



Environmental Protection Agency  
Office of Environmental Enforcement (OEE) Air  
Emissions Monitoring Guidance Note (AG2)

Revision 7 - May 2021

This publication is designed to be read in conjunction with [AG2 Index of Preferred Methods](#)

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**The original version of this guidance note was prepared and published by the EPA in 2007. This document is a revision of that original that has been prepared to reflect the changes in regulatory and monitoring practices that have occurred in the interim. The table below lists the main amendments to the original.**

Version No.	Date	Amendment
7	May 2021	Update on Appendix 1 to reflect the Regulator's approach in relation to CEN-TS 17337 requirements for reactive gases
6	Jan. 2021	Update of Section 9.5.5 on Proficiency Tests requirements
5	Nov. 2020	Update of all relevant legislation, standards and guidance, including relevant requirement of ISO17025:2017
		Updates to chapter 7 (Equipment), chapter 8 (Personal competency) and chapter 9 (Organisation). The changes incorporate content from the withdrawn standard DD CEN/TS 15675:2007. Specifically, these changes advise what the Agency require for the application of ISO17025 to the practice of stack testing.
		Addition of a default suite of parameters for TA Luft inorganics
		Update to Index of Preferred Methods (IoPM).

		Removal of all Environmental Agency MIDs references, and inclusion of relevant MIDs content into in a new appendix in the IoPM.
4	May 2018	Revision of the VOCs suite (Appendix 2)
3	Sep. 2017	Revision of air monitoring reports minimum content.
		The inclusion of a standardized approach to VOC monitoring and reporting.
		Update to mandatory EN ISO/IEC 17025 accredited parameters.
		Update to Index of preferred methods.
		Reminder of gas density calculation requirements for isokinetic monitoring and volumetric flow results at combustion processes.
2	Feb. 2014	Revision of multiple sections to reflect EPA requirement for ISO 17025 accredited testing.
		Removal of Index of Preferred Methods to separate document and update of the Index.
		The inclusion of highlight panels that identify recent developments and add focus on the most important parts of each section.
		Expanded chapter on measurement uncertainty and data reporting.

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## Preface

The Office of Environmental Enforcement (OEE) is one of the five offices in the Environmental Protection Agency. The OEE's functions include the regulation of activities licensed under the EPA and Waste Management Acts. It is the policy of the OEE to provide information and advice, via published guidance to those it regulates to secure environmental improvements, while ensuring value for money.

This *Air Emission Monitoring Guidance Note* (AG2) is one of a series of guidance notes that the OEE has published on the general theme of air pollution. It is complemented by the Index of preferred Methods. The series also includes:

**AG1 - Guidance Note on Site Safety Requirements for Air Emissions Monitoring**

**AG3 - Air Guidance Note on the Implementation of EN 14181**

**AG4 - Air Dispersion Modelling from Industrial Installations Guidance Note**

**AG5 - Odour Impact Assessment Guidance for EPA Licensed Sites**

**AG6 - Air Guidance Note - Surface VOC Emissions Monitoring on Landfill Facilities**

**AG7 - Guidance Note on Landfill Flare and Engine Management and Monitoring**

**AG8 - Air Guidance Note for In-house Air Monitoring Teams**

**AG9 - Odour Emissions Guidance Note**

**AG10 - Guidance Note on EPA requirements for calculation of flue gas volume flow rate from energy consumption using Annex E of ISO EN 16911-1**

**AG11 - Guidance Note on Monitoring of Stack Gas Emissions from Medium Combustion Plants**

**AG12 - Guidance note on EPA requirements for alternative monitoring when continuous emission systems are off-line (AG12)**

This guidance note is intended for use by all EPA staff (e.g. licensing and enforcement staff), the licensed operators, and the test houses that provide an emissions monitoring service. The objective is to raise awareness among EPA staff and operators of best practice in the field of stack testing, so that they in turn will require test houses to provide a good quality service. The EPA advises that licensees have regard to this guidance when outsourcing their emission monitoring programme.

Throughout the guidance note, there are examples given of licence conditions, which are typical of those found in EPA licences. In reality, licence conditions will vary somewhat from one licence to the next, so reference should be made to the current licence for the site, to determine the legal obligation for monitoring.

In some existing EPA licences (IE, IPC, and waste), the methods prescribed for monitoring atmospheric emissions may differ from the recommendations in this guidance. These instances can be dealt with on a case by case basis, and alterations to the monitoring methods may be permitted with the prior approval of the EPA. New and revised licences should seek to adopt the recommendations of this guidance.

This guidance is aimed at improving the overall quality of stack emission monitoring. The programme of monitoring will depend on the nature and complexity of the site operations. The use of best practice in atmospheric source monitoring is an important strand in operators' efforts to protect the environment and licensed operators should ensure that the practices described in this guidance are applied to their monitoring programmes, as soon as reasonably practicable.

The guidance has been divided into this main document and the Index of Preferred Methods (i.e. the list of standard methods acceptable to the EPA) that can be viewed using the following [web link](#).

## Health and Safety

It is a condition of all EPA licences that safe and permanent access is provided to all sampling and monitoring points. This condition has in the past and will continue to be the focus of inspectors' site visits and audits, and failure to comply will result in enforcement action. Those persons with responsibility for the commissioning and management of stack testing programmes shall have regard to EPA [Guidance Note on Site Safety Requirements for Air Emissions Monitoring \(AG1\)](#) and fulfill all legal requirements for safety the workplace as set out by the [Health and Safety Authority \(HSA\)](#).

If persons involved in stack testing of EPA licensed sites have any concerns regarding safety or sampling access at a particular site, they should raise the matter with the company immediately, and if their concerns are not adequately addressed within a reasonable time- frame, then they should contact the EPA for assistance. The EPA will seek to enforce the appropriate condition of the licence to effect the necessary improvements.

## Historical developments

From 1 January 2014, the EPA required that contractors carrying out monitoring of stack gas emissions to atmosphere become accredited to the EN ISO/IEC 17025 standard for the parameters specified.

Details of the policy issued in March 2012 can be found at the following link. Any queries on this policy should be directed to the EPA Air Enforcement Team – [airthematic@epa.ie](mailto:airthematic@epa.ie)

[Policy: Monitoring of Stack Emissions at EPA Licensed Sites – Environmental Protection Agency](#)

This replaces the earlier requirement which permitted non-accredited monitoring at most licensed sites and that only certain sites (e.g. incinerators) need employ contractors that are accredited. These requirements' criteria are considered by the EPA to be appropriate in the context of the [BAT Reference Report on Monitoring of Emissions to Air and Water from IED installations](#) and the [Industrial Emissions Directive \(2010/75/EC\)](#) which seeks to bring more consistency to the application of BAT across the EU. Most Irish-based contractors will seek EN ISO/IEC 17025 accreditation from the Irish National Accreditation Board (INAB). Contractors that hold appropriate accreditation to the EN ISO/IEC 17025 standard from other national accreditation bodies will be acceptable to the EPA, provided that they comply with the requirements of EPA guidance notes AG1, AG2, etc.

## Revision of this document.

This guidance note will be the subject of periodic review and amendment. The most recent version of this note is available on the EPA website: <http://www.epa.ie/>. If you have any particular queries on this document then please contact [airthematic@epa.ie](mailto:airthematic@epa.ie)

## References and weblinks.

Web links in this document were validated prior to publication. Over time some of these links will go out of date. Where this occurs, the reader is advised to visit the source web site to obtain the most up to date version. If the reader experiences difficulty finding any of the referenced sources, then please contact [airthematic@epa.ie](mailto:airthematic@epa.ie)

# 1 Introduction

This guidance note (AG2) was commissioned by the EPA to provide information on the subject of air emission monitoring in the Irish context. The monitoring of air pollution at source (stack-emission monitoring) is known colloquially as ‘stack testing’, and this is the term that will be used in this guidance.

