EUROPEAN COMMISSION
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CLIMA.A.3 - Monitoring, Reporting, Verification

# Guidance Document

## The Monitoring and Reporting Regulation – Continuous Emissions Monitoring Systems (CEMS)

**MRR Guidance document No. 7, final version of 13 November 2013**

This document is part of a series of documents provided by the Commission services for supporting the implementation of Commission Regulation (EU) No. 601/2012 on the monitoring and reporting of greenhouse gas emissions and Commission Regulation (EU) 600/2012 on the verification of greenhouse gas emission reports and tonne-kilometre reports and the accreditation of verifiers pursuant to Directive 2003/87/EC of the European Parliament and of the Council[1] of 21 June 2012.

The guidance represents the views of the Commission services at the time of publication. It is not legally binding.

This document takes into account the discussions within meetings of the informal Technical Working Group on the Monitoring and Reporting Regulation under WGIII of the Climate Change Committee (CCC), as well as written comments received from stakeholders and experts from Member States. This guidance document was unanimously endorsed by the representatives of the Member States at the meeting of the Climate Change Committee on 13 November 2013.

All guidance documents and templates can be downloaded from the Commission's website at the following address: http://ec.europa.eu/clima/policies/ets/monitoring/documentation_en.htm.

[1] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:181:0030:0104:EN:PDF

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# 1 INTRODUCTION

## 1.1 About this document

This document has been written to support the M&R and A&V Regulations, by explaining its requirements in a non-legislative language. While M&R Guidance Document No. 1 provides a general overview on monitoring and reporting of emissions from installations under the EU ETS and A&V Explanatory Guidance (EGD I) serves the same purpose for accreditation and verification, this document (Guidance Document No. 7) explains in more detail the requirements for continuous emissions monitoring systems (CEMS)[2] for M&R as well as for A&V purposes. The set of guidance documents is further complemented by electronic templates[3]. However, it should always be remembered that the Regulation is the primary requirement.

This document interprets the Regulation regarding requirements for installations. It also builds on guidance and best practice developed during the first two phases[4] of the EU ETS (2005 to 2007 and 2008 to 2012), in particular the experience gathered by the Member States based on the Monitoring and Reporting Guidelines[5] (MRG 2007). It takes into account the valuable input from the task force on monitoring established under the EU ETS Compliance Forum, and from the informal technical working group (TWG) of Member State experts established under Working Group 3 of the Climate Change Committee.

## 1.2 How to use this document

Where article numbers are given in this document without further specification, they always refer to the M&R Regulation. For acronyms, references to legislative texts and links to further important documents please see the Annex.

This document only refers to emissions starting from 2013. Although most of the concepts have been used in the MRG 2007 before, this document does not provide a detailed comparison with the MRG 2007.

*In order to allow this document to be read as a self-standing document, chapter 2 is taken from sections 4.3.3 and 8 of Guidance Document 1 (general guidance for installations) for reasons of completeness. If you have already read these relevant sections in Guidance Document 1 you may proceed directly to chapter 3 of this current document*

[2] The term Automated Measuring System (AMS) is also widely used throughout the EU. However, an AMS can also refer to a continuous monitoring system for ambient air-quality, so this document will use the acronym “CEMs” or, for transferred/inherent CO2 and CCS, “CMS”.

[3] Note that Member States may define their own templates, which must contain at least the same information as the Commission’s templates.

[4] Within this documents, as in some Member States, the term 'phase' is used with the same meaning as 'trading period' (Article 3(2) of the MRR).

[5] The MRG 2007 have been repealed by Article 76 of the MRR but reference is kept here for completeness reasons.

## 1.3 Where to find further information

All guidance documents and templates provided by the Commission on the basis of the M&R Regulation and the A&V Regulation can be downloaded from the Commission's website at the following address:

**http://ec.europa.eu/clima/policies/ets/monitoring/documentation_en.htm**

The following documents for M&R are provided[6]:

- Guidance document No. 1: "The Monitoring and Reporting Regulation – General guidance for installations". This document outlines the principles and monitoring approaches of the MRR relevant for stationary installations.
- Guidance document No. 2: "The Monitoring and Reporting Regulation – General guidance for aircraft operators". This document outlines the principles and monitoring approaches of the MRR relevant for the aviation sector.
- Guidance document No. 3: "Biomass issues in the EU ETS": This document discusses the application of sustainability criteria for biomass, as well as the requirements of Articles 38, 39 and 53 of the MRR. This document is relevant for operators of installations as well as for aircraft operators.
- Guidance document No. 4: "Guidance on Uncertainty Assessment". This document for installations gives information on assessing the uncertainty associated with the measurement equipment used, and thus helps the operator to determine whether he can comply with specific tier requirements.
- Guidance document No. 5: "Guidance on sampling and analysis" (only for installations). This document deals with the criteria for the use of non-accredited laboratories, development of a sampling plan, and various other related issues concerning the monitoring of emissions in the EU ETS.
- Guidance document No. 6: "Data flow activities and control system". This document deals with establishing procedures for data flow activities and the control system in place. It also provides guidance for carrying out a risk assessment.
- Guidance document No. 7: "CEMS". The current document.

[6] This list is at the current stage non-exhaustive. Further documents may be added later.

Furthermore, the Commission provides the following electronic templates[7]:

- Template No. 1: Monitoring plan for the emissions of stationary installations
- Template No. 2: Monitoring plan for the emissions of aircraft operators
- Template No. 3: Monitoring plan for the tonne-kilometre data of aircraft operators
- Template No. 4: Annual emissions report of stationary installations
- Template No. 5: Annual emissions report of aircraft operators
- Template No. 6: Tonne-kilometre data report of aircraft operators
- Template No. 7: Improvement report for installations
- Template No. 8: Improvement report for aircraft operators

Besides these documents dedicated to the MRR, a separate set of guidance documents on the A&V Regulation is available under the same address. Furthermore, the Commission has provided guidance on the scope of the EU ETS which should be consulted to decide whether an installation or part thereof should be included in the EU ETS. That guidance is available under **http://ec.europa.eu/clima/policies/ets/docs/guidance_interpretation_en.pdf**

Although not directly related to monitoring issues, with the exception of reporting on relevant changes in the installation under Article 24 of the Community-wide Implementation Measures, the set of guidance documents and templates provided by the Commission on the allocation process for the third phase are also acknowledged at this point. That set of guidance can be found under **http://ec.europa.eu/clima/policies/ets/benchmarking/documentation_en.htm**

All EU legislation is found on EUR-Lex: **http://eur-lex.europa.eu/**

[7] This list is at the current stage non-exhaustive. Further templates may be added later.

# 2 CEMS IN THE MRR

## 2.1 Measurement based approaches

Compared to the MRG 2007, the provisions for measurement based methodologies have been significantly updated.

In contrast to the calculation based approaches, the greenhouse gases in the installation's off-gases are themselves the object of the measurement in the measurement based approaches. This is difficult in installations with many emission points (stacks) or indeed impossible where fugitive emissions[8] have to be taken into account. There can also be complications where biomass containing source streams are involved. On the other hand, the strength of the measurement based methodologies is the independence of the number of different fuels and materials applied (e.g. where many different waste types are combusted), and their independence of stoichiometric relationships (this is why $N_2O$ emissions usually have to be monitored in this way).

The MRR applies the premise that with current equipment it is not possible to continuously measure the biomass fraction of the emitted $CO_2$ with sufficient reliability. Therefore the MRR requires any biomass to be determined by a calculation based approach for subtracting it from the total emissions determined by measurement. However, subject to the scientific progress expected, future updates of the MRR could look to include further provisions for determining biomass by measurement[9].

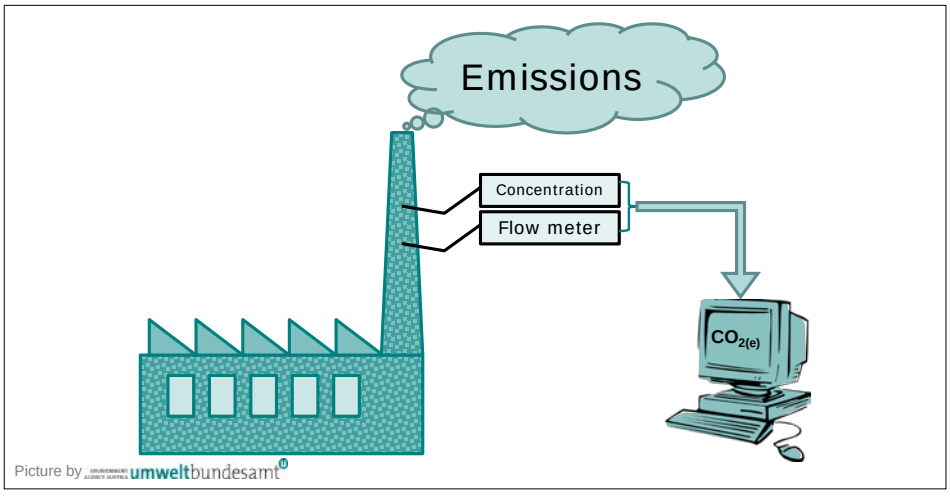


*Figure 1: Schematic description of a continuous emission measurement system (CEMS).*

[8] Fugitive emissions are emissions which are not led through a duct, such as emissions from open furnaces, or leakages from pipeline systems.

[9] See guidance document No. 3 on biomass issues for further options to use more flexible ways of determining biomass fraction.

The application of CEMS (Continuous Emission Measurement Systems[10]) always requires two elements:

- Measurement of the GHG concentration[11]; and
- Volumetric flow of the gas stream where the measurement takes place.

According to Article 43 of the MRR, the emissions are first to be determined for each hour[12] of measurement from the hourly average concentration and the hourly average flow rate. Thereafter all hourly values of the reporting year are summed up for the total emissions of that emission point. Where several emission points are monitored (e.g. two separate stacks of a power plant), this data aggregation is carried out first for each source separately, before adding the emissions of all sources to result in the total emissions[13].

## 2.2 General requirements for CEMS

In addition to what has been outlined in section 2.1 about measurement based methodologies, further points are to be taken into account:

- In contrast to the MRG 2007, CEMS are now put on equal footing with calculation based approaches, i.e. it is not necessary any more to demonstrate to the CA that using a CEMS achieves greater accuracy than the calculation approach *using the most accurate tier* approach. However, minimum tier requirements have been defined implying uncertainty levels comparable to those of calculation approaches are applicable. Thus, the operator must demonstrate to the CA that those tiers can be met with the CEMS proposed. Table 1 gives an overview on defined tiers for measurement based approaches.
- The measurement based emissions must be corroborated using a calculation based approach. However, no specific tiers are required for this calculation. Thus, this is a considerable simplification compared to the MRG 2007, where at least lower tiers had to be applied.
  Due to the non-stoichiometric nature of $N_2O$ emissions from nitric acid production, no corroborating calculation is required for those emissions.
- Carbon monoxide (CO) emitted to the atmosphere shall be treated as the molar equivalent amount of $CO_2$ (Article 43(1))[14].
- Concentration measurements may be difficult in gas streams containing very high $CO_2$ concentrations. This is in particular important for measure-

[10] Article 3(39) of the MRR defines: 'continuous emission measurement' means a set of operations having the objective of determining the value of a quantity by means of periodic measurements, applying either measurements in the stack or extractive procedures with a measuring instrument located close to the stack, whilst excluding measurement methodologies based on the collection of individual samples from the stack.

[11] This may need additional corrections, such as for moisture content.

[12] Pursuant to Article 44(1), operators shall use shorter periods than an hour, where this is possible without additional costs. This takes account of the fact that many measurement systems generate automatically half-hourly values due to other requirements than the MRR. In such case, the half-hourly values are used.

[13] "Total" here means total of all emissions determined by CEMS. This does not exclude that further emissions from other parts of the installation are determined by calculation approaches.

[14] This implies that also the amount of CO emitted needs to be measured.

ment of $CO_2$ transferred between installations for the capture, pipeline systems for the transport and installations for geological storage of $CO_2$. In such cases $CO_2$ concentrations may be determined indirectly, by determining the concentration of all other constituents of the gas and subtracting them from the total (Equation 3 in Annex VIII of the MRR).

- Flue gas flow may be determined either by direct measurement, or by a mass balance[15] using only parameters which are easier to measure, namely input material flows, input airflow and concentration of $O_2$ and other gases which need to be measured also for other purposes.
- The operator must ensure that the measurement equipment is suitable for the environment in which it is to be used, and regularly maintained and calibrated. Nevertheless the operator must be aware that equipment may fail once in a while. Therefore Article 45 outlines how data from missing hours are to be conservatively replaced. The operator has to make provisions for such data substitution when developing the monitoring plan[16].
- Operators must apply EN 14181 ("Stationary source emissions – Quality assurance of automated measuring systems") for quality assurance. This standard requires several activities:
  - QAL 1: Testing whether the CEMS is meeting the specified requirements. For this purpose EN 14956 ("Air quality. Evaluation of the suitability of a measurement procedure by comparison with a required uncertainty measurement") and EN 15267-3 ("Air quality – Certification of automated measuring systems – Part 3: Performance criteria and test procedures for automated measuring systems for monitoring emissions from stationary sources") are to be used. (→ section 3.3.1)
  - QAL 2: Calibration and validation of the CEM; (→ section 3.3.2)
  - QAL 3: Ongoing quality assurance during operation; (→ section 3.3.3)
  - AST: Annual surveillance test (→ section 3.3.4)

  According to the standard, QAL 2 and AST are to be performed by accredited laboratories, QAL 3 is performed by the operator. Competence of the personnel carrying out the tests must be ensured.

  This standard does not cover quality assurance of any data collection or processing system (i.e. IT systems). For those the operator has to ensure appropriate quality assurance by separate means, including in accordance with Articles 58(3) and 60 of the MRR.
- Another standard to be applied is EN 15259 ("Air quality – Measurement of stationary source emissions – Requirements for measurement sections and sites and for the measurement objective, plan and report")
- All other methods applied in the context of the measurement based approach should be based also on EN standards. Where such standards are not available, the methods shall be based on suitable ISO standards,

[15] Article 43(5) allows the use of "a suitable mass balance, taking into account all significant parameters on the input side, including for $CO_2$ emissions at least input material loads, input airflow and process efficiency, as well as on the output side including at least the product output, the $O_2$, $SO_2$ and $NO_x$ concentration".

[16] In accordance with point (4)(a)(ii) of section 1 of Annex I of the MRR, the monitoring plan must contain: "the method for determining whether valid hours or shorter reference periods for each parameter can be calculated, and for substitution of missing data in accordance with Article 45".

standards published by the Commission or national standards. Where no applicable published standards exist, suitable draft standards, industry best practice guidelines or other scientifically proven methodologies shall be used, limiting sampling and measurement bias.

The operator shall consider all relevant aspects of the continuous measurement system, including the location of the equipment, calibration, measurement, quality assurance and quality control.

- The operator shall ensure that laboratories carrying out measurements, calibrations and relevant equipment assessments for continuous emission measurement systems (CEMS) shall be accredited in accordance with EN ISO/IEC 17025 for the relevant analytical methods or calibration activities. Where the laboratory does not have such accreditation, the operator shall ensure that equivalent requirements of Article 34(2) and (3) are met.

*Table 1: Tiers defined for CEMS (see section 1 of Annex VIII of the MRR), expressed using the maximum permissible uncertainties for the annual average hourly emissions.*

| | **Tier 1** | **Tier 2** | **Tier 3** | **Tier 4** |
|---|---|---|---|---|
| $CO_2$ emission sources | ± 10% | ± 7.5% | ± 5% | ± 2.5% |
| $N_2O$ emission sources | ± 10% | ± 7.5% | ± 5% | N.A. |
| $CO_2$ transfer | ± 10% | ± 7.5% | ± 5% | ± 2.5% |

## 2.3 $N_2O$ emissions

Section 16 of Annex IV of the MRR deals with determining $N_2O$ emissions from certain chemical production processes, which are covered by Annex I of the EU ETS Directive (production of nitric acid, adipic acid, glyoxal and glyoxylic acid), or which may be unilaterally included pursuant to Article 24 of the Directive (production of caprolactam). $N_2O$ emitted from the activity "combustion of fuel" is not covered. $N_2O$ emissions usually have to be determined using a measurement based approach.

In addition to the points mentioned under sections 2.1 and 2.2, the following specific points should be noted:

- In subsection B.3 of section 16 of Annex IV specific requirements for determining the flue gas flow are given. Where needed, the oxygen concentration must be measured in accordance with subsection B.4.
- Subsection B.5 specifies requirements for *calculation* of $N_2O$ emissions in the case of specific periods of unabated $N_2O$ emissions (e.g. when the abatement system fails) and where measurement is technically not feasible.

For calculating $CO_{2(e)}$ emissions from $N_2O$ emissions, the operator shall use the following formula:

$$Em = Em(N_2O) \cdot GWP_{N_2O} \quad (1)$$

Where

*Em* ..... *emissions expressed as* t $CO_{2(e)}$

*Em($N_2O$)* .....emissions of $N_2O$ in tonnes

*$GWP_{N2O}$* ..... Global warming potential of $N_2O$ as listed in MRR Annex VI section 3 Table 6.

## 2.4 Transferred / inherent $CO_2$ and CCS

The MRR has brought a considerable change compared to the MRG 2007 where "transferred $CO_2$" is concerned.

Under the new rules, $CO_2$ being not emitted, but transferred out of an installation may be subtracted from that installation's emissions only if the receiving installation is one of the following (Article 49(1)):

- a capture installation for the purpose of transport and long-term geological storage in a storage site permitted under Directive 2009/31/EC;
- a transport network with the purpose of long-term geological storage in a storage site permitted under Directive 2009/31/EC;
- a storage site permitted under Directive 2009/31/EC for the purpose of long-term geological storage.

In all other cases, the $CO_2$ transferred out of the installation counts as emission of the originating installation.

In order to make the calculation consistent in the case of a "CCS chain" (i.e. several installations together performing the capture, transport and geological storage of $CO_2$), the receiving installation has to add that $CO_2$ to its emissions (see sections 21 to 23 of Annex IV of the MRR), before it may again subtract the amount transferred to the next installation or to the storage site. Thus, CCS installations are monitored using a form of mass balance approach, where some of the $CO_2$ entering or leaving the installation (i.e. at the transfer points) is monitored using continuous measurement systems.

For these continuous measurement systems (CMS) the rules specified for CEMS (→sections 2.1 and 2.2) apply *mutatis mutandis*, i.e. the same with only those things changed which need to be changed (the word "emissions" has to be omitted from CEMS). In particular the provision of "indirect" $CO_2$ measurement[17] is applicable. The highest tier (tier 4) has to be used, unless unreasonable costs or technical infeasibility are demonstrated. As a special provision, it is important to clearly identify the transferring and receiving installations in annual emissions report, using the unique identifiers which are also used in the ETS registry system.

For monitoring at the interface between installations, the operators may choose whether the measurement is carried out by the transferring or receiving installation (Article 48(3)). Where both carry out measurements and where the results deviate, the arithmetic mean shall be used. If the deviation is higher than the uncertainty approved in the monitoring plan (MP), a value with conservative adjustment is to be reported by the operators, which needs the approval of the competent authority.

[17] I.e. determining the concentration of all other constituents of the gas and subtracting them from the total (Equation 3 in Annex VIII of the MRR).

# 3 QUALITY ASSURANCE LEVELS (QAL)

## 3.1 Overview of the relevant standards

The following standards are required for application of CEMS in accordance with the MRR:

- EN 14181 ("Stationary source emissions – Quality assurance of automated measuring systems") for quality assurance of the CEMS[18].
    - Supporting guidance can be found in CEN/TR 15983:2010 ("Stationary source emissions – Guidance on the application of EN 14181:2004")
- EN 15259 ("Stationary source emissions – Requirements for the measurement sections and sites and for the measurement objective, plan and report"): This standard describes how to achieve accurate and reliable results in emission testing, including in relation to sampling position.

In order to apply these standards correctly, further standards are important:

- EN ISO 14956 ("Air quality – Evaluation of the suitability of a measurement procedure by comparison with a required measurement uncertainty"): This is required because it is referenced by EN 14181. It describes the QAL 1 procedure, which is required by EN 14181.
- EN 15267-3 ("Air quality – Certification of automated measuring systems – Part 3: Performance criteria and test procedures for automated measuring systems for monitoring emissions from stationary sources"): Again, this standard is required for correctly carrying out the QAL 1 procedure. It should be noted that EN 15267-3 is an application of EN ISO 14956 and is now often used to define testing procedures for CEMS and the determination of uncertainties in the measurement.

For the determination of the flue gas flow, the following standards are important:

- EN ISO 16911 ("Stationary source emissions - Manual and automatic determination of velocity and volume flow rate in ducts")
    - Part 1: Manual reference method (EN ISO 16911-1)
    - Part 2: Automated measuring systems (EN ISO 16911-2)

  EN ISO 16911-2 applies EN 14181, EN 15267-3, EN ISO 14956 and EN 15259 as normative (i.e. mandatory) references.

Further helpful standards, which are not explicitly mentioned anywhere else in this Guidance Document, are:

- Carbon dioxide: ISO 12039 ("Stationary source emissions - Determination of carbon monoxide, carbon dioxide and oxygen - Automated methods")
- Moisture, as a peripheral measurement under EN 14181: EN 14740 ("Stationary source emissions - Determination of the water vapour in ducts")

[18] Note that relevant aspects of ISO 12039:2001 ("Stationary source emissions -- Determination of carbon monoxide, carbon dioxide and oxygen -- Performance characteristics and calibration of automated measuring systems") may also be considered.

- Nitrous oxide, for subsection B.2 of section 16 Annex IV: EN ISO 21528 ("Stationary source emissions - Determination of the mass concentration of dinitrogen monoxide ($N_2O$) - reference method: Non-dispersive infrared method")
- Nitrogen dioxide, for Article 43(5), point (a): EN 14792 ("Stationary source emissions - Determination of mass concentration of nitrogen oxides ($NO_x$) - reference method: chemiluminescence")
- Oxygen, for subsection B.4 of section 16 Annex IV and as a peripheral measurement under EN 14181 and for Article 43(5), point (a): EN 14789 ("Stationary source emission - Determination of volume concentration of oxygen ($O_2$) - Reference method – Paramagnetism")
- Sulphur dioxide, for Article 43(5), point (a): EN 14791 ("Stationary source emissions - Determination of mass concentration of sulphur dioxide - reference method")

The latest CEN Standards can be downloaded from the following CEN website:

**http://www.cen.eu/cen/Sectors/TechnicalCommitteesWorkshops/CENTechnicalCommittees/Pages/Standards.aspx?param=6245&title=Air%20quality**

## 3.2 How to demonstrate compliance with tier requirements

**Determination of the uncertainty to be compared with the tier requirements in the MRR**

For calculating (average hourly, kg/h) $CO_2$ emissions the MRR requires the use of equation 2 in Annex VIII of the MRR:

$$GHG\ emissions_{av\ hourly} = \frac{\sum_i GHG\ conc_{hour\ i}[g/Nm^3] \cdot flue\ gas\ flow_i\ [Nm^3/h]}{hours\ of\ operation \cdot 1000} \quad (2)$$

Values for the concentration and the flue gas flow shall be consistent and relate to the same conditions, e.g. to dry flue gas at standard conditions.

The uncertainty associated with the determination of the concentration will have to be combined with the uncertainty associated with the determination of the flue gas flow:

$$u_{av\ hourly\ emissions} = \sqrt{u_{GHG\ concentration}^{\ 2} + u_{flue\ gas\ flow}^{\ 2}} \quad (3)$$

Please note that the uncertainty according to the MRR always corresponds to a 95% confidence interval. The uncertainty assessment has to be carried out ac-

cordingly, i.e. multiply the combined standard uncertainty with a coverage factor of 2 to obtain the expanded uncertainty.[19]

> The resulting expanded uncertainty associated with the average hourly emissions is the value which needs to be compared to the uncertainty associated with the tier required by the MRR for the relevant emission source (see section 1 of Annex VIII of the MRR and Table 1 in section 2.2 of this document)

As a first step, it is recommended to perform this calculation using the uncertainty associated with the determination of the concentration obtained by the QAL1 procedure (see section 3.3.1). This preliminary uncertainty assessment can already be done before buying the equipment. For some CEMS this uncertainty is readily available where a QAL1 calculation is already attached to an EN 15267-3 certification.

If the CEMS already fails to meet the uncertainty threshold of the tier required by the MRR using the uncertainty obtained by QAL1, the operator should either:

- use another CEMS, OR
- demonstrate that other CEMS meeting the required tier are also not available (i.e. it is technically not feasible) or they would incur unreasonable costs[20]

However, the uncertainty associated with the determination of the concentration obtained by the QAL2 procedure (see section 3.3.2) is the relevant input parameter for demonstrating compliance with the MRR. Only if the CEMS also fails to meet the uncertainty threshold of the tier required by the MRR, obtained by QAL2, do the bullet points above then become mandatory. Note that QAL2 does not take into consideration uncertainty resulting from drift since this is addressed by QAL1 (see section 3.3.1) and QAL3 (see section 3.3.3).

**The application of EN 14181**

The main application of EN 14181 but also of all other standards mentioned in that standard is the continuous emission monitoring of air pollutants, e.g. $NO_x$, $SO_2$,... Since the same physical measurement principles and required quality assurance can be applied for measuring $CO_2$ or $N_2O$ continuously, the MRR also requires the provisions of this standard to be followed. However, there are some important differences between CEMS for air pollutants and for GHGs which impact QAL1 procedures, but are also important for the rest of this guidance document.

**Difference between application of CEMS for air pollutants and for greenhouse gases**

The main differences are:

[19] For details regarding the general rules of error propagation please see section 8.2 of Guidance Document No. 4 on uncertainty assessment. For where to find other guidance documents please see section 1.3.

[20] To determine whether costs can be considered unreasonable, please see section 4.6.1 of Guidance Document 1 for further information or consider using the tool for unreasonable costs. Both are provided on DG CLIMA's homepage: http://ec.europa.eu/clima/policies/ets/monitoring/documentation_en.htm

- There is no emission limit value (ELV) associated with the emissions of greenhouse gases (GHGs) laid down in the MRR. In EN 14181 the ELV serves as a reference value for the QALs. Therefore a suitable substitute must be defined for the application of this standard for measuring GHGs. Article 59[21] requires the use the annual average hourly concentration of the greenhouse gas as the substitute for the ELV.
- For air pollutants the parameter of interest is the concentration of the particular air pollutant in the flue gas (e.g. in mg/Nm³) to demonstrate compliance with relevant legislation. For calculating GHGs emission under the MRR the parameter of interest is the (average hourly) mass-flow of emissions (e.g. in kg/h), i.e. concentration of the GHG multiplied by the flue gas flow (see formula (2) above).

**Determination of the flue gas flow**

Article 43(5) leaves the operator with the following two options to determine the flue gas flow:

a) calculation by means of a suitable mass balance, taking into account all significant parameters on the input side, including for $CO_2$ emissions at least input material loads, input airflow and process efficiency, as well as on the output side including at least the product output, the $O_2$, $SO_2$ and $NO_x$ concentration;

b) determination by continuous flow measurement at a representative point.

In the case of a), the uncertainty related to the flue gas flow will have to be calculated by error propagation taking at least into account the listed input and output parameters of the mass balance. Guidance on how to perform those calculations can be found in Annex III of Guidance Document 4.

In the case of b), assessing the representativeness of the measurement point(s) with regards to the flue gas needs to be based on the provisions in EN 15259, similar to finding representative points for the concentration profile in the flue gas. It is recommended to use the EN ISO 16911-2 which follows, as far as possible, the structure of EN 14181.

In any event, peripheral measurements and calculations such as flue gas flow, oxygen and moisture are not covered by the QAL procedures of EN 14181 or EN 14956. Therefore, quality assurance related to the determination of the flue gas flow is only covered by the more general requirements in Articles 58 and 59. In particular, Article 59(1) requires the operator that all relevant measuring equipment involved has to be calibrated, adjusted and checked at regular inter-

[21] Article 59(2): "With regard to continuous emission measurement systems, the operator shall apply quality assurance based on the standard Quality assurance of automated measuring systems (EN 14181), including parallel measurements with standard reference methods at least once per year, performed by competent staff.
Where such quality assurance requires emission limit values (ELVs) as necessary parameters for the basis of calibration and performance checks, the annual average hourly concentration of the greenhouse gas shall be used as a substitute for such ELVs. Where the operator finds a non-compliance with the quality assurance requirements, including that recalibration has to be performed, it shall report that circumstance to the competent authority and take corrective action without undue delay"

vals including prior to use, and checked against measurement standards traceable to international measurement standards, where available. Article 58(3)(a) requires an appropriate procedure for this quality assurance to be in place. However, in the case of a), the QAL procedures of EN 14181 can still be applied for certain parameters such as $NO_x$ and $SO_2$. For the flue gas flow, again it is recommended to use EN ISO 16911-2 for the implementation of Articles 58 and 59.

## 3.3 Overview of the QALs

Table 2 gives an overview of the quality assurance levels (QALs) and information about the timelines and responsibilities.

*Table 2: Overview of the QALs*

| | QAL1 | QAL2 | QAL3 | AST |
|---|---|---|---|---|
| **When?** | Before installation of the CEMS | Installation and calibration | During operation | Starting one year after QAL2 |
| **Frequency** | Once | At least every five years* | Continuously[22] | Annually |
| **Who?** | Operator | Accredited laboratory | Operator | Accredited laboratory |
| **Relevant standards** | EN 14181, EN ISO 14956, EN 15267-3 | EN 14181, EN 15259 | EN 14181 | EN 14181, EN 15259 |

* See section 3.3.2 for more detail

### 3.3.1 QAL1

The quality assurance level 1 (QAL1) procedure is used to demonstrate the potential suitability of the CEMS before it is installed. This quality assurance level is not covered by EN 14181 but by EN ISO 14956. The CEMS has to meet the requirements in EN ISO 14956. Furthermore, EN 15267-3 provides the detailed procedures covering the QAL1 requirements of EN 14181 and the input data for QAL3. By using these standards it has to be proven that the total uncertainty of the results obtained from the CEMS meets the uncertainties required by the MRR.

In QAL1 the total uncertainty is calculated by summing all the relevant uncertainty components arising from the individual performance characteristics. This includes taking account of all (major) sources of uncertainty (influence quantities) contributing to the uncertainty associated with the value of interest, i.e. the GHG concentration in this case. The total uncertainty of the measurement value

[22] Please note that the term “continuously“ does not necessarily mean that the QAL3 has to been done every few seconds or even shorter periods. It just means that QAL3 is an on-going quality control which is done in parallel to normal operation but may also be done on a weekly or monthly basis depending on the relevant CEMS model.

is then determined by calculating the combined uncertainty by the means of error propagation.

Information regarding the performance characteristics of the CEMS can be obtained e.g. from the specifications of its manufacturer or from other tests performed, e.g. certification systems under type approval schemes or other national schemes. An instrument-type that has been appropriately tested in accordance with EN 15267-3 can then be taken as automatically meeting QAL1 (as long as the scope of the EN 15267-3 tests confirms the instrument suitable for the type of process(s) at the destination installation). In those cases the QAL1 results accompanying the CEMS certification can be used without further calculations.

If such data is not available for a particular CEMS it may be substituted by data provided in the manufacturer's specifications of similar CEMS.

As part of a preliminary uncertainty assessment, the uncertainty obtained from QAL1, amended by the uncertainty associated with the determination of the flue gas flow, might be compared with the uncertainty required by the MRR (see section 3.2).

Please note that this only serves as an indicator to assess the suitability of the CEMS but it is not sufficient to demonstrate compliance with the MRR (see section 3.3.2).

### 3.3.2 QAL2

EN 14181 requires that only measurements obtained with a calibrated measuring instrument shall be used. Therefore, QAL2 tests have to be performed on suitable CEMS, i.e. instruments having passed QAL1 testing and that have been correctly installed and commissioned. For correct installation the MRR requires the use of EN 15259. Correct positioning of the measurement equipment is of utmost importance to obtain representative values for the concentration and flue gas flow. Article 42(2) of the MRR requires all measurements, calibrations and relevant equipment assessments for CEMS to be performed by laboratories accredited in accordance with EN ISO/IEC 17025 for the relevant analytical methods or calibration activities, or meeting equivalent requirements according to Article 34(2) and (3).

The QAL2 calibration function is established from the results of a number of parallel measurements performed with a Standard Reference Method (SRM). This involves a minimum of 15 valid measurements in accordance with section 6.3 of EN 14181. Again, EN 15259 is to be used to determine appropriate locations for sampling using the SRM. The SRM shall be placed as close as possible to the CEMS. For parallel flow rate measurements the use of EN ISO 16911-1 is recommended.

It is not sufficient to use the measurement of reference materials (e.g. gases of known composition = "span gases") to obtain the calibration function. This is because potentially interfering flue gas components and the representativeness of sampling points cannot be assessed appropriately by using reference materials alone.

It is important that the GHG concentrations during calibration are as close as possible to the expected concentrations during normal operating conditions. Note that as described for QAL1, EN 14181 refers to ELVs. However, ELVs are not set in relation to EU ETS GHGs. The MRR accommodates this by stating that under such circumstances, the annual average hourly concentration of the GHG shall be used as a substitute for the ELV. There is added relevance in connection with measurement of $N_2O$ emissions since concentrations during periods without abatement differ significantly from those during normal operations. In this case, it may be necessary to operate more than one CEMS, if the range and calibration of a single instrument (CEMS) is not sufficient to cover both concentrations within the required uncertainty.

The variability is then calculated as the standard deviation of the differences between each concentration value obtained by the CEMS and corresponding values obtained by the SRM measured in parallel (see sections 6.6. and 6.7 of EN 14181 for more details). EN 14181 states that the CEMS passes the variability test if the following condition is fulfilled:

$$s_D \leq \sigma_0 \cdot k_V \qquad (4)$$

Where

$s_D$ ..... standard deviation of the differences between CEMS values and corresponding SRM values in parallel measurements

$\sigma_0$ ..... uncertainty required by relevant legislation

$k_V$ ..... test value for variability (based on a $\chi^2$-test, with a β-value of 50%, for N numbers of paired measurements)

However, this is not sufficient in the case of CEMS applied to GHGs in accordance with the MRR, where the uncertainty associated with the flue gas flow also needs to be taken into account. As a consequence, the standard deviation calculated above divided by the test value $k_V$ only has to be used as the "$u_{GHG\ concentration}$" value[23] in equation (3) in section 3.2.

Therefore, the variability of the measured values obtained with the CEMS compared to the SRM, amended by the uncertainty associated with the determination of the flue gas flow, is the uncertainty to be compared with the uncertainty required by the MRR.

Pursuant to EN 14181 a QAL2 procedure shall be performed at least every 5 years for every CEMS or more frequently if so required by legislation or by the competent authority.

Furthermore, a QAL2 procedure shall be performed in case of:

- any major change in plant operation (e.g. change in flue gas abatement system or change of fuel), OR

[23] Note that this uncertainty currently is only the standard uncertainty corresponding to a 68% confidence interval. Conversion into the expanded uncertainty (corresponding to a 95% confidence interval) will be done after combination with the uncertainty associated with the determination of the flue gas flow by application of a coverage factor of 2 (see equation (3)).

- any major changes or repairs to the CEMS, which will influence the results obtained significantly.

The calibration function is valid in the range from zero to the highest SRM value at standard conditions plus an extension of 10%. Additionally, the competent authorities may accept alternative provisions when applying the valid calibration range, e.g. a competent authority may allow an extension of the valid calibration range by using surrogates (see chapter 5). It is recommended that process operators consult their competent authorities for guidance on this subject.

EN 14181 requires the validity of the valid calibration range to be evaluated by the operator on a weekly basis. A full new calibration (QAL2) shall be performed, reported and implemented within 6 months, if any of the following conditions occur:

- more than 5 % of the number of measured values from the CEMS, calculated weekly, are outside the valid calibration range for more than 5 weeks in the period between two ASTs or QAL2 tests, OR
- more than 40 % of the number of measured values from the CEMS, calculated weekly, are outside the valid calibration range for more than one or more weeks.

Note that for periods with missing data or data outside the valid calibration function surrogate data has to be provided as described in chapter 5.

### 3.3.3 QAL3

After the acceptance (QAL1) and calibration (QAL2) of the CEMS, the QAL3 procedure is described as ongoing quality control. Its objective is to demonstrate that the CEMS is stable and does not drift significantly, and it is therefore in control during its operation so that it continues to function within the uncertainties required by the MRR. This procedure is used to check whether drift and precision determined during the QAL1 remain under control. This is achieved by calculation of the standard deviation at zero and span level[24] and the use of control charts (e.g. Shewart, CUSUM). More details on the use of control charts and calculating the standard deviation, including influencing parameters to be taken into account, can be found in section 7.2 and Annex C of EN 14181 and in its supporting document CEN/TR 15983.

Section 7.3 of EN 14181 describes how the standard deviation ($s_{AMS}$) can be regularly calculated taking into account the observed drift at zero and span levels. The results, combined with the uncertainty associated with the flow rate (see formula (2) in section 3.2), allow checking regularly whether the required uncertainty is still met.

Section 8.3.2 of CEN/TR 15983 explains that the frequency of zero and span checks should be based on the maintenance interval. This interval is determined during QAL1, e.g. during performance testing of the CEMS for approval

[24] In EN 15267 part 3, the span point is defined as the “value of the output quantity (measured signal) of the AMS for the purpose of calibrating, adjusting, etc. that represents a correct measured value generated by reference material between 70 % and 90 % of the range tested”

to the requirements of standards such as EN 15267-3. It describes the maximum allowable interval between zero and span checks. Based on the type of control charts used and the frequency applied, decision rules for taking corrective action (e.g. adjustment of the CEMS) will be prepared. This allows taking appropriate corrective action in a timely manner.

*Example* (see example in section D.1 of CEN/TR 15983): for a Shewart control chart action limits for taking corrective action are defined as twice the $s_{AMS}$ around the zero and span measurement reference values. Decision rules for taking corrective actions may be e.g. when three consecutive data points are beyond one of the action limits or eight consecutive points are on the same side of the center line etc.

It is recommended to perform zero and span checks with a frequency higher than the maintenance interval. A low frequency imposes a higher risk for the CEMS being out of control for longer periods. Please note that CEMS being out of control for longer periods will more likely result in larger data gaps that will need to be closed by making conservative estimates.

In many CEMS the QAL3 tests are conducted automatically within an instrument. Some of these CEMS also correct zero point and reference point when the required performance is not met anymore. In any event, the implementation and performance of the QAL3 procedures given in the EN 14181 are the responsibility of the plant owner. For MRR purposes the plant owner corresponds to the operator of the installation.

### 3.3.4 Annual Surveillance Test (AST)

The annual surveillance test checks the variability and the validity of the calibration function annually. Its purpose is for the measurement equipment to demonstrate:

- that it functions correctly and its performance remains valid, AND
- that its calibration function and variability remain as previously determined.

This procedure is similar to QAL2. In addition to the check of the calibration function, a check of linearity, interferences and zero & span drift are part of the functional test. The AST check of the validity of the calibration function has to involve at least five parallel measurements between the CEMS and the SRM.

Note that the EN 14181 requires the AST to be performed by an experienced testing laboratory. However, Article 42(2) of the MRR is more stringent by requiring that all measurements, calibrations and relevant equipment assessments for CEMS are performed by laboratories accredited in accordance with EN ISO/IEC 17025 for the relevant analytical methods or calibration activities, or meeting equivalent requirements according to Article 34(2) and (3).

# 4 CORROBORATING WITH CALCULATION OF EMISSIONS

Article 46 requires the operator to corroborate emissions determined by CEMS by calculating the annual emissions of each considered greenhouse gas for the same emission sources and source streams[25]. Those corroborating results do not have to be based on tier compliant methodology. However, in many cases default values or metering of source streams will be available anyway. In such cases it is recommended to use, to the extent possible, the standard or mass balance methodology pursuant to Articles 24 and 25.

Article 46 is further supported by point (iii) of Article 62(1)(c) which requires the internal review and validation of data associated with the comparison of the results obtained by CEMS and corroborating calculations to be covered by a written procedure pursuant to Article 58(3)(d). A summary of this procedure has to be included in the monitoring plan. This summary could be as follows:

| **Item according to Article 12(2)** | **Possible content (examples)** |
|---|---|
| Title of the procedure | Review & Validation of CEMS data |
| Traceable and verifiable reference for identification of the procedure | ETS_Management_CEMS_R&V |
| Post or department responsible for implementing the procedure and the post or department responsible for the management of the related data (if different) | HSEQ deputy head of unit |
| Brief description of the procedure | • Responsible person calculates the annual quantity of lignite consumed as the sum of all invoiced amounts.<br>• The annual amount of lignite consumed is multiplied by the NCV and EF laid down in Annex VI of the MRR to obtain the annual emissions.<br>• If annual emissions obtained by calculation deviate by more than 5% from annual emissions obtained by CEMS the responsible person checks with responsible person for maintaining CEMS equipment results for each week or even shorter periods.<br>• Upon the outcome of these checks appropriate corrective action is taken. |
| Location of relevant records and information | Electronically: “Z:\ETS_MRV\CEMS\corr_calc.xlsx” |
| Name of the computerised system used, where applicable | Standard office software and normal network drives |
| List of EN standards or other standards applied, where relevant | n.a. for corroborating calculations, EN 14181/15259/14956/15267-3 for CEMS data |

[25] Article 46: “*The operator shall corroborate emissions determined by a measurement-based methodology, with the exception of nitrous oxide (N2O) emissions from nitric acid production and greenhouse gases transferred to a transport network or a storage site, by calculating the annual emissions of each considered greenhouse gas for the same emission sources and source streams. The use of tier methodologies shall not be required.*”

# 5 MISSING DATA

Article 45 lays down several requirements for cases where data are missing or lost. The following cases are covered in this Article:

- Valid hour or shorter reference periods[26] in accordance with Article 44(1) cannot be provided for one or more parameters
  - Valid hour or shorter reference periods cannot be provided for parameters directly measured as concentration. In these cases substitution values have to be calculated as the sum of an average concentration and twice the standard deviation. Please note that these two parameters need to reflect the whole reporting period unless another reference period is more appropriate and reflecting the specific circumstances. E.g. if an installation measuring $N_2O$ observes a data gap of the concentration and at the same time the abatement equipment was out of operation, the substitution values have to reflect operation conditions during non-abatement periods.
  - Valid hour or shorter reference periods cannot be provided for parameters other than concentration, e.g. flue gas flow.
    In this case substitute values of that parameter through a suitable mass balance model or an energy balance of the process have to be obtained. In the case of missing reference periods for the flue gas flow the aspects related to case a) in section 3.2 have to be considered.
    The operator shall validate the results by using the remaining measured parameters of the measurement-based methodology and data at regular working conditions considering a time period of the same duration as the data gap. Please note that the larger the number of missing reference periods the more demanding an uncertainty assessment associated with the mass or energy balance substitutes will have to be to still demonstrate compliance with the tier required by the MRR.

  For both cases a procedure on how to close those data gaps has to be established in accordance with Article 65. General guidance can be found in the TF's paper on conservative estimates and closing data gaps *[to be referenced here once it is finalised].*
- In the case of any part of the CEMS being out of operation for more than five consecutive days, Article 45(1) requires the operator to inform the competent authority without undue delay. The intended corrections or corrective actions in accordance with Article 63 have to be covered by a procedure in accordance with Article 58(3)(e). A summary of this procedure has to be part of the monitoring plan approved by the competent authority.

[26] According to Article 44(1), hourly or shorter reference periods shall be calculated by using all data points available in the hour or shorter reference period.

# 6 VERIFICATION OF CEMS

The AVR requires the verifier to carry out certain activities in the process analysis. These activities include checking the implementation of the monitoring plan, performing substantive data testing and checking specific monitoring and reporting issues such as the on-going validity of the information used to calculate compliance with the uncertainty levels set out in the approved MP. The key guidance note on process analysis (KGN II.3) provides guidance on these specific activities.

These activities should be carried out regardless of whether a calculation or measurement based methodology is applied. The verifier's risk analysis remains of key importance to both, but the focus and specifics of the checks on the control activities, procedures and the plausibility checks on the data will be different in the case of a measurement based methodology. This chapter aims to describe these specifics, including what a verifier should look for when assessing the application of the EN 14181.

## 6.1 Checking the data flow activities

The verifier has to assess whether the data flow as described in the approved MP meets the actual practice by testing the data flow activities, checking the data trail and following the sequence and interaction of the data flow activities. The verifier traces the data back to the primary sources, checks the existence, consistency and validity of these primary source data, follows each processing step in the data flow and assesses the responsible persons carrying out these data flow activities. Although the primary data sources and process flows are different if a measurement based methodology is applied, the basic requirements of checking the data flow activities are equally applicable. The verifier must carry out the same activities as explained in section 2.1 of KGN II.3.

Examples of specifics that the verifier will consider when checking the data flow of the measurement based methodology include:

- location of stacks/ducts and continuous measurement systems;
- process types and variations (e.g. whether the $CO_2$ or $N_2O$ concentration remains within the valid range[27], review of historical data, meter readings);
- how meter readings are transferred to the data management system;
- diagrams of emission points, location of sampling points;
- calculations and aggregation of data.

[27] $N_2O$ concentrations are particularly susceptible to being outside the valid calibration range during periods without abatement

## 6.2 Checking the control activities

The verifier must test the control activities, based on the verifier's analysis of the inherent and control risks involved. Section 2.2 of KGN II.3 outlines the different control activities and the checks that verifiers carry out on these activities. Application of EN 14181 is a key element in the quality assurance of continuous measurement systems. When checking the control activities the verifier must include certain checks on the application of the QALs and AST.

**QAL1**

The principles and scope of QAL1 are described in section 3.3.1. The verifier should for example check:

- whether a QAL1 has been executed by assessing the report that has been drafted by the manufacturer, supplier or operator of the measurement system;
- whether the conditions in the installation match the conditions covered by the QAL1 assessment;
- whether relevant sources and components of uncertainty have been considered in the uncertainty calculations; e.g. the uncertainty of the $O_2$ analyser if relevant.
- whether the uncertainty associated with the concentration determination, combined with the uncertainty associated with the flow determination concentration determination, meets the uncertainty requirements for the overall emission measurement approved in the MP.

As mentioned in section 3.3.1 some CEMS may have been appropriately tested in accordance with EN 15267-3 and can therefore be taken as automatically meeting QAL1. In those cases the QAL1 results accompanying the CEMS certification can be used without further calculations and the verifier can just check whether the calculation is attached to the certification, the scope of certification is appropriate and the resulting uncertainty complies with the requirements of the approved MP.

**QAL2**

The principles and scope of QAL2 are described in section 3.3.2. The key outcome of QAL2 is the variability of the calibration function (derived in-situ) which allows calculation of the contribution of the concentration measurement to the overall uncertainty and to demonstrate compliance with the tier requirements in the approved MP. Therefore, this procedure is crucial. However, since EN 14181 requires this step to be carried out by a competent laboratory the AVR does not require the verifier to duplicate the work of the laboratory. Instead the correct implementation of that procedure should be checked.

The verifier should for example check:

- whether QAL2 has been executed within the timeframe according to Table 2 (p. 16) of this document (every 5 years) or more frequently in response to other EN 14181 findings (e.g. QAL3), or other requirements;

- whether EN 15259 has been used for installation of the CEMS. Note that the correct installation of the CEMS is a prerequisite for QAL2;
- whether the required functionality tests have been performed and passed;
- whether the testing and calibration results have been documented and whether corrective and preventive actions have been taken into account by the operator as necessary;
- whether the laboratory that performed the QAL2 tests is accredited. If the laboratory is accredited, the verifier checks whether the scope of accreditation covers the areas of relevance to QAL2 testing and EU ETS and whether the certificate is appropriate and valid for the EU ETS reporting period. If a non-accredited laboratory is used or the accreditation does not cover the required scope, the verifier performs the checks described in the A&V FAQs published by the Commission;
- whether the correct calibration function has been programmed in the CEMS;
- whether an appropriate annual average hourly concentration of the greenhouse gas has been used as a substitute for the ELVs for the calibration. There is added relevance in connection with measurement of $N_2O$ emissions since concentrations during periods without abatement differ significantly from those during normal operations (see footnote 27);
- whether any major change in the plant operation or any major change or repair in the CEMS has occurred which affects the appropriateness of the current QAL2 assessment; and whether a new QAL2 procedure has been carried out in that case.

**QAL3**

As mentioned under section 3.3.3, QAL3 entails the establishment and implementation of a procedure that ensures on-going quality control. The verifier should check that the procedure:

- has been correctly implemented throughout the year and is up to date;
- covers the information required of QAL3 by EN 14181;
- is recorded in control charts;
- ensures that results have been properly documented;
- allows for and where necessary has resulted in appropriate action (e.g. adjustment, maintenance, re-calibration) where drift and/or precision is found to be out of control.

**AST**

The verifier should check that an AST report is available for the reported year and assess this report. Similar checks as those relating to the QAL 2 procedure should be performed. This includes for example whether:

- recommendations from previous AST and QAL2 tests have been taken into account;
- whether the correct calibration function has been programmed in the CEMS;

- during the last AST a minimum of five parallel SRM measurements have been carried out evenly distributed over one working day;
- the required functionality tests have been performed and passed;
- the laboratory that performed the AST tests is accredited, whether its accreditation scope covers the areas of relevance of AST testing and EU ETS, and whether the accreditation is valid for the EU ETS reporting period. If these criteria are not met, the verifier performs the checks described in the A&V FAQs.

**Flue gas flow**

The MRR does not mention a specific standard to be used for flow measurement. However, section 3.2 of this guidance document recommends the use of EN 16911. Furthermore, the MRR allows the alternative determination of the flue gas flow by calculation. For further guidance see section 3.2.

The verifier should check whether:

- appropriate standards have been used such as EN 15259 and EN ISO 16911-2 and whether these standards have been applied correctly;
- the continuous flow measurement is representative (if Article 43(5)(b) of the MRR is applied);
- the calculations in the mass balance are correctly applied (in the case of application of Article 43(5)(a) of the MRR): e.g. checking whether the input data in the calculation formulae result in the correct emission data, whether all parameters in the mass balance have been taken into account, performing plausibility checks on the input and output data, checking plausibility of measured values;
- relevant sources and components of uncertainty have been considered in the uncertainty calculations for all relevant parameters (see Article 43(5) of the MRR);
- the validity of the information used for uncertainty calculations can be confirmed, e.g. through calibration reports, service and maintenance reports, manufacturer's specifications;
- the uncertainty associated with the flow determination, combined with the uncertainty associated with the concentration determination, meets the uncertainty requirements for the overall emission measurement approved in the MP.

**Other peripheral measurements and calculations**

As mentioned in section 3.2 peripheral measurements and calculations are not covered by the QAL procedures or EN 14956. The more general requirements on quality assurance apply, which means that the verifier carries out the checks on these quality assurance control activities as described in section 2.2 of KGN II.3.

## 6.3 Checking the procedures

The operator is required to establish and implement certain procedures that are specifically relevant for the measurement based methodology. These include a procedure that ensures a comparison between the CEMS and corroborative calculations; procedures to close data gaps; procedures for internal data review and procedures for corrections and corrective action. As described in section 2.3 of KGN II.3, the verifier checks whether these procedures:

- are present, properly documented and retained;
- contain the information required by EN 14181 and relevant standards as well as the approved monitoring plan;
- have been correctly implemented throughout the year and are up to date;
- are effective to mitigate the inherent and control risks.

## 6.4 Carrying out analytical procedures and data verification as part of substantive data testing

Substantive data testing consists of analytical procedures, data verification and assessing the correct application of the monitoring methodology to detect misstatements and non-conformities. The extent to which this data testing is carried out depends on the outcome of the verifier's risk analysis and the verifier's assessment of the data flow, the control activities and the procedures. More information on these different activities is provided in KGN II.3. Basically the same checks are performed by the verifier when assessing the application of the measurement based methodology and verifying the relevant data.

An additional check that is specifically required for measurement based methodology is outlined in Article 16(2)(g) of the AVR. Verifiers must check the measured values by using the results of the corroborative calculations performed by the operator (see section 4 for the requirements on corroborative calculations).

Examples of CEMS-specific checks that the verifier will make during analytical procedures, data verification and the assessment of the measurement based methodology are:

- checks on what standards are applied and whether these standards are complied with;
- check on representativeness of measurements;
- completeness of hourly data and of substitution data for incomplete hours;
- checks on the calculations and underlying measurements if the flow rate is calculated;
- checks on the calibration and maintenance documentation for flow and concentration measurements;
- checks on whether the correct substitute value has been used if there have been missing data (see section 5);
- checks on whether the CA has been notified in the case of any part of the CEMS being out of operation for more than five consecutive days.

## 6.5 Transfer of $CO_2$ and CCS

Section 2.4 explains the requirements for transferred/inherent $CO_2$ and CCS, including the CEMS rules. Article 17(3) of the AVR contains specific requirements on what a verifier should check in these cases.

In addition to the general requirements on checking the implementation of the monitoring plan and substantive testing the verifier must for example check whether:

- there are differences between the measured values at the transferring and the receiving installation and whether these can be explained by the uncertainty of the measurement systems;
- the correct arithmetic average of measured values has been used in the emission reports of the transferring and receiving installation.

If the measured values at the transferring and the receiving installation cannot be explained by the uncertainty of the measurement systems, the verifier must check whether:

- adjustments were made to align the difference between the measured values;
- these adjustments are conservative and do not lead to an underestimation of emissions or overestimation of transferred $CO_2$ for the transferring installation;
- the CA has approved the adjustments;
- a new QAL2, maintenance or other corrective actions are performed to avoid the same situation in future.

## 6.6 Addressing non-conformities and non-compliance issues

If the verifier identifies anomalous values in the measurement results, non-conformities or non-compliance with EN 14181 and other standards, the verifier should report this to the operator. The operator is then required to correct these or take corrective action. Where approval of the CA is required, the verifier should direct the operator to the CA.

If these issues are not corrected before issuing the verification report to the operator the verifier assesses whether these issues have a material impact on the emission data. In any case, outstanding issues must be reported in the verification report. For more information please see section 3.2.13 and 3.3 of the Explanatory Guidance (EGD I), the key guidance note on the scope of verification (KGN II.1) and the key guidance note on the verification report (KGN II.6).

The verifier can also make recommendations for improvements in the verification report if it identifies areas for improvement in the QAL/ AST or other procedures and control activities.

# 7 ANNEX

## 7.1 Acronyms

EU ETS.....EU Emission Trading Scheme

MRV.....Monitoring, Reporting and Verification

MRG 2007 ..Monitoring and Reporting Guidelines

MRR.....Monitoring and Reporting Regulation (M&R Regulation)

AVR .....Accreditation and Verification Regulation (A&V Regulation)

MP .....Monitoring Plan

Permit .....GHG emissions permit

CIMs .....Community-wide fully harmonised Implementing Measures (i.e. allocation rules based on Article 10a of the EU ETS Directive)

CA .....Competent Authority

AER .....Annual Emissions Report

QAL.....Quality Assurance Level (QAL1 is covered by EN 14956, QAL2 and 3 and AST by EN 14181)

AST.....Annual Surveillance Test

AMS.....Automated Measuring System; this term is used in EN 14181. For MRR purposes equals the term “CEMS”.

$s_{AMS}$.....standard deviation of the CEMS used in QAL3 (see section 7.3 of EN 14181)

CEMS .....Continuous Emission Measurement System

SRM.....Standard Reference Measurement

MS .....Member State(s)

GD .....Guidance document

EGD.....Explanatory Guidance Document

KGN.....Key Guidance Note

TF .....Task Force (M&R Task Force of the EU ETS Compliance Forum)

CCS .....Carbon Capture and Storage

## 7.2 Legislative texts

**EU ETS Directive**: Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, most recently amended by Directive 2009/29/EC. Download consolidated version: **http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2003L0087:20090625:EN:PDF**

**M&R Regulation**: Commission Regulation (EU) No. 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council.
**http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:181:0030:0104:EN:PDF**

**A&V Regulation**: Commission Regulation (EU) No. 600/2012 of 21 June 2012 on the verification of greenhouse gas emission reports and tonne-kilometre reports and the accreditation of verifiers pursuant to Directive 2003/87/EC of the European Parliament and of the Council.
**http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:181:0001:0029:EN:PDF**

**MRG 2007**: Commission Decision 2007/589/EC of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council. The download of the consolidated version contains all amendments: MRG for $N_2O$ emitting activities, aviation activities; capture, transport in pipelines and geological storage of $CO_2$, and for the activities and greenhouse gases only included from 2013 onwards. Download: **http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2007D0589:20110921:DE:PDF**