Technical Guidance Note (Monitoring)

M5

Monitoring of stack gas emissions from medium combustion plants and specified generators

Environment Agency
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Version 1

Foreword

This technical guidance note is one of a series providing guidance on monitoring to regulators, process operators and those with interests in monitoring.

It provides information on how to monitor emissions from medium combustion plants and specified generators.

Feedback

If you have any comments on this technical guidance note please contact our National Customer Contact Centre at:

Email: enquiries@environment-agency.gov.uk

Status of this technical guidance note

This technical guidance note may be subject to review and amendment following its publication. The latest version can be found at: www.mcerts.net.

Contents

1. Medium Combustion Plant Directive and Specified Generator Regulations

This technical guidance note (TGN) has been produced to provide a standardised approach to monitoring stack gas emissions from plants regulated under the Medium Combustion Plant Directive[1] and for other specified generators (SG).

Medium sized combustion plants (MCPs) are a significant source of emissions of air pollutants. Implementation of the MCPD makes an important contribution to improving air quality by providing a means to reduce emissions of SO_2, particulates and NO_2.

MCPs are used to generate heat for large buildings (such as, offices, hotels, hospitals and prisons) and industrial processes, as well as for power generation. Implementing the MCPD will help to reduce air pollution by bringing in emission controls for these combustion plants in the 1-50 MW net rated thermal input range. The MCPD requires all plants in scope to be registered or permitted and sets limits on the levels of pollutants that these plants can emit. It also requires operators to test emissions from their plants to demonstrate compliance with emission limits.

Within the UK, there has been rapid growth in the use of low cost, small scale flexible power (mainly diesel) generators. The MCPD requirements are not sufficient to tackle emissions from the increased use of these generators, so additional generator emissions controls mean that these generators are subject to regulations. These Specified Generator Regulations[2] (SGR) apply controls to combustion plant of up to 50 MW net rated thermal input, which are used to generate electricity.

2. Approach to monitoring

The MCPD states that sampling and analysis of polluting substances and measurements of process parameters, as well as any alternatives shall be based on methods enabling reliable, representative and comparable results. This TGN defines the approach for meeting this requirement. Where available and practical to do so, methods complying with European standards have been specified.

For SO_2 emissions reporting, the MCPD allows other procedures, such as sulphur in fuel analysis, to be used as an alternative to periodic stack gas measurements, provided they are verified and approved by the competent authority (see Annex A).

The MCPD and SGRs specify that emissions monitoring results are standardised to a dry gas, at standard temperature and pressure (273.15K and 101.3kPa). They are also reported to a reference O_2 concentration of 3% for liquid or gaseous fuels, 6% for solid fuels and 15% for engines and gas turbines (further information on reference conditions used in stack emissions monitoring is available from TGN M2[3]).

For larger MCPs, measurements using continuous emissions monitoring systems (CEMs), may be used as an alternative to periodic measurements. This involves using an appropriately certified CEM that is calibrated against parallel periodic measurements, which are carried out by an organisation with accreditation for these measurements. Further information is provided in TGN M20[4].

3. Sample locations

TGN M1[5] describes the requirements for sample locations and facilities for measuring flow, particulates and gas concentrations of stack gas emissions. The requirement for measuring gas concentrations are much simpler than those for measuring flow and particulates. Therefore, where the measurement is of concentrations of gaseous species alone, a sampling location can be chosen that does not have to take into account the requirements to measure flow and particulates. This means requirements on designing a measurement section to measure gas concentrations alone are less stringent than for measuring flow or particulates. Also, provided the gases are well mixed, the approach to sampling is more straightforward because single point sampling may be carried out rather than multipoint grid sampling. These simpler arrangements will exist for most measurements carried out to meet the requirements of the MCPD and SGRs.

Where gas sampling only is required, it is acceptable to sample from a location close to the MCP or SG, where the gases are well mixed (for example a downstream location that is close to the combustion zone is assumed to be well mixed).

4. MCERTS accredited stack emissions monitoring

For some MCPs and SGs, monitoring shall be carried out by an organisation that has MCERTS accreditation (see Box 1 and Monitoring Quick Guide 11[6]) for the measurement methods specified in the operator's permit. The decision on whether MCERTS accredited monitoring is required is primarily based on the size of the MCP and SG, the type of fuel it uses and the number of hours of operation (further information can be found on GOV.UK).

Box 1 MCERTS

MCERTS is a Monitoring Certification Scheme for instruments, monitoring and analytical services. The scheme is built on proven international standards and provides industry with a framework for choosing monitoring systems and services that meet agreed performance specifications. MCERTS reflects the growing requirements for regulatory monitoring to meet European and international standards. It brings together relevant standards into a scheme that can be easily accessed by manufacturers, operators, regulators and test houses. Further information on MCERTS is available at www.mcerts.net.

To obtain MCERTS accreditation, organisations that carry out stack emissions monitoring must be accredited by the United Kingdom Accreditation Service (UKAS) to show they have reached the standard set out in the MCERTS Performance standard for stack emissions monitoring[7]. This standard specifies how to plan, carry out and report stack emissions monitoring.

5. Emissions monitoring by organisations that service and maintain MCPs and SGs

5.1 Scope

Organisations that service and maintain MCPs and SGs may carry out compliance monitoring of emissions for the MCPD and SGRs, provided the MCP and SG operate below a maximum net rated thermal input, use agreed fuels or operate below a minimum number of hours (further information can be found on GOV.UK). Independent third party accreditation, such as MCERTS for stack emissions monitoring organisations, is not required for these MCPs and SGs for the following reasons:

- individually they present little risk to the environment
- the emissions monitoring procedure is relatively straightforward

- they often only operate intermittently, so it is more practical to use the monitoring results from a routine service visit
- emissions monitoring makes up a small part of the work of service engineers, who service and maintain MCPs and SGs

Emissions measurements made by a service engineer can be used for compliance reporting. If more than one measurement is made over the reporting period, the maximum emission for each reportable determinand shall be reported for this reporting period.

Where organisations that service and maintain MCPs and SGs are permitted to take measurements for demonstrating compliance with the MCPD and SGRs, the sampling and quality assurance procedures below shall be followed.

5.2 Measuring system requirements

Portable monitoring systems must be selected that have met the requirements of MCERTS certification for emissions monitoring systems (this includes the MCERTS scheme for handheld emissions monitoring systems[8] and the MCERTS scheme for transportable emissions monitoring systems[9]). As an interim, measurement systems that have been assessed against the requirements of EN 50379-2[10] may be used, provided the assessment has been made by an organisation with accreditation for these performance requirements (e.g. TUV). However, when analysers are replaced, they shall be replaced by analysers that have MCERTS certification. From the 1 January 2025, all analysers shall be MCERTS certified.

The sample probe will be exposed to gases at high temperatures (e.g. >250°C). Therefore, it shall be made of temperature resistant material (for example Inconel).

5.3 Annual quality control

A lack of fit (linearity), zero and span check shall be carried out annually or after a major repair to the analyser (e.g. change of electrochemical sensor). This can be carried out by a service organisation or other suitable organisation (e.g. a calibration laboratory or the manufacturer of the analyser).

An annual service report shall be produced for each analyser. This shall include a summary of the service work carried out on the analyser, along with the test results for the performance characteristics and associated performance criteria (see Table 1).

Table 5.1: Analyser performance characteristics and associated performance criteria*

Performance characteristic	Performance criteria		
	CO, NO	NO_2	O_2
Zero check	≤5%[a]	≤3%[a]	≤0.4%[b]
Span check	≤5%[a]	≤5%[a]	≤0.4%[b]
Lack of fit	≤5%[a]	≤3%[a]	≤0.4%[b]

[a] Percentage value of the typical ELV or concentration, if an ELV if not specified
[b] Values are given as percentage values of oxygen volume concentration (volume fraction)

*The tests shall be carried out in accordance with the requirements of the MCERTS performance standard for highly portable emissions monitoring systems.

If an annual service report shows that a measuring system has failed an annual test, a review of the monitoring results, which have potentially been affected, shall be sent to the competent authority by the organisation that services and maintains MCPs and SGs.

5.4 Ongoing analyser performance checks

The following quality control procedures are carried out at a frequency dependant on the proven stability of the analyser. If the analyser has very stable characteristics, then these checks may only need to be carried out annually or after a major repair to the analyser (e.g. change of an electrochemical sensor).

The span gases used for the gas analyser checks are CO in nitrogen or CO in nitrogen and O_2, NO in nitrogen, NO_2 in air or nitrogen, and O_2 in nitrogen. The mixtures can be combined e.g. O_2 and CO with a balance of nitrogen. Dry ambient air (21% O_2) may also be used as a span gas for the O_2 sensor.

Span gas concentrations shall be at a typical ELV value or the typical concentration, where an ELV is not specified.

NO_2 sensors are generally designed to measure much lower concentrations than NO sensors, so the span gas shall be chosen accordingly.

The sampling system shall be assembled and the analyser warmed up, according to the manufacturer's instructions.

Zero and span gases shall be injected at the probe tip using an assembly that includes a t-piece to prevent the system becoming pressurised. Gases shall flow through all parts of the sample interface (including any exhaust lines). During this check, no adjustments shall be made to the system, except those necessary to achieve the correct gas flow rate to the analyser. The analyser flow rate shall be set to the value recommended by the analyser manufacturer. Each reading shall be allowed to stabilize before recording the result. After achieving a stable response, the gas shall be disconnected and the system purged with ambient air.

If the zero and span test results are not within the specifications in Table 1, corrective action shall be taken and the calibration check shall be repeated until an acceptable performance is achieved.

5.5 Sample strategy and process operating conditions

The sample strategy may vary depending on the type, age and availability of the MCP or SG.

It is common practice to measure performance and emissions at different operating conditions, which reflect the MCP's ability to follow the load. For example, a burner with 5:1 turndown can be measured at 20% and 100% output, along with a number of intermediate steps. A simpler, typically older, MCP can be measured at low and high fire, with a medium fire measurement taken, if the MCP can be set for this. The result of each single measurement should be made at half hour intervals, where possible, with the maximum value being reported.

Due to the intermittent operation of some MCPs, the sample periods can be limited to a few minutes at a time, which means that the sample strategy has to be adapted to shorter time periods.

If measurements are made during periods of start-up and shutdown, these results shall not be included in the final result.

5.6 Emission test procedure

The sampling system shall be assembled and the analyser shall be warmed up, according to the manufacturer's instructions.

Before the start of the test, a check shall be carried out at the sample location (near the sample port) on the O_2 sensor of the analyser, using ambient air. This check shall meet the criteria specified in Table 1.

The sample probe shall be inserted into the sample location. Sample gas extraction shall be carried out at the same rate used during the performance checks. A constant sample rate shall be maintained during the test.

At the end of the test, the sample probe shall be removed from the stack, and the measuring system shall be purged with ambient air for a minimum of 5 minutes, to clear the system of sample gas.

If post-test zero and span checks are required, then no seals in the sample handling system shall be broken until after they have been completed.

5.7 Reporting results

The following information shall be recorded for each test by the monitoring organisation:

- permit number
- name of operator and installation
- date of the monitoring visit
- report version number
- site address
- name of organisation carrying out the monitoring
- date of report
- unique identification of emission point(s)
- date and start and finish times of test(s)
- determinands measured
- emission limit value (mg/m^3)
- concentration measured (mg/m^3)
- reference conditions (dry gas, 273.15K, 101.3kPa, O_2 of 3%, 6% or 15%)
- description of process / operating conditions
- name & model number of analyser
- serial number of analyser
- MCERTS certification of the measurement system
- calibration due date of the analyser

This information is not submitted to the competent authority but shall be kept, for a minimum of 6 years by the operator.

5.8 Quality assurance

Service engineer organisations shall have monitoring procedures that meet the requirements of this TGN. These procedures shall be included in a management system, such as ISO 9001[11], which has been certified by a third party that has been accredited by UKAS.

The competent authority may also carry out a programme of audits of onsite emissions monitoring to establish that the procedures in this TGN are being met. These audits may also include audits of organisations that carry out the annual service and calibration checks of the measurement system.

6. Particulate monitoring

The method for measuring particulates in stacks is defined by EN 13284:1[12].

Due to the complexity of this type of measurement and the specialist equipment required, it shall be carried out by an organisation with MCERTS accreditation for EN 13284-1.

The measurement shall be carried out in a straight section of duct or a stack, as described in TGN M1. A sample port needs to be installed of sufficient size to allow access for the sampling equipment. Due to the type of equipment required to carry out particulate sampling, additional access and platform requirements may be necessary.

Appropriate measurement locations, access and platform requirements shall be planned when designing a MCP or SG. For existing MCPs and SGs, retrofitting of suitable sample points and access platforms may be expensive and in some cases not possible, due to space restrictions. Under circumstances, where limited access prevents the installation of a permanent platform, temporary structures may be used, provided it is fully justified by the operator and the monitoring organisation.

To help reduce practical difficulties related to sampling small ducts, specialist small scale particulate sampling equipment has been developed.

In order to meet the limit of detection requirements of EN 13284-1, a specified volume of gas should be sampled, which based on the sample flow rate will dictate the sample time duration (the minimum sample time specified in EN 13284-1 is 30 minutes). For gas emissions with low dust levels (e.g. <2 mg/m^3), the sample time can be increased up to a recommended maximum of 2 hours.

The potential for long sample times makes it difficult to apply EN 13284-1 effectively to MCPs and SGs that have short intermittent operation (e.g. few minutes at a time). In order to comply with the standard the operator could, if stable operation was possible, run the plant for a minimum 30 minute sample period. Another option is to carry out cumulative sampling, where the sample equipment is installed for sufficient time to collect a sample over a longer time period, based on active sampling during periods of intermittent operation.

7. Measurement Uncertainty

Measurement uncertainty quantifies the dispersion around the true value, inherent in a measurement result. The uncertainty assigned to a result represents the range of values about the result in which the true value is expected to lie. Uncertainty should be quantified to show that the measurement is fit for purpose, by demonstrating that the uncertainty of the measurements are within certain criteria. The statement of uncertainty includes a value for the level of confidence. This quantifies the probability that the true value lies within the region defined by the confidence interval. The measurement uncertainty defines the size of the region in which the true value is expected to lie, and the confidence interval defines how likely this is.

Monitoring organisations have procedures for determining their measurement uncertainty, which are based on the performance of the equipment they use. The spatial and temporal variability during sampling can be ignored from the determination of measurement uncertainty. Also, longer term process variability is not a contributing factor to measurement uncertainty, which means its effect is not taken into account when reporting the measurement uncertainty. A detailed example of how a measurement uncertainty is determined for stack emissions monitoring is provided in TGN M2.

For MCERTS accredited organisations, it is a mandatory requirement for them to calculate their uncertainty using the approach outlined in TGN M2. They must also ensure their maximum uncertainty does not exceed the values specified in TGN M2.

For organisations that service and maintain MCPs and SGs, a fixed expanded measurement uncertainty of ±20% is specified for nitrogen oxides (NOx). This is derived from the measurement uncertainty from MCERTS performance tests and the effect of O_2 correction.

Monitoring results shall be corrected to the required reference conditions and reported to the competent authority, without subtraction of the measurement uncertainty. After monitoring results have been reported, the measurement uncertainty will be considered by the competent authority, when assessing compliance with an emission limit.

Annex A: Reporting SO_2 emissions based on fuel sulphur content of fuels

As an alternative to the direct measurement of SO_2 in flue gas, the MCPD states that other procedures, verified and approved by the competent authority, may be used to determine the emissions of SO_2. Calculation of the SO_2 emission from the fuel sulphur content, assuming complete oxidation of the fuel sulphur, is often used in place of direct measurement but only for unabated plants that are not fitted with flue gas desulphurisation abatement.

The MCPD requires that emissions monitoring is undertaken when firing a fuel or fuel mix that is likely to result in the highest level of emissions. Therefore, the calculation of the SO_2 emission from the fuel sulphur content shall be performed on the highest representative fuel sulphur content fired during the compliance period.

A.1 Liquid Fuels

The sulphur content of gas oil is regulated under the Sulphur content of liquid fuels regulations[13], which means an SO_2 Emission Limit Value (ELV) is not specified in the MCPD for gas oil. This approach is also applied to other similar low sulphur fuels with a sulphur content less than 0.1% by mass, such as bio-diesel and burning oil.

When firing liquid fuels, other than gas oil, for combustion plants (at 3% O_2) and engines/gas turbines (at 15 % O_2), without flue gas desulphurisation abatement, the approximate fuel sulphur contents, which correspond with the various ELVs specified in the MCPD, are given in Table A.1. In order to demonstrate compliance, the sulphur content of the fired fuel shall be lower than the applicable threshold values. Table A.1 is applicable to petroleum fuels, ranging from light to heavy fuel oil with a net calorific value in the range 39.5 to 42.5 MJ/kg.

As an alternative to flue gas measurement, SO_2 emissions can be reported using the maximum value of the fuel sulphur during the compliance period. The fuel sulphur content may be provided by the fuel supplier, as either a measured value or as a maximum fuel sulphur specification. Alternatively, the operator may use sulphur analyses of fired fuel samples that are provided by an appropriately accredited analytical laboratory.

Table A.1 Liquid fuels: fuel sulphur equivalence to ELVs

Fuel type	Fuel sulphur % by mass	ELV SO_2 (mg/m^3)	
		at 3% O_2	at 15% O_2
Liquid fuels, other than gas oil	0.2%	350	120
	0.5%	850	290
	1.0%	1700	570

A.2 Solid Fuels

When firing solid fuels at combustion plants (at 6% O_2),without flue gas desulphurisation abatement, the approximate fuel sulphur contents that correspond with the various ELVs specified in the MCPD, are given in Table A.2. In order to demonstrate compliance, the sulphur content of the fired fuel shall be lower than the relevant threshold values. Table A.2 is applicable to biomass and commercially traded hard coal.