Stack testing in Ireland prior to 1994 was confined mainly to those sites that were licensed under the Air Pollution Act 1987. With the advent of the EPA IPC and Waste licensing regimes in the 1990’s the number of sites where stack testing is undertaken has increased significantly.

The Comité Européen de Normalisation (CEN) and the International Organization for Standardization (ISO) standard methods for the measurement of air pollutants can be obtained from the National Standards Authority of Ireland. The range of methods now covers the vast majority of the pollutants that need to be monitored at licensed sites in Ireland.

An essential adjunct to this guidance document is:

The Index of Preferred Methods [[web link](#)]

The index (i.e. the list of standard methods acceptable to the EPA) also includes guidance on the application and implementation of standard methods. It is maintained as a standalone document to facilitate revision upon the publication of new methods.

## 1.1 The Irish Regulatory system

The Environmental Protection Agency Act 1992<sup>ii</sup> provided for an integrated approach to pollution control from industrial sources. The EPA replaced the Local Authorities as the main regulator of industrial emissions. Over 70 industrial classes came within the scope of IPC licensing, and these are listed in the First Schedule of the 1992 Act. While IPC licensing was being implemented in Ireland from 1994, the EU IPPC Directive (96/61/EC) was finalised in September 1996. The IPPC Directive was transposed into Irish law in 2003 with the enactment of the Protection of the Environment (PoE) Act 2003<sup>iii</sup>. While the 1992 Act anticipated and implemented most of the requirements of the Directive, the PoE Act 2003 made legislative provision for the remaining elements. The introduction of the Industrial Emissions Directive, as discussed below, has resulted in a reworking of the EPA regulatory regime for industrial activities. Depending on the activity, the

### Development of Industrial Licensing at European level.

The Industrial Emissions Directive 2010/75/EU (IED) brings together in one instrument the provisions of a number of earlier sector specific directives that have relevance for those involved in air emissions monitoring, (e.g. the Large Combustion Plants Directive 2001/80/EC<sup>iv</sup>, the Incineration of Waste, Directive 2000/76/EC<sup>v</sup> and the Solvents Directive 1999/13/EC<sup>vi</sup>). It also incorporates the provisions of the Integrated Pollution Prevention and Control Directive 2008/1/EC<sup>vii</sup>

While the IED recasts earlier directives, it does not substantially alter the specifics of those directives that relate to air emissions monitoring, (e.g. the emission limit values, the requirements for continuous monitoring, the permitted uncertainty of measurement, etc.). In the context of this guidance the directives’ principal points of relevance are:

- It specifies the use of Comité Européen de Normalisation (CEN) standards for monitoring and calibration. If CEN standards are not available, ISO, national or other international standards which ensure the provision of data of an equivalent scientific quality shall apply;

EPA now issues one of three types of licence. The types of licence are Industrial Emissions (IE), Integrated Pollution Control (IPC) and Waste.

- The BAT programme for exchange of information between member states shall encompass “The performance of installations .... in terms of emissions. The techniques used and associated monitoring”. Where BAT Reference documents have been revised and BAT Conclusions (BAT-C) documents have been issued, the associated emission levels (AEL) must be used as the basis for setting emission limit values in new and revised licences for that activity.

Best Available Techniques (BAT) was introduced as a key principle in the IPPC Directive. To meet the requirements of the Directive, relevant sections of the EPA Act 1992 were amended to replace BATNEEC (Best Available Techniques Not Entailing Excessive Cost) with BAT. The fundamental criteria for determining BATNEEC and BAT are very similar. The [European IPPC Bureau](#) organises exchange of information between member states and industry and produces BAT reference documents (BREFs), which Member States are required to take into account when determining best available techniques generally or in specific cases. Of particular relevance to this guidance note is the [Reference Report on Monitoring of Emissions to Air and Water from IED installations \(2018\)](#). The guidance states:

*It is the responsibility of the competent authority to establish and set appropriate quality requirements, and to consider a range of safeguards. For the purposes of compliance assessment, use of the following is good practice:*

- Standard methods of measurement, where available;
- Certified instruments;
- Certification of personnel;
- Accredited laboratories.

#### **Revision of BREF**

The BREF reference document on the Reference Report on Monitoring of Emissions to Air and Water from IED installations was first published in July 2003. [The European Commission Joint Research Centre update revised and republished this guidance in 2018](#)

The [European Union \(Medium Combustion Plant\) Regulations 2017](#) were signed into law in December 2017. Their purpose is to limit emissions to atmosphere from boilers and other stationary combustion plants in the 1-50 MWTH (thermal input) range.

**Medium Combustion Plant (MCP) – emissions testing**

The following summarises the MCP Directive requirements for monitoring of emissions and assessment of compliance:

- Periodic measurements shall be conducted — every three years for plant with rated thermal input between 1 MW and 20 MW and every year for plant with rated thermal input greater than 20 MW.
- Sampling and analysis of polluting substances shall be based on methods enabling reliable, representative and comparable results. Methods complying with harmonised EN standards shall be presumed to satisfy this requirement. Suitable methods can be found in the Index of Preferred Methods.
- There are some exceptions to the above rules, and the reader is referred to the Annex III of the directive for these details and [Agency guidance AG 11](#).

**1.2 Licence compliance monitoring**

An inherent part of the EPA licensing system is the imposition of emission limit values on discharges to atmosphere. The EPA sets these limits having regard to the principles of BAT and the overriding imperative that ground level pollutant levels beyond the boundary remain below the appropriate Air Quality Standards (e.g. statutory EU Air Quality Standards or World Health Organisation Air Quality Guidelines).

The responsibility for monitoring rests, in the first case, with the licensed operator. This is referred to as ‘self-monitoring’. Some of the Irish operators have an in-house capability in stack testing, although the function is more usually ‘contracted-out’.

The EPA has defined Minimum Criteria for Air Emission Monitoring and these criteria are detailed in Chapter 2 of this guidance document.

The licence stipulates the frequency of monitoring, and often allows for the scope of the monitoring to be altered with the approval of the EPA. Where ongoing monitoring indicates compliance with the licence limits over a significant time period, the company may apply to the EPA for a reduction in their monitoring requirements, or to amend the parameters that are required to be monitored. The EPA also commissions stack testing at licensed sites. EPA data is used to assess compliance, and can also be used to indicate whether the licensee’s monitoring data is reliable. All reports, whether self-monitoring or EPA-generated, are placed on the public file. Monitoring data that is found to exceed the licence limit value may be the subject of enforcement action up to, and including, prosecution.

It is important to point out that the scope of this guidance note is confined to *manual stack emission monitoring* (stack testing) only (otherwise known as periodic or dis-continuous monitoring). It does not cover the use of continuously operating Automated Measuring Systems (AMS), although these systems do depend on the use of periodic stack testing for the purpose of their calibration. A separate guidance note ([AG3](#)) has been developed for the implementation of EN14181 in Ireland, (EN14181 is a standard that deals with the Quality Assurance of AMSs).

