Environmental Protection Agency

Office of Environmental Enforcement (OEE)

Guidance Note on EPA requirements for calculation of flue gas volume flow rate from energy consumption using Annex E of ISO EN 16911-1.

Air Guidance Note 10

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Johnstown Castle Estate

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Disclaimer

Limitation of use

This is a general guidance document; the EPA reserves the right to apply different criteria depending on location specific requirements, and may require an alternative route towards compliance than that which is contained herein.

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Foreword

The ISO standard for manual and automatic determination of gas velocity & flow rate is – *"Stationary source emissions – Manual and automatic determination of velocity and volume flow rates in ducts - ISO EN 16911-1:2013*". Part 1 of the standard outlines manual methods to be used for the calibration of continuous monitoring equipment, or other compliances purposes. Part 2 outlines the requirements relating to the certification and calibration of continuous flow monitors.

This guidance aims to clarify the requirements of EN ISO 16911-1 – Annex E, it does not restate the requirements of the standard, so organisations should reference both documents. The EPA has provided this guidance for organisations to reference when calculating flue gas volume flow rate from energy consumption. Many EPA licenses require automatic or continuous air flow measurement, however, in certain circumstances, and with agreement from the EPA, organisations use the calculation method. Organisations should reference EN ISO 16911-1 (Annex E) and this guidance, when preparing calculations.

If the Annex E calculation method is used for continuous flow rate measurement, it must be verified annually by carrying out parallel Standard Reference Method (SRM) stack testing using ISO17025 accredited laboratories/organisations.

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Section 1: Introduction & Scope

This guidance is aimed at organisations in the large combustion plant and waste incineration sectors, which are licensed by the EPA.

This guidance aims to clarify the requirements for calculation of flue gas volume flow rate from energy consumption using Annex E of ISO EN 16911-1. Under Section 9.2 of EN 16911-2, licensees are required to validate the calculation method by means of a Quality Assurance Level 2 (QAL2), and check it yearly by means of an Annual Surveillance Test (AST) in accordance with EN14181. Both QAL2's and AST's require parallel monitoring, therefore there is a requirement for sampling ports on a stack to sample as per the requirements of EN15259. Use of the calculation method is not a way to avoid the installation of sampling ports for standard reference method sampling.

The ISO EN 16911 Standard was published in 2013, the standard prescribes methods for gas velocity and flow measurement in a duct, and is divided into 2 parts:

Part 1 of ISO EN16911-1

Part 1 specifies methods for periodic determination of axial velocity and volume flow rate of gas within emission ducts and stacks[1]. Methods prescribed in the standard include differential pressure, vane anemometer, tracer gas dilution, tracer method using transit time, and flow rate from energy consumption for combustion processes. In order to be used as an SRM, the user must demonstrate that the performance characteristics of the method are equal to, or better than the performance criteria defined in the standard, and that the overall uncertainty with a level of confidence of 95% is determined and reported.

Differential pressure (Annex A), vane anemometer (Annex B), tracer gas dilution (Annex C) and tracer transit time (Annex D) methodologies are not included in this EPA guidance document. Refer to EN16911-1 for more detail.

Part 2 of ISO EN 16911-2

Part 2 describes specific requirements for automated measuring system (AMS) flow monitoring[2]. Part 2 specifies conditions and criteria for the choice, mounting, commissioning, and calibration of AMS used for determining the volume flow rate from a source in ducted gaseous streams. It prescribes certification, calibration, and control of continuous flow monitors.

EPA Licensed facilities

Many EPA licenses require automatic or continuous air flow measurement, however, in certain circumstances, or with agreement from the EPA, organisations may calculate gas velocity and flow from energy consumption. Organisations should reference EN ISO 16911-1 (Annex E), and this guidance when preparing calculations.

EPA licenced sites are typically required to measure gas volumetric flow automatically, or continuously with *'Standard Methods'* equipment. SRMs can be used for the calibration of CEMS stack flow meters and for periodic compliance or validation testing (i.e. validation of QAL1, QAL2, QAL3 or AST volumetric data).

[1] See ISO https://www.iso.org/standard/57947.html for full summary of EN ISO 16911-1
[2] See ISO https://www.iso.org/standard/57948.html for full summary of EN ISO 16911-2

In most instances, volumetric flow is measured using a CEMS or AMS system. In instances where continuous or automatic measurement is not possible, licensees shall use the methods prescribed in ISO EN 16911-1, and specifically Annex E. If a licensee plans to determine volumetric flow by calculation, they must agree the use of this method with the EPA. Under Section 9.2 of EN 16911-2, licensees are required to validate the calculation method by means of a QAL2, and check it yearly by means of an AST, in accordance with EN16911-2. If the QAL2 or AST fails, the calculation procedure shall be investigated, and if necessary rectified prior to retesting with another QAL2. Licensees must also validate the calculation methodology by carrying out parallel standard reference method measurements using ISO17025 accredited test laboratories.

Section 2: Implementing Part 1 Annex E of EN ISO 16911-1

ISO EN 16911-1 provides a method for determining gas velocity and volume flow within a duct, it provides alternative methods to determine volume flow rate and average velocity. This guidance will summarise the methods described in Annex E of the standard '*Determine the volume flow rate using a calculation-based approach to derive the flow from the energy consumption of a combustion process'.*

Annex E EN 16911-1– Methodology

Principle

The general method is to multiply the energy consumption by a fuel factor, in order to obtain the dry stoichiometric stack gas flow rate at standard reference conditions (0% O_2, 273.15 K and 101.325 kPa)

The energy consumption can be determined directly, by measurement of fuel flow rate and specific energy. Indirectly the energy consumption can be measured from plant output and thermal efficiency.

For mass emissions reporting and ELV compliance purposes, the dry stoichiometric flow rate is then corrected to a given reference oxygen content, it is then multiplied by emissions concentrations reported at the same reference conditions. Licensees shall ensure consistency with reference conditions is maintained in all calculations. Licensees shall ensure consistency with units, i.e. m^3/s or m^3/hr or m^3/day.

The Annex E method requires a variety of technical data available for input into the calculation method. The required inputs, steps and outputs can be found in Annex E of the standard, and are summarised as:

- **Key Inputs –** Fuel flow, with net specific energy in MJ/kg; input: gas release (fuel factor), *S* [m^3/MJ]
- **Calculation:** 'Process heat release' See Annex E of the ISO EN 16911-1
- **Inputs (alternative):** energy production, *P,* in MW with thermal efficiency
- **Calculation:** 'flue gas volume flow rate' See Annex E of ISO EN 16911-1

The above definitions, symbols, equations, and calculations can be found in Section 4 '*Symbols and abbreviated terms'* of the standard.

Organisations should follow the methodologies, calculations, and formats prescribed in Annex E Section E.1 to E.6 (inclusive) of the standard.

Fuel Factors

Fossil and biomass fuel factors are provided in Annex E of the standard, and should be adhered to. Peat is not included in Annex E. If peat is being used as a fuel, the licensee will have to calculate the fuel factor themselves, and submit this to the EPA for agreement.

It should be noted that tools are available for calculation range of fuel factors. These are provided by VGB in the 'Fuel Properties' tab of the VGB Excel workbook, described in Section 4.3 here. VGB is the Technical association of energy plant operators worldwide. They provide guidance and interpretation of standards to the power plant industry.

Energy Consumption

For gas and liquid fuels, the energy consumption can be derived directly from the metered fuel consumption. It is important that organisations have validated, certificated, and calibrated metered fuel consumption data. Ensure that the meter is maintained as per manufacturers recommendations.

For solid fuels or unmetered consumption, energy consumption can be derived from the plant energy production, and the fractional thermal efficiency (see page 56 of the standard)

Calculation of flue gas volume flow rate

The stoichiometric dry flue gas volume flow rate at reference conditions in m^3/s is calculated from the fuel factor and thermal input (see page 57 of the standard).

Performance requirements

The performance requirements are given as expanded uncertainties at 95% confidence, these are set depending on the fuel type (Table E.4 see page 57 of the standard). The performance requirements for the main calculation inputs are given in Table E.5 of Annex E (see page 58 of the standard).

Example uncertainty calculations

Three example uncertainty calculations are provided for coal, biomass, and gas fired power plants in Annex E of the standard.

Biomass and Gas fired plants require detailed uncertainty calculations.

Section 3: Uncertainties

Annex E requires the following expanded uncertainties; ≤ 2% for gas, ≤ 3% for oil, and ≤ 7.5% of the flow rate for solid fuel firing. As per Table E5 in En16911 Annex E.

From a practical point of view, it should then be sufficient to meet the over-arching ±7.5% uncertainty requirement, and demonstrate compliance by means of a QAL2 verification.

The calculation method shall be verified by means of a QAL2, and checked yearly by means of an AST, in accordance with EN 14181. QAL2 'calibration' factors are not applied to the calculation method, rather they are to verify the accuracy of the calculation method. This contrasts with the installation of a flow monitor which is subject to calibration, and requires QAL2 factors to be applied.

Section 4: Application, queries and records

If an organisation plans to determine volumetric flow by calculation, they must agree the use of this method with the EPA. The organisation must submit the procedure and parameters used for the calculation, as well as detailed methodologies employed for written agreement with the EPA. Calculations should follow the methodology specified in EN16911-1.

Should the licensee or organisations involved in the operation of large combustion plants have difficulty in implementing or calculating flue gas volume flow rate from energy consumption using Annex E of EN 16911-1, queries can be submitted to airthematic@epa.ie

Records of the calculations, figures and data used should be retained on-site by the licensee and shall be submitted to the EPA as required. The EPA should be able to replicate the calculations from the data provided, and obtain the same results.

The calculation method should be verified at least annually as part of an AST, as per the EN 16911-2 standard, and every 3 or 5 years as part of the QAL2.

Reference Documents:

AG2 Air Guidance Note 2 , 'Emissions Monitoring Guidance Note (AG2)', Revision 4 – EPA Ireland.

AG3 Air Guidance Note 3 'Air Guidance Note on the Implementation of I.S EN 14181 (AG3) Version 2 – EPA Ireland

EN ISO 16911-1: 2013 Stationary source emissions – Manual and automatic determination of velocity and volume flow rate in ducts – Part 1: Manual Reference Method

EN ISO 16911-2: 2013 Stationary source emissions – Manual and automatic determination of velocity and volume flow rate in ducts – Part 2: Automated measuring systems

VGB PowerTech Flue gas flow rate calculation for mass emissions reporting – Part 1: The pathway from DIN 1942, to EN 12952-15, to EN-ISO 16911-1, Frans Blank, David Graham and Henrik Harnevie

VGB PowerTech Validated methods for flue gas flow rate calculation with reference to EN 12952-15, VGB European Working Group Emissions Monitoring. Vattenfall, KEMA and E ON.

VGB PowerTech Verifying flue gas flow rate calculation at power plants, for emissions reporting purposes, by means of stack testing and data evaluation to EN ISO 16911:2013. Uniper, DNV GL, ENGIE Laborelec