THE MOST CERTAIN THING ABOUT THE NEW INDUSTRIAL EMISSIONS PACKAGE IS THAT WE HAVE AN ISSUE WITH UNCERTAINTY

The role of measurement uncertainty in ensuring an effective transition to lower emissions from European industry

Under the umbrella of the Industrial Emissions Directive (IED) and its Best Available Techniques (BAT) principle, the concept of measurement uncertainty is especially relevant for two different objectives: on the one hand, instruments and measuring methods have to achieve a maximum permissible uncertainty in order to be used to monitor emissions in IED installations; on the other hand, for reporting and compliance purposes, a measured value should be checked against the related emission limit value after subtraction of the uncertainty in order to ensure legal certainty. In this article we will focus on the second application of the uncertainty concept in the implementation of IED and BAT Conclusions.

While the IED specifies basic requirements to achieve stated confidence intervals for the main pollutants in Annexes V and VI, certain authorities may specify a performance criterion for the uncertainty. For example, they may specify that the uncertainty cannot be more than 10% of a prescribed Emission Limit Value (ELV). Such a specification would prevent users of methods with large uncertainties gaining any benefit due to the subtraction of the uncertainty from measured values as described above. Otherwise, theoretically if a laboratory/method had an uncertainty of 50 % of the ELV, it would be easier for the plant to be compliant, compared to a method with a lower uncertainty. This could encourage a preference for poor performing laboratories/methods over good performing laboratories/methods. N.B., this is clearly more of an issue if the uncertainty assigned to the measurement results is an overly conservative estimate.

IED and relevant BAT Conclusions are the legislative reference in the EU to environmental permits for industrial installations that are covered under IED, Annex I. Environmental permits are drafted by competent authorities that will consider how a specific installation can implement Best Available Techniques (where technique is meant as both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned). When setting ELVs in a permit there are three key elements that should be properly assessed:

- the ELVs must be capable of being monitored in practice
- monitoring requirements and data quality requirements must be specified together with the ELVs
- compliance assessment procedures must also be specified together with the ELVs so that they can be readily understood.

Lower ELVs provide a clear reflection of the ambition to reduce pollutant emissions, and reflect the potential for BAT. However, an ELV should be set so that the monitoring required in order to determine compliance is within the capability of available measurement methods, until technological progress allows for better performances. For example, in order to obtain detectable quantities of dioxins from stack emissions it is usually necessary to sample over several hours. In this case the averaging time should correspond to this practical sampling duration. The limit setting process must therefore take into account the technical limitations of the relevant monitoring methods which will include consideration of detection limits, response times, sampling times, possible interferences, general availability of the methods and possible use of surrogates.

Clarity about the relationship between ELVs and the monitoring framework is essential to make sure that these limit values have meaning. Good practice recommends that monitoring requirements to be included with Emission Limit Values in permits should cover – directly or indirectly:

- legal and enforceable status of the monitoring requirement
- averaging period of ELV and reported measured data
- pollutant or parameter being limited
- data quality requirements
- requirements on location for sampling and measurements
- timing requirements of sampling and measurements (continuous/periodic)
- reference conditions and requirements on measurement of peripheral data
- feasibility of limits with regard to available measurement methods
- general approach to the monitoring available for relevant needs
- reference to technical details of particular measurement methods
- self-monitoring arrangements
- operational conditions under which the monitoring is to be performed

- compliance assessment procedures
- reporting requirements
- quality assurance and control requirements
- arrangements for the assessment and reporting of exceptional emissions.

As mentioned at the beginning of this article, it is necessary to make a distinction between the uncertainty of a method or an instrument, which has to be assessed in order to decide if it is good enough to be used to monitor emissions, and the uncertainty associated to a measured value, that has to be set in order to allow for proper reporting and ensure compliance with emission limit values. Evaluating the uncertainty of a specific method/instrument is not sufficient in itself to provide a value that can be associated with a measurement in order to prove compliance. The measured value can be compared with the limit, taking account of the associated uncertainty in measurements. When monitoring is applied for compliance assessment it is particularly important to be aware of measurement uncertainties during the whole monitoring process. This is a complex exercise, even more so if one considers the complex relationship between an emission limit value and its monitoring requirements: especially given that in the quality assurance procedures, many target values are defined with respect to the ELV (for example as a given percentage of the ELV).

The uncertainty of a measurement is a parameter, associated with the measurement result, that characterises the dispersion of the values that could reasonably be attributed to the measurand (i.e. the extent to which measured values can actually differ from the real value). In general, the uncertainty is expressed as a plus or minus interval around the measurement result with a 95% statistical confidence.

When the permit explicitly specifies an applicable standard method for the regulated parameter, as in the case of a periodic measurement, the means to determine the measurement uncertainty should be fully described in the standard method. When the permit leaves open the choice of a standard method for the regulated parameter, the external dispersion corresponds to the uncertainty of a measurement result. This includes the systematic differences (i.e. bias) that may exist between the results obtained with different applicable standard measurement methods for the same regulated parameter. However, for continuously monitored parameters, as mentioned above, it is necessary for compliance assessment to evaluate the uncertainty of a measured value, which for a continuously measured parameter will include uncertainty of the Standard Reference Method (SRM), uncertainty of the Automated Measuring System (AMS) and uncertainty of the quality assurance procedures such as the ones laid down in EN14181. It comes as an obvious conclusion that using for example parameters from the QAL2 procedure such as its standard deviation will not provide a technically sound approach to evaluate the overall measurement uncertainty for purposes of compliance with an ELV.

Identification of the uncertainty sources can be useful to calculate the total uncertainty. This is a difficult but important exercise, especially if we consider the direction that the current review of the Industrial Emissions Directive is taking. It is also especially important in those cases when the measurement results are close to the ELV. The Commission published its proposal for IED review in April 2022. It includes several changes including for Article 15.3 that should state:

"The competent authority shall set the strictest possible emission limit values that are consistent with the lowest emissions achievable by applying BAT in the installation, and that ensure that, under normal operating conditions, emissions do not exceed the emission levels associated with the best available techniques (BAT-AELs) as laid down in the decisions on BAT conclusions referred to in Article 13(5). The emission limit values shall be based on an assessment by the operator analysing the feasibility of meeting the strictest end of the BAT-AEL range and demonstrating the best performance the installation can achieve by applying BAT as described in BAT conclusions."

We can read in this new wording of Article 15.3 that the Commission is explicitly supporting competent authorities to set ELVs at values that are below the upper end of BAT-AELs. Should this proposal go through the co-decision process as it is it would require a much higher ambition than what is the status quo. That said, this proposal is also complemented by the addition of Article 15a on compliance assessment, stating:

"1. For the purpose of assessing compliance with emission limit values in accordance with Article 14(1), point (h), the correction made to measurements to determine the validated average emission values shall not exceed the measurement uncertainty of the measuring method. [Note of the authors: strictly speaking this should be the measurement uncertainty of the measured results]

2. The Commission shall by [the first day of the month following 24 months after the date of entry into force of this Directive] adopt an implementing act establishing the measuring method for assessing compliance with emission limit values set out in the permit with regard to emissions to air and water. This implementing act shall be adopted in accordance with the examination procedure referred to in Article 75(2). The method referred to in the first subparagraph shall address, as a minimum, the determination of validated average emission values and shall set out how measurement uncertainty and the frequency of exceedance of emission limit values are to be taken into account in the compliance assessment."

If the future scenario for IED installations is to strive to achieve the most ambitious ELV based on BAT-AEL ranges while at the same time having to respect compliance rules set directly in the IED, it is necessary that the approach towards "how measurement uncertainty" is "to be taken into account in the compliance assessment" should be technically sound and guarantee the legal certainty for both operators and competent authorities.

Conclusions

The challenges of monitoring, including how to determine measurement uncertainty, are no secret to the metrology community. However, the world outside this bubble discovered, only a few years ago, that measurement uncertainty has a significant impact on compliance with the legislation and that it responds to technical constraints and cannot be bent to human willpower. Even now, the discussion among policy makers seems to revolve around "we have to be more ambitious on uncertainty than just the values mentioned in the IED". As any expert in monitoring will know very well, monitoring aspects such as uncertainty are determined by the actual capabilities of instruments and methods and it is not possible to arbitrarily set a requirement on uncertainty without considering what can practically be done (taking into account technological progress).

Given the review of the IED and the new proposals on the table for compliance assessment, all IED installations will eventually face the challenge of coping with the linkages between ELVs and their monitoring requirements. Developing a common and sensible approach will provide a sound basis for legal certainty when it comes to compliance with ELVs, especially if in the future ELVs will be set closer and closer to operating values.

One step that would be of great help industry and regulatory authorities would be to develop common approaches to determine the uncertainties in measured values, approaches which are pragmatic and practical to apply, while taking into account the complex issues we have introduced, albeit very superficially, in this article.

The main sources of uncertainties are those associated with the measurement steps of the monitoring data production chain, such as:	
SRM	sampling plan
	taking of the sample
	sample pre-treatment,
	transport/storage/preservation of the sample,
	sample treatment,
	analysis/quantification.
AMS	System uncertainties from QAL1
	Repeatability
	Linearity
	Sampling (parts not controlled by QAL3)
	Sample flow
External sources	uncertainties in flow measurements when loads are calculated
	uncertainties in data handling, e.g. the uncertainties related to missing values when calculating a daily or other average
	uncertainties due to the dispersion of results associated with systematic differences ("bias") that may exist between results obtained with different applicable standard measurement methods for the same regulated parameter
	uncertainties due to the use of secondary method or of surrogates
	uncertainties due to inherent variability (e.g. of a process or weather conditions).
Quality assurance process (EN 14181)	Calibration to a 'worse' performing SRM (15 repeats locked into a calibration function for 3 yrs)
	Drift (QAL3)
	AST not detecting change in calibration
	Change in emission matrix (interferent compounds)
	Different measured components (HCl vs chlorides)
	Inhomogeneity in sample plane (larger stack – power sector)
Additional uncertainty sources if reporting mass emission	Additional uncertainty in emission rates (load)
	Flow
	Representativeness of flow/concentration
	Conversion to common basis
	Missing data

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