Note: the term ‘Continuous Emission Monitoring Systems’ (CEMs) is often used instead of AMS

### 1.3 Scope of guidance note

One of the central tenets of modern environmental regulation is that the information is made freely and suitably available to the public. In the case of atmospheric emissions from licensed sites the following groups have a role to play:

- EPA staff, both licensing personnel that formulate the limit values and monitoring requirements and enforcement personnel that assess the adequacy and compliance of the data;
- The licensee who must either procure the services of a commercial contractor (test house) or provide an in-house testing capability;
- The commercial contractor(s) who conduct the field-work and analysis of the samples.

The regulatory system that exists in Ireland covers a very broad range of emissions and limit values. In volumetric flow rate terms, this ranges from laboratory fume hoods as low as 50 Nm<sup>3</sup>/hr to power plants at over 1,000,000 Nm<sup>3</sup>/hr, while emission concentration limits can range from as little as 0.10 ng/Nm<sup>3</sup> for dioxins and up to 1,700 mg/Nm<sup>3</sup> for sulphur dioxide.

The monitoring frequency at these points can vary, but the normal range of frequency is from monthly to annually. While some licences stipulate the monitoring method to be employed, other licenses require the chosen method to be agreed with the EPA after the licence has been issued.

Whereas the most frequent use of stack testing is for the purpose of compliance monitoring, there are many other instances where stack testing may be required, these include;

- The generation of emissions data as part of the licence application or licence review process. The EPA has encountered many instances in which unreliable data has been provided at the application phase and compliance problems arise when alternative methods are employed post-licensing. It is particularly important that the licence application data is based on good monitoring practice as outlined in this note and the use of appropriate standard methods;
- The reporting of emission inventories at national and international level (e.g. Pollutant Release and Transfer Register (PRTR) – <http://prtr.epa.ie>);
- Commissioning of process or abatement plant to confirm that emission levels meet the manufacturers' or regulators' specification. Stack tests are an integral part of the abatement plant test programme that is a condition of many licences;
- Supporting data for air dispersion models that are used to evaluate the impact of atmospheric emissions.
- The generation of data for use in mass balance calculations, and the study of fugitive and non-scheduled releases;
- Assessment of process efficiency or process control;
- The validation of a proposed sampling/measurement method through the comparison with a Standard Reference Method.

The EPA has published a separate guidance note (AG3) on the implementation of the EN 14181 standard for the quality assurance of Continuous Emission Monitoring Systems (CEMS).

In addition to the IE, IPC and Waste licensing regimes, there are other forms of environmental regulation that can require the need for stack testing. This guidance should also assist where monitoring of emissions to atmosphere is required at some other types of facilities that are subject to the following statutory control:

- Emission Trading (Emissions Trading Regulations <sup>ix</sup>);
- Petroleum Storage (Control of VOC emissions Regulations <sup>x</sup>).
- Medium Combustion Plant (MCP regulations).

This guidance describes current best practice in stack emission monitoring, and it establishes criteria that should be met by those conducting this work. A separate document (available on-line) provides a listing of preferred standard methods that will serve to harmonise Irish monitoring practices with other EU member states. The latest version of this Index of Preferred Methods can be found [here](#).

## **1.4 Other sources of information on stack emission monitoring**

### **1.4.1 IPPC Bureau**

The European IPPC Bureau (EIPCB) produce a series of reference documents (BREF notes) pertaining to the industrial sectors that are subject to regulation under the Industrial Emissions Directive. Included among these notes is the BREF note on the Reference Report on Monitoring of Emissions to Air and Water from IED installations. This document provides information to guide permit writers and operators of installations in meeting their obligations under the Directive with regard to monitoring requirements of industrial emissions at source.

### **1.4.2 CEN (the European Standards Organisation)**

Comité Européen de Normalisation (CEN) is the European standards body whose responsibility includes the development of new standard methods for the measurement of air pollutants. A number of these standard methods have been published in recent years and more will follow in the future. It is mandatory for these standards to be adopted at national level in all EU member states. The Irish standard methods can be purchased from the National Standards Authority of Ireland NSAI. Standards that are currently in the course of development can be found at CEN TC264 web site, which is the CEN Technical Committee for Air Quality.

### **1.4.3 The Source Testing Association**

The Source Testing Association (STA) is based in the UK and was formed in 1995. It is a non-profit organisation that represents businesses that are involved and have an interest in air emission measurement. The majority of its members are in the UK, but its international membership is growing, and a number of these are Irish-based organisations. Some of its aims and objectives are;

- Contribute in the development of industry standards, codes, safety procedures and operating principles;
- Encourage the personal and professional development of practicing source testers and students;
- Maintain a body of current sampling knowledge.

The STA web link is [www.s-t-a.org](http://www.s-t-a.org)

### **1.4.4 Monitoring Certification Scheme (MCERTS)**

MCERTS is the Environment Agency of England's scheme that provides for the certification of equipment, persons and accreditation of organisations that are involved in the measurement of emissions. MCERTS-accredited testing is a mandatory requirement of the Environmental Permitting Regulations in England and Wales. The [EA web site](#) contains a range of valuable information on stack testing, which includes:

- Technical guidance notes;

- Method Implementation Documents;
- Information on certification of personnel and equipment;
- Information on accreditation of organisations;
- A tool for assessing the monitoring arrangements of operators.

#### **1.4.5 US EPA**

The US EPA was one of the earliest sources of references on stack testing methods, particularly when there were no national standard methods. With the advent of CEN standards, the use of the US EPA standards within European facilities has been in decline.

Comparatively speaking, US EPA standard methods are very prescriptive. This makes it difficult for a test house outside of the USA to comply fully with the method. Those that do comply however can expect to achieve a high degree of repeatability of measurement. The following US EPA web link accesses the [Emission Measurement Centre](#) directly.

## 2 EPA minimum criteria for air emissions monitoring

To ensure the generation of consistent, high quality and robust stationary source emissions monitoring data from EPA licensed sites, the EPA specified minimum acceptable criteria for this monitoring from 1 January 2014, which were as follows:

- Contracted monitoring: From 1 January 2014, the EPA requires that where periodic (i.e. not continuous emissions) monitoring of stack gas is carried out at EPA licensed sites, the work is completed by an EN ISO/IEC 17025 accredited organisations (to include the relevant pollutants within the scope of accreditation);
- Monitoring by in-house teams: Where monitoring work is carried out by in-house teams, the organisation is not required to hold EN ISO/IEC 17025 accreditation, but must meet criteria specified by the EPA in order to be permitted to continue carrying out the monitoring work as required by the licence, and may be subject to audits to assess the adequacy of the monitoring.

### 2.1 Contracted monitoring

#### General requirements

From 1 January 2014, the EPA requires that contractors carrying out monitoring of stack gas emissions to atmosphere are accredited to the EN ISO/IEC 17025 standard, if they wish to monitor these parameters at EPA-licensed sites. It is important to note that the laboratory analysis must also be accredited to the standard. The minimum requirements for accreditation and the applicable dates were:

- From 1<sup>st</sup> January 2014: Total particulates, NO<sub>x</sub>, SO<sub>2</sub>, CO, TVOC (by FID), dioxins, velocity and temperature, oxygen, and moisture. Where monitoring for other parameters is to be carried out, the parameter must be included within the EN ISO/IEC 17025 management system documentation (procedures, etc.) to assure the quality of the monitoring;
- From 1<sup>st</sup> January 2015, the following additional parameters were included: HCl, formaldehyde, metals, and speciated organics. Where monitoring for other parameters was carried out, the parameter must be included within the EN ISO/IEC 17025 management system documentation (procedures, etc.) to assure the quality of the monitoring.

A contractor may choose not to include some of the specific parameters listed above within their scope of accreditation, but in such cases the EPA will not accept any monitoring results for those parameters which are not within the contractor's scope of accreditation (once the relevant deadline had passed). Where a contractor wishes to monitor for parameters which are not specifically listed above, the parameter to be monitored must still be included within the EN ISO/IEC 17025 management system and documentation.

- From 2016, the EPA recommended that any additional parameters that may be considered commercially viable, e.g. HF, ammonia should be added to the scope of accreditation. However, failing this, where a contractor wishes to carry out monitoring for a given pollutant, inclusion within the EN ISO/IEC 17025 management system will suffice for these parameters. Monitoring for such parameters shall, as a minimum, be carried out in line with the requirements of the EPA AG2 guidance document.
- From 1<sup>st</sup> January 2019, accreditation is required for the following additional parameters: Ammonia, Hydrogen Fluoride, and Carbon Dioxide (for stack gas density calculation in combustion processes only).

Deadlines for use of EN ISO/IEC 17025 accredited contractors (by pollutant)				
	Must be accredited by Jan 2014	Must be accredited by Jan 2015	Must be accredited by Jan 2019	QMS & documented procedures (examples)
Parameters	<ul style="list-style-type: none"> <li>- Total particulates (low &amp; high range)</li> <li>- NO<sub>x</sub>, SO<sub>2</sub>, CO</li> <li>- VOC (by FID)</li> <li>- Velocity and temperature</li> <li>- Dioxins</li> <li>- Oxygen</li> <li>- Moisture</li> </ul>	<ul style="list-style-type: none"> <li>- HCl</li> <li>- Formaldehyde</li> <li>- Metals (incl. mercury)</li> <li>- Speciated organic carbon e.g. TA Luft organics (I, II, III)</li> </ul>	<ul style="list-style-type: none"> <li>- Ammonia</li> <li>- Hydrogen Fluoride</li> <li>- CO<sub>2</sub> (for air density calculation in combustion processes only)</li> </ul>	<ul style="list-style-type: none"> <li>- Odour</li> <li>- Mercaptans,</li> <li>- Hydrogen sulphide</li> <li>- Amines,</li> <li>- CVOC's, phenol</li> <li>- Total aldehydes</li> <li>- Isocyanate, methanol, MDI</li> <li>- Bioaerosols, Methyl Isobutyl Ketone (MIBK)</li> <li>- Isopropanol Note 1,</li> <li>- Isopropyl acetate</li> <li>- PM10 PM2.5</li> <li>- others</li> </ul>
<p>Note 1: Some of these parameters may be specified as stand-alone limits, other times they may be included as part of TA Luft Class I, II, &amp; III limits. It is preferable for the analytical laboratory to be accredited for the organic substances being targeted. The following suite of substances will cover most applications:</p> <p>Ethanol, Cyclohexane, Acetone, 2-Propanol, Dichloromethane, Ethyl Acetate, Hexane, Heptane, Methyl Ethyl Ketone, Methyl-iso-,butyl Ketone, , Toluene, m + p- Xylene, o-Xylene , tetrahydrofuran, Trichloroethylene, Tetrachloroethylene, Chlorobenzene, Cyclohexanone, Benzene, Carbon Tetrachloride, Chloroform, 1,2- Dichlorobenzene.</p>				

**Applicability**

The above requirements are initially applicable to stationary source emissions monitoring in stacks/ducts/vents or hoods and biofilters at EPA licensed installations/facilities.

Accredited monitoring services will not be required for other emissions monitoring, such as monitoring of landfill gas emissions from the surface of landfills and monitoring of surface emissions from open biofilters (though accredited monitoring will be required for monitoring of emissions from landfill gas flares and engines, which are typically monitored for combustion gases and TVOCs). Accreditation may be required for such monitoring in the future.

For Medium Combustion Plants with a rated thermal input greater than 5MW, the EPA will not accept monitoring results from a monitoring contractor who does not hold accreditation to the ISO17025 standard.

The EPA can provide clarification on the requirements for accredited monitoring where uncertainties arise on specific sites, (contact [airthematic@epa.ie](mailto:airthematic@epa.ie)).

### Quality Management System for pollutants not requiring accreditation

The contractor will be required to have a documented Quality Management System (QMS) in place, including a clearly documented procedure for the non-accredited parameters which is broadly in line with the objectives of EN ISO/IEC 17025 (training records, equipment maintenance protocols, etc. in line with what is described in AG2). This may then be audited by the EPA.

As a minimum, all emissions monitoring must be carried out in line with the requirements of EPA Air Monitoring Guidance Note AG2. This includes the use of relevant standards in line with the [Index of Preferred Methods](#).

In very exceptional circumstances the EPA may agree (under the relevant licence conditions) an alternative method that is not in the Index of Preferred Methods where it can be justified by the licensee. This includes the use of electrochemical cells for flue gases monitoring.

## 2.2 In-house monitoring

EPA Air Monitoring Guidance Note AG8 provides a detailed instruction for sites that wish to engage in in-house monitoring.

The BAT Reference Document on the Reference Report on Monitoring of Emissions to Air and Water from IED installations makes specific reference to self-monitoring and indicates that 'for self-monitoring activities the use of recognised quality management systems, and periodic check by an external accredited laboratory instead of formal own accreditation *can be appropriate*'. The EPA deems this approach to be appropriate, *specifically in relation to monitoring being carried out by licensee's own staff*. This is in line with practices in some other European countries where accreditation may not be required for in-house monitoring teams if other specified criteria are met.

### Advance approval of in-house monitoring

Any licensee proposing to monitor emissions to atmosphere from a licensed emission point for assessment of compliance with a licence emission limit value must notify the EPA of the scope of monitoring proposed to be carried out by the licensee (standard form be provided for licensee to complete with all the necessary details) including the parameters to be monitored at each emission point, the method to be used, the competence of the personnel carrying out the monitoring, any external analytical requirements, and the frequency of monitoring.

As a minimum, all emissions monitoring *must* be carried out in line with the requirements of EPA Air Monitoring Guidance Note AG2. This includes the preparation of relevant procedures, training records, quality control documents, etc. In very exceptional circumstances, the EPA may agree an alternative method where it can be justified by the licensee. However, apart from under very exceptional conditions, the method employed should be one from the [Index of Preferred Methods](#).

The site must, where requested, notify the EPA in advance of all in-house compliance related monitoring exercises. This monitoring work may be audited by the EPA, or by an appointed contractor. The costs of this inspection will be charged to the licensee as part of their annual financial charges. Where a licensee fails to address deficiencies identified in their in-house monitoring, the EPA may not accept in-house generated results and may require the licensee to employ EN ISO/IEC 17025 accredited contractors.

In addition, third-party check monitoring by an EN ISO/IEC 17025 accredited contractor must be carried out at one of the licensed emission points on an annual basis as a cross-check on the

licensee monitoring. The data obtained during this cross-check monitoring can be used to generate a separate monitoring report for the purposes of scheduled licence compliance monitoring, but this requirement will be kept under review and will be dependent on the site's performance.

In-house monitoring shall also address the following requirements:

- Where the parameter requires mandatory accreditation in the table above, and an external contract laboratory is to be used for analysis of collected samples, this laboratory must be accredited to EN ISO/IEC 17025 (for the parameter being analysed), i.e. the same requirement as for stack testing contractors.
- As part of the documentation system the licensee will need to specify the minimum criteria required for personnel carrying out emissions monitoring. This will be subject to EPA review and comment;

Note: These requirements for in-house monitoring exclude monitoring for emergency purposes or process monitoring, for example monitoring of emissions in the event of a failure of a primary emissions monitoring system or process monitoring not for reporting compliance against limit values.

### 3 Stack emission monitoring – first principles

This section introduces some basic principles of stack emissions monitoring, these principles apply to all stack testing campaigns regardless of the pollutants being measured or the purpose of the measurements. It sets out the basic types of monitoring activity, and the best-practice criteria to which an organisation should adhere if it is to produce credible emissions data. The section also discusses the units of measurement, and the concept of reference quantities (i.e. oxygen and moisture).

#### 3.1 Types of monitoring

A stack emissions test involves the determination of one or more of the following;

- Pollutant mass or volume concentration;
- Reference quantities;
- Mass flowrate or a volumetric flowrate.

These determinations are covered by two basic types of site activity:

- Sample collection: The collection of stack gas samples for subsequent laboratory analysis;
- Direct measurement: The on-site measurement of stack gas properties using portable analysers.

The following sections describe the best practice criteria that apply to the two types of monitoring, both collectively and individually. Appendix 1 – On site Quality Assurance (QA) checks in standards for commonly measured pollutants, provides an audit checklist to aid the assessment of an organisation's performance against the requirements of the commonly used standard methods.

#### 3.1.1 Best practice for sample collection and direct measurement

The following are general criteria that should be met in all cases:

- The stack gas which is sampled/measured should be representative of the stack gas as a whole;
- The technique employed, particularly the volume sampled and the analytical measurement method, is suited to the pollutant and the application, (e.g. range, analytical limit of detection, linearity, response time, and measurement uncertainty);
- The sample/measurement system is leak-tight (demonstrated by field tests);
- The material and condition (e.g. temperature) of the sample/measurement systems is such that there is neither loss of pollutant nor addition of interfering species or contaminants;
- Any supporting measurements that are required such as volumetric flowrate, oxygen and moisture are conducted using suitable techniques and are simultaneous with the sampling/measurement process.
- Operation of equipment and subsequent recovery and handling of samples should be conducted in a way that avoids contamination.

#### 3.1.2 Best practice specific to sample collection

Sample collection requires the extraction of a measured volume of stack gas from the main gas stream using a vacuum pump. The sample stream is generally removed via a sample probe (often heated to prevent condensation) and the pollutant of interest is collected in a sample trap. Typical sample traps include filters for the removal of particulate matter, impinger bottles (bubblers) containing a liquid solution that absorbs the pollutant from the sample stream, and solid adsorbents

such as activated charcoal, silica gel, or a specific polymeric resin that adsorbs the pollutant onto its surface. The relevant Standard Reference Methods contain performance specifications. Examples of the factors that are critical to stack tests using sample collection are:

- The volume of gas sampled is accurately measured and corrected to standard conditions of temperature and pressure (e.g. using a cumulative gas meter, a critical orifice or a flow rate meter in unison with a stopwatch);
- The volume of gas sampled is sufficient to ensure that when the Limit of Detection (LoD) of the laboratory measurement system is taken into account, LoD is low enough to satisfy the monitoring objective; Some manual methods specify a LoD in terms of a percentage of the ELV (usually 10%).
- Particulates and droplets are sampled isokinetically, and using a grid-measurement approach where appropriate;
- The sample trap is recovered with the necessary care, uniquely labeled, appropriately stored and transported with chain of custody to the analytical laboratory. Some manual methods specify sample storage and transport requirements;
- Where impingers traps are utilised that there is sufficient contact time and that there is a sufficient number of traps to ensure quantitative capture, and to assess carryover of any pollutant between traps. For solid phase traps where a “one-shot” analysis, such as Thermal Desorption Gas Chromatography-Mass Spectrometry (GCMS) is employed, a second charcoal tube should be utilised (in parallel) to facilitate analysis by Solvent Desorption chromatography. Manual methods usually specify a requirement for capture efficiency of the impinger train;
- Field blanks are an important part of quality control in manual sampling, as they are used to ensure that no significant contamination has occurred during all the steps of the measurement. This includes the equipment preparation, transport and installation on-site, as well as the subsequent analytical work in the laboratory. EN standard methods specify procedures for performing field blanks. Generally, a field blank is taken at the operator’s site in an identical manner to the normal samples in the measurement series; except that the probe does not have to be inserted into the stack and no gas is drawn through the sample train. Unless a standard method specifies alternative criteria, the field blank result is acceptable if it does not exceed 10 per cent of the emission limit value (ELV). If this requirement is not met, then a retest is necessary.

### 3.1.3 Best practice specific to measurement using portable analyser

Portable analysers can be used to measure gas concentration directly on site. An integrated sample pump extracts waste gas from the stack and delivers it to the measurement chamber in the analyser. Analysers measure gas concentrations in volume terms (e.g. ppm) the data are converted to mass-based concentration ( $\text{mg}/\text{Nm}^3$ ) using the molecular weight of the determinands.

There is a range of measuring principles that can be employed; for example, Flame Ionisation Detection (FID) for organic species, Chemiluminescence for oxides of nitrogen, Non-Dispersive Infra-Red or Fourier Transform Infra-Red (FTIR) for sulphur dioxide, etc. The analysers may be of the fully portable variety that are brought to the sampling platform or the semi-portable variety that remain at ground level (usually in a mobile laboratory) and the stack gas is delivered to analysers via a heated sample line. Some of the more complex analysers provide qualitative analysis of unknown pollutants (e.g. Scanning FTIR or portable GCMS). However, as a general rule, the more complex the equipment, the greater the need for good quality assurance practices and highly trained operators. The factors that are critical to stack tests using portable monitoring equipment are:

- The range of the analyser is appropriate to the purpose of the measurement. In general, the lower the range, the more accurate the measurement. This is because accuracy is usually expressed as a percentage of range. So, for example, it would not be appropriate to use an analyser whose range is 1 to 100 mg/Nm<sup>3</sup> to measure pollutant levels in and around an emission limit value of 5 mg/Nm<sup>3</sup>;
- Calibration before and after measurement using standards that are traceable to certified reference materials. In general, the standard gas mixtures used should be in line with the expected measurement concentration [or at the very least the emission limit value (ELV)]. The relevant Standard Reference Methods contain requirements for the specifications of measurement equipment and calibration (span) gas and zero gas, as well as procedures for setting up the analyser and sampling system on site;
- An annual systems check using high concentration gas standards. These checks provide an assurance that the analyser can reliably measure at concentrations above the normal emission limit values.
- The analyser is free from any interference that can be caused by substances in the waste gas other than the determinand;
- The analyser is suited to the environment in which it is being operated;
- A non-specific detection system cannot be used to measure the levels of a specific chemical substance in an emission, unless that substance is the sole component of the emission to which the detection system is sensitive and the instrument response factor for the substance is known, (e.g. the use of a portable FID to measure levels of toluene in an emission).

### 3.2 Units of measurement

Three units of measurement are commonly used to describe emissions to atmosphere. These are the basis of emission limit values that are set in licences;

- Mass concentration: The mass of pollutant per unit volume of waste gas emitted (e.g. mg/Nm<sup>3</sup>);
- Volume concentration: The volume of pollutant per unit volume of waste gas emitted (e.g. ppm, ppb);
- Volumetric flow rate: The volume of waste gas emitted per unit time (e.g. Nm<sup>3</sup>/h);
- Mass flow rate: The mass of pollutant emitted per unit time (e.g. kg/h or g/s).

#### 3.2.1 Normal temperature and pressure

Units of mass concentration and volumetric flow rate contain a volume term (e.g. m<sup>3</sup>). The volume of a gas is dependent on its temperature and pressure. The convention employed is to correct the flow and concentration values relative to a predefined temperature and pressure, known as standard reference conditions. Mass concentration and volumetric flow rate results must be corrected to standard reference conditions before comparison with a licence emission limits values.

The following text is taken from the Monitoring BREF *In the context of the IED and the BREFs, the terms reference conditions and standard conditions are often used in the same sense and are thus interchangeable. This usually means that the measured emission concentrations are converted to a temperature of 273.15 K and a pressure of 101.3 kPa. In many cases, the standard conditions also include a reference oxygen level and a correction to dry gas, (e.g. for flue-gases from combustion or incineration processes).*

Standard reference conditions of Temperature and Pressure are defined as 273.15K and 101.325 kPa. This is usually referred to as STP.

*Note: Historically, this has also been referred to as Normal Temperature and Pressure and a cubic metre expressed on this basis as Nm<sup>3</sup>.*

The equations that are used to correct emission data to STP are demonstrated in Appendix 2 – Calculations.

### 3.2.2 Mass emission flow rate

The majority of licence limits are set in terms of mass concentration limits (e.g. 100 mg/Nm<sup>3</sup>). A smaller number of licence limits are set in terms of mass emission rate (e.g. kg/h), which defines the absolute quantity of material emitted in any time period.

Mass emission rate = Mass concentration x volumetric flow rate.

The calculation is only valid when the concentration and volumetric flow terms are expressed on the same basis with respect to temperature, pressure and reference conditions (oxygen and water vapour).

The use of this equation is a common source of error in the reporting of stack emission measurements, (see examples in Appendix 2 – Calculations).).

A **mass flow threshold** (e.g. > 2 kg/h) is a mass flow rate, above which, a mass concentration limit applies (e.g. 100 mg/Nm<sup>3</sup>). This form of limit value is typically set at vents that exhibit very low volume flow rate, (nb.: volume flow rate measurement must always form part of the emission testing programme, if flow is not detected then the method limit of detection must be stated).

### 3.3 Reference quantities

In order make comparisons (e.g. to avoid dilution effects or changes in stack gas moisture content), reference quantities are used to correct an emission result to a standardised format (i.e. standard reference conditions). In general terms, the requirement to correct emission data to standard reference conditions of oxygen and moisture arises primarily for combustion processes and the calculations use data on the oxygen and moisture content of the waste gas.

There are well-established conventions for reporting emission data, and these have been adopted in EU directives and are included in licences, where relevant.

In such cases, both mass concentration and volumetric flow data undergo correction to reference conditions. The measurement of reference quantities in the stack gas (oxygen and moisture) is therefore essential in these cases. The measurement of reference quantities should be conducted simultaneously with the measurement of pollutant concentration (and flow if necessary).

### 3.3.1 Oxygen

The combustion of a carbon-based fuel consumes oxygen. The oxygen content present in the combustion air (approximately 21.0%) that is fed to a furnace will be depleted to some lower level in the exhaust gas.

EPA licenses typically require emission data from combustion sources to be reported at reference oxygen conditions. Determination of stack oxygen levels must coincide with pollutant monitoring.

Reference oxygen conditions are defined according the type of fuel and combustion system. For example:

- Gas and liquid fuels - 3% reference O<sub>2</sub>;
- Solid fuels - 6% reference O<sub>2</sub>;
- Waste incineration - 11% reference O<sub>2</sub>;
- Gas turbines - 15% reference O<sub>2</sub>;
- Other fuels (e.g. fume thermal oxidiser):- The application of reference oxygen conditions will be determined on a case-by-case basis. The reference oxygen level is an inherent part of the abatement plant design and its value shall be determined by way of a test programme when the plant is being commissioned;
- Emissions from all sources: Temperature 273.15K, Pressure 101.325kPa (**no correction for oxygen or water content**). For example, this may apply to the wood panel industry, which have combustion plants as an integral part of the drying process and necessarily dilute with ambient air to effect control of the drying process.

The equations that are used to correct emission data to reference oxygen conditions are demonstrated in Appendix 2 – Calculations.

### 3.3.2 Moisture

Correction of emission data for moisture is necessary for certain types of sources. The combustion of a carbon fuel forms moisture (water vapour, H<sub>2</sub>O) while some other emissions contain moisture by virtue of the process or the method of abatement. The presence of moisture in a gas stream takes up space that would otherwise be occupied by pollutant, so the pollutant concentration expressed on a dry gas basis will always be higher than if it were expressed on a wet gas basis. The reverse is true for volumetric flow rate or sample volume data. Measurements made on a 'wet basis' (e.g. heated FID c/w heated sample line) often need to be corrected to a 'dry' basis before comparison with ELVs.

Licences typically require emissions from combustion plant to be reported on a dry gas basis. Sampling and determination of stack moisture must coincide with pollutant monitoring.

The equations that are used to correct emission data to reference oxygen conditions are demonstrated in Appendix 2 – Calculations .

The following are a number of points that are worth noting in relation to moisture in stack gases.

- Water present as a vapour occupies 1,000 times the volume of water that is present in liquid

form (droplets);

- Droplets in a gas stream can make compliance assessment more complex. The droplets can themselves contain pollutant species or a derivative of the pollutant, which is not the subject of an emission limit value. When it is deemed necessary to sample droplets, the sampling for pollutant determination should be isokinetic. A separate sampling run for moisture determination only should account for the vapour phase moisture only and should employ a straight probe (without sample nozzle) and low flowrate sampling (~1 – 5 l/min);
- Some emission limit values are expressed on a wet gas basis. Where the monitoring technique has dried the gas prior to measurement then the results will need to convert back to the wet basis using the stack gas moisture result.

## 4 Planning and factors affecting the monitoring process

The production of monitoring data follows several consecutive steps that all need to be performed according to either standards or application specific instructions to ensure good quality results. Those steps are:

- Planning;
- Site measurement;
- Reporting results.

The steps in each process are shown in Figure 1.

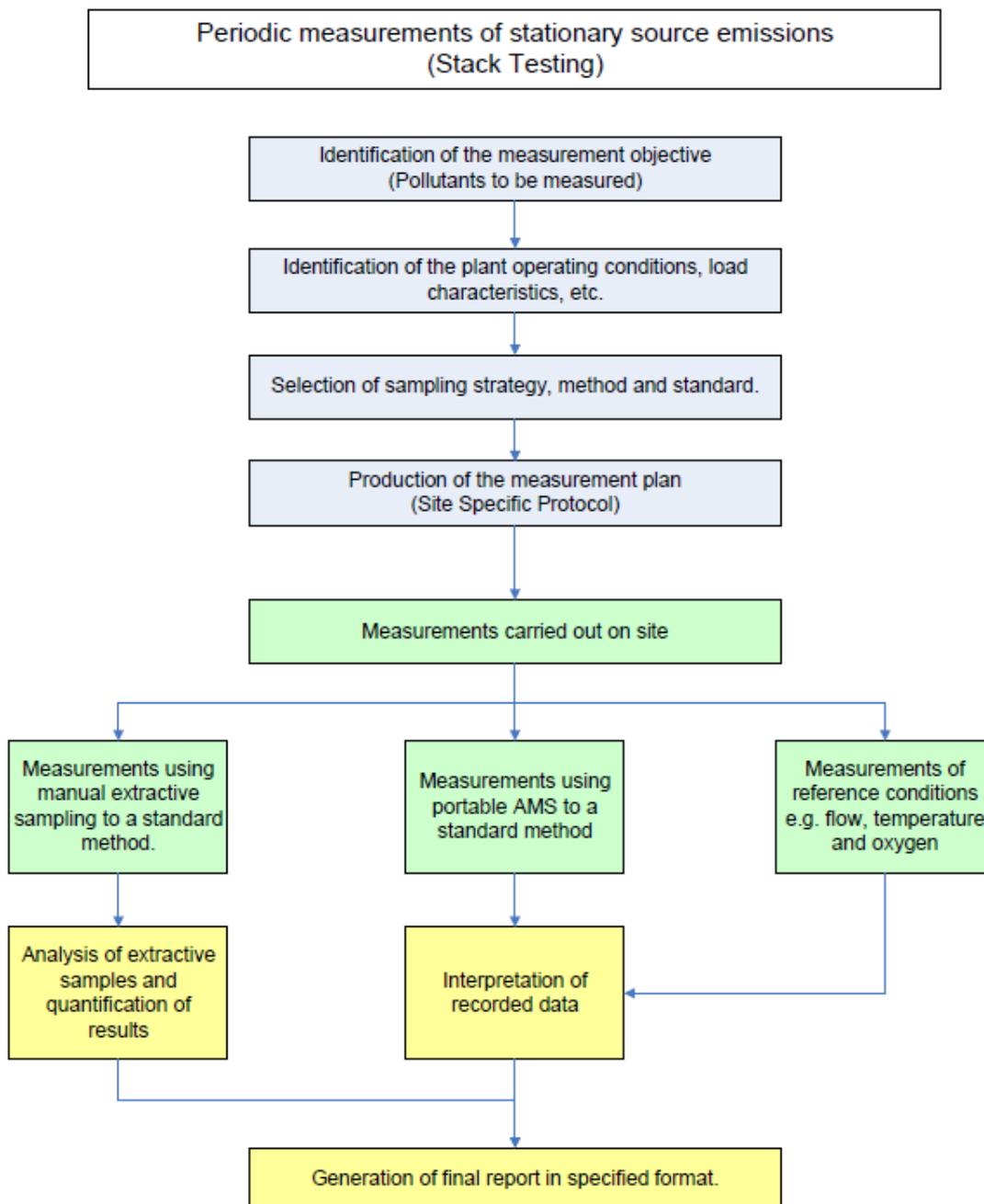


Figure 1 The monitoring process

## 4.1 Planning to meet the monitoring objective

Standard method *EN 15259, Air Quality – Measurement of stationary source emissions – Measurement strategy, measurement planning, reporting and design of measurement sites*, defines the requirements in relation to planning a monitoring campaign.

Without proper planning, a monitoring project can expend a substantial amount of time and effort, and produce little of value at its conclusion. A monitoring project, like any other, must have a clear objective that is understood by all parties involved in the project and at all levels, (e.g. the field technician must be as familiar with the objective as his/her management team). Once the objective is defined, then a monitoring plan must be designed and agreed by all parties. The measurement plan is often referred to a ‘Site Specific Protocol’.

These planning tools are discussed further in Chapter 9, and an example is given in Appendix 3 (Site Review) and Appendix 4 (Template, Site Specific Protocol).

### The two key elements in the planning of a stack emission monitoring campaign:

- Site reconnaissance and review: A preliminary visit to the monitoring site, which identifies and records essential information for determining an appropriate measurement method and developing a site-specific protocol. A site review must also include a safety risk assessment;
- Site specific protocol (SSP): A protocol specific to the monitoring site, which describes methods to be employed, and the factors to be controlled to ensure the validity of monitoring results. The Agency may request to inspect a SSP prior to monitoring being carried out

## 4.2 Compliance monitoring

Some of the many possible reasons for conducting stack testing were outlined in Section 1 (e.g. determination of abatement efficiency, process modification, the calibration of continuous emission analysers, etc.). However, for the purpose of this section, the focus will be on the most common reason, licence compliance.

In the case of the licensee conducting self-monitoring, there are two issues of compliance that must be addressed. Firstly, the licensee must conduct the monitoring in the manner prescribed in the licence and in accordance with this guidance note. Secondly, the monitoring results should not exceed the emission limit values.

When the objective of monitoring is compliance assessment, the licence should be the first source of reference in the design of a monitoring plan. The following sections detail the key questions that must be addressed by the plan.

### 4.2.1 Where to monitor

To demonstrate compliance with an emission limit value (ELV), the monitoring must be conducted post-abatement plant so that the waste gases are representative of those that are released to atmosphere. When determining gaseous species, the monitoring plane must be such that the waste stream is homogenous across the plane otherwise appropriate modification must be made to the monitoring technique. Further information is available in EN 15259 (S8.3, Determination of homogeneity) and in the Index of Preferred Methods.

When determining duct volumetric flow rate and/or sampling isokinetically especially for particulates, the monitoring plane must be in a section of duct, which contains a sufficiently steady and even flow profile, in order to achieve representative sampling. The EPA’s Guidance Note (AG1)

and EN 15259 provide further detail to ensure that the monitoring site is located to meet these criteria. The mere presence of monitoring ports is not grounds for the selection of the monitoring plane.

**Selection of monitoring location**

Emission monitoring should be conducted at a location that permits a representative determination of the pollutant levels being emitted to atmosphere. The EPA require a risk-based assessment when a decision is being made on the need for a homogeneity test in accordance with EN 15259 (see further detail in the Index of Preferred Methods).

In situations where for reasons of safety, or historical reasons, the monitoring site is not located at the optimum position (as defined in the standard method) then deviations from the standard may in some exceptional circumstances be employed with the agreement of the EPA. Under these circumstances, estimation of the uncertainty of measurement is complicated and not possible to quantify.

**4.2.2 When to monitor**

Several time-based factors are relevant for the monitoring of stack emissions generally and for licence compliance in particular. They are:

- The time period within the overall process over which the sample/measurement is taken;
- The averaging time (duration) during which monitoring occurs;
- The frequency of monitoring.

By its nature, self-monitoring bestows the licensee with a great deal of control over the timing of compliance assessment measurements. The time at which the measurement is conducted should depend on the process. A process that is known to generate steady state emissions can be measured at any time. When the process emissions vary with time, then information will be needed about those factors that affect the emission level so that the timing of the measurement can properly reflect the average emission (e.g. for use in IPPC/IE licence application) or the maximum emission (e.g. for use in compliance assessment).

**Monitoring at peak emission**

Periodic monitoring for compliance assessment purposes should be conducted when the process is at a maximum sustainable level (where reasonably practical). The monitoring team must liaise with the licensee so that they are aware of the relevant activities and processes taking place during the test period, and this detail should be included in the test report.

The scheduling of monitoring campaigns must take account of this requirement. The monitoring report must detail the process conditions (preferably through the use of Emission Indicating Parameters along with the emission results).

In relation to the duration of a measurement, the interpretation clause of most licences issued by the EPA states that “no 30-minute mean value shall exceed the emission limit value.” There are some exceptions to this rule including certain limits that derive directly from EU Directives (e.g. dioxin monitoring). What this means for most monitoring campaigns, is that any individual sample on which a single measurement value will be made should be collected over, at least, a 30-minute period. It may be necessary however to collect some pollutants over a period exceeding 30 minutes which is long enough to collect a measurable amount of pollutant (e.g. particulate, metals and

dioxin/furans). In such cases, the monitoring time may require to be defined, particularly where discharge rates are very low, in order to meet criteria necessary for robust analysis and assessment. Where such circumstances prevail, the above interpretation cannot be applied and a pragmatic assessment (possibly using a pro rata approach) of the likelihood of non-compliance is required.

Direct measurements using an analyser making discrete measurements at very short time intervals (e.g. every five seconds for FID or 1 minute for FTIR), should ideally cover a period of not less than 30 minutes with the highest 30-minute average being reported. In the case of volume flow, the licence typically states, “*no hourly or daily mean value, calculated on the basis of appropriate spot readings, shall exceed the relevant limit value*”. This means that the volumetric flow rate readings taken over a shorter period may be extrapolated to hourly or daily values provided there are no significant variations in flow that would render the extrapolation invalid. Where assessment of compliance requires averaging of multiple monitoring periods then the integrated average value for each monitoring period (e.g. 3 x 30 minutes) should be averaged to determine the reportable value. This reportable value should be quoted together with the range of measurements used for its calculation.

#### **Period of monitoring**

In most cases, compliance tests are based on a 30 minute monitoring period (i.e. 30 minute average). There are some exceptions to this rule, and these exceptions will be detailed in the Interpretation Condition of the licence<sup>a</sup>.

The licence defines the frequency of self-monitoring. When determining the frequency, the EPA seeks to balance the requirement for monitoring with the emission characteristics, risk to the environment, practicalities of sampling, and the costs. Occasionally, the monitoring frequency for a pollutant which is particularly difficult or complex to measure/ analyse can be reduced by maintaining a higher monitoring frequency of a parameter whose concentration is related to the original, but which may be more practicable or cost-effective to measure (e.g. the measurement of total particulate in place of its constituent components such as the active pharmaceutical ingredient). Where the emission derives from a variable or batch type process (e.g. different solvents used in pharmaceutical batch processing) then the timing of successive monitoring campaigns (e.g. over the year) should seek to cover all emission scenarios with priority being given to those that present greatest risk to the environment.

The philosophy behind determining timing requirements is discussed in the [Reference Report on Monitoring of Emissions to Air and Water from IED installations](#).

### **4.2.3 Multiday monitoring campaigns**

The completion of a monitoring campaign may take several days, depending on the number of parameters to be tested, and the minimum sampling times. On those occasions where reference conditions for oxygen and moisture apply, measurements of oxygen and moisture shall be carried out on each day of the campaign and representative values of oxygen and moisture shall be used for correcting results to standard reference conditions for those parameters tested on each day.

If results must be presented in mass emission units then the volumetric flow shall be calculated at each day where parameters to be expressed in mass emission units are tested.

<sup>a</sup> In the case of periodic monitoring an instrumental technique will typically be employed for just 30 minutes and the average of all readings collected over that period will be used to assess compliance. In the case of an installed Automated Monitoring System (i.e. continuous monitoring) discrete 30-minute averages will be recorded and used to assess compliance (i.e. 2 reportable results per hour). An AMS may also be configured to produce “a rolling 30 minute average” (e.g. a new 30 minute average every minute)., [Refer also to [Air Guidance Note on the Implementation of EN 14181 \(AG3\)](#)]

#### 4.2.4 Emission Indicating Parameters

It is not uncommon for stack emission results to be reported without any further information concerning the measurement other than the time and date. Emission Indicating Parameters (EIP) allows the monitoring result to be put in context and provide relevant information about those aspects of the plant operation that influence the atmospheric emissions. They require a detailed knowledge of the plant operation, normally the preserve of plant operators. Stack emissions testing staff should identify EIPs during the site review (i.e. the reconnaissance exercise), record the status of EIPs during the monitoring visit and include this information in the monitoring report. Examples include:

- Rotogravure printing: the solvent type and content of the ink, the ink delivery rate, the press temperature, the status of abatement plant, printing rate (m/s), etc.
- Cement plant: Clinker source and loading rate, alternative fuels source and load rate, kiln temperature, oxygen level, and status of abatement plant, etc.
- Electrical generation (MW) and fuel used in case of power plants;
- Rate of material processed (tons/hour) for cement, chemical or pharmaceutical plants;
- Rate of items processed per hour for general manufacturing processes;
- Percentage with regards maximum capacity where appropriate (steam boilers)
- Incinerators: Rate of waste consumption.

The more detailed the information the more value is added to the monitoring result (commercially sensitive information may be exempted on request to the EPA). Emission trends may be identified over successive monitoring events, and the information is most valuable when estimating the long-term plant emissions (e.g. for the site Annual Environmental Report). The information may be used to modify processes and reduce emissions.

##### **Plant information to support periodic monitoring**

Relevant plant information should be included in the emissions monitoring report to enhance the value of the monitoring effort, (c.f.: Appendix 5, - Stack emission monitoring report). The onus is on the licensee to provide the information requested in Appendix 6 to the air monitoring contractor to be included in the air monitoring report

Similarly, where the stack is fitted with an Automated Measuring System (AMS), the data from the system should be used to provide a result in a form that allows direct comparison with the manual stack measurement result (i.e. averaging time, units and reference conditions). The availability of AMS data and associated information should be determined during the site review and referenced in the site-specific protocol. The onus is on the licensee to provide the contractor with this information, so it can be included in the air monitoring report.

## 5 Measurement uncertainty and data reporting

All measurements, particularly those associated with dynamic processes, such as stack emissions, are subject to an inherent doubt as to their absolute value. This is due to the combination of individual factors associated with the many variables involved in the sampling and analysis procedures. This is known as *Uncertainty of Measurement* and may be defined as the range of values within which the “true” value of any measurement could be expected to lie with a given statistical confidence.

It should be stressed that the “true” value is a conceptual term, as it can never be exactly measured (without uncertainty); however, it is important to quantify any uncertainty, so that the results can be properly interpreted.

It is important to be able to show that the measured value is “fit for purpose” by taking account of the Uncertainty of Measurement and assessing its impact on the likelihood of non-compliance. For example, a value of 6.5 mg/Nm<sup>3</sup> alone gives no indication of the range of possible concentrations. It is simply a number in isolation, whereas 6.5 ± 0.5mg/Nm<sup>3</sup> clearly defines the range of possible concentrations. This latter value plus its uncertainty of measurement implies that the “true” concentration would be likely to lie within the range 6.0 – 7.0 mg/Nm<sup>3</sup> with a defined degree of confidence (typically 95%). This enables regulatory bodies to interpret measurements and their uncertainties with respect to limit values and issues regarding demonstration of compliance. The licensees are given the benefit of the doubt, so if the result is over an ELV, but the MU brings it under the limit, then the result is considered to be compliant.

### **Measurement Uncertainty and EN ISO/IEC 17025 accredited emission monitoring.**

It is beyond the scope of this guidance to deal substantively with all aspects of Measurement Uncertainty (MU). However, the proper evaluation and reporting of MU is an inherent part of the EN ISO/IEC 17025 quality standard, and one that must be addressed by the accredited organisation. Measurement Uncertainty must be determined and reported for all test measurements. The measurement uncertainty needs to be taken into account to ensure that it is appropriate for the monitoring to be performed.

### 5.1 The Calculation of Measurement Uncertainty

A generic approach to calculation of measurement uncertainty is described in the Guide to the Expression of Uncertainty in Measurement (GUM)<sup>xi</sup>. This document describes a procedure in which individual uncertainty sources are identified, quantified and combined to provide the measurement uncertainty. This approach is often described as a bottom-up approach. There is another technique for determining the uncertainty of a measurement, which is to repeat the measurement a number of times, compare with a standard reference method (SRM), and examine the spread of the results, known as a top-down approach. This has often been used to characterise measurement methods, by performing large-scale inter-laboratory studies to determine the repeatