable to the country concerned.

7. A report shall be prepared which identifies the similarities to the RM and the differences. Any new procedures used shall be explained. Each area of uncertainty shall be listed with its uncertainty value, and the overall uncertainty of the NRM.

Conclusions.

Whereas we have come a long way since the first inaugural meeting of CEN/TC 264, in 1991, in ensuring that standards are validated in the field, so that operators have faith in the accuracy (generally repeatability and reproducibility) of the methods, there is still some way to go before we can be satisfied that “overall uncertainty” has been covered. There is no doubt in my mind that CEN standard methods are needed for consistency throughout Europe, but these should not be rushed or produced as an after-thought. They should be planned from the outset, and should be “performance-type” standards, that do not need a strategy on how to show equivalency.

Furthermore funding is going to be required to an even higher level in the future if we are to ensure that relevant standards are compared in the field and that uncertainty is evaluated fully.

We have to move away from prescriptive standards towards performance standards, so as not to stifle innovation in analytical techniques and air pollution measurement in general. Long gone are the days when we could make-do with a very prescriptive standard, compiled by a group of experts, closeted in a room for meeting after meeting. Field validation of standards is here to stay, and we have to find ways to make funds available to carry out the vital work to establish the comparability and uncertainty of methods. CEN/TC 264 have a wealth of experts at their disposal, when required. We can no longer sit back and wait to be told what to do. We need to be pro-active and be involved from the outset, when directives are being formulated. In this way we can better plan our work and make sure that standards are produced synonymously with legislation, and funds and experts are available at crucial times.