There will be some absorption of SO_2 by the fuel ash. This will depend on the composition of the ash and the type of dust abatement plant installed. Coal ash typically absorbs up to 5% of the released SO_2. Biomass ash can absorb much higher proportions of the released SO_2.

The fuel sulphur thresholds given in Table A.2 are therefore conservative. In situations where the fuel sulphur is higher than this threshold but there is significant ash absorption, it is necessary to measure the flue gas emission to demonstrate compliance.

Table A.2 Solid fuels: fuel sulphur equivalence to ELVs

Fuel type	Fuel sulphur % by mass (as received)	SO_2 ELV (mg/m^3) at 6% O_2
Solid biomass	0.058%	200
	0.087%	300
Other solid fuels: Coal	0.174%	400
	0.477%	1100

Note 1: there are no ELV and reporting requirements for plants firing exclusively woody biomass.
Note 2: dried biomass pellets can be assumed to contain 10% moisture.
Note 3: the solid fuel sulphur content is based on the 'as received' fuel at the applicable moisture content, not the dry or dry, ash-free fuel. In order to determine the 'as received' sulphur content, the dry sulphur content is multiplied by (1 - %moisture/100%).

A.3 Determining the reportable SO_2 concentration

The reportable SO_2 concentration can be determined by scaling the SO_2 concentrations, equivalent to 0.1% fuel sulphur, given in Table A.3 below.

Table A.3 Factors to be used for SO_2 reporting

Fuel type	Fuel sulphur % by mass (as received)	SO_2 (mg/m^3 at 273K, 101.3kPa)		
		at 3% O_2	at 6% O_2	at 15% O_2
Fuel oil	0.1%	169	-	56
Solid biomass	0.1%	-	344	-
Other solid fuels: Coal	0.1%	-	230	-

For example:

- a boiler firing liquid fuel with a sulphur content of 0.25% will emit an SO_2 concentration of 422.5 mg/m^3 at 3% O_2 [= (0.25%/0.1%) * 169 mg/m^3].
- a gas turbine firing liquid fuel with a sulphur content of 0.05% will emit an SO_2 concentration of 28 mg/m^3 at 15% O_2 [= (0.05%/0.1%) * 56 mg/m^3].
- a boiler firing dried biomass, with a sulphur content of 0.02%, will emit an SO_2 concentration of 68.8 mg/m^3 at 6% O_2 [= (0.02%/0.1%) * 344 mg/m^3].

A.4 Use of factors for other fuel types

If an operator wants to report SO_2 emissions based on fuel sulphur content of other types of fuels, they shall seek approval to do this from the competent authority.

References

1. 2015/2193/EU Directive on the limitation of certain pollutants into the air from Medium Combustion Plants

2. EPR 2018 Schedule 25B 2 (1) – Specified Generators, available from www.legislation.gov.uk

3. Technical Guidance Note (Monitoring) M2, Monitoring of stack gas emissions to air, Environment Agency, available from www.mcerts.net

4. Technical Guidance Note (Monitoring) M20, Quality assurance of continuous emission monitoring systems, Environment Agency, available from www.mcerts.net

5. Technical Guidance Note (Monitoring) M1, Sampling and safety requirements for monitoring stack releases to atmosphere, Environment Agency, available from www.mcerts.net.

6. Monitoring Quick Guide 11, MCERTS Manual stack emissions monitoring, Environment Agency, available from www.mcerts.net

7. MCERTS, Manual stack-emission monitoring: performance standard for organisations, Environment Agency, available from www.mcerts.net

8. MCERTS performance standard for highly portable emissions monitoring, Environment Agency, available from www.mcerts.net

9. MCERTS performance standards and test procedures for continuous emissions monitoring systems (CEMs) and transportable-CEMs, Environment Agency, available from www.mcerts.net

10. EN 50379-2 Specification for portable electrical apparatus designed to measure combustion flue gas parameters of heating appliances - Part 2: Performance requirements for apparatus used in statutory inspections and assessment

11. ISO 9001, Quality management systems - Requirements

12. EN 13284-1 Stationary source emissions – Determination of low range mass concentration of dust Part 1: Manual gravimetric method

13. EPR 2007 Sulphur content of liquid fuels regulations, available from www.legislation.gov.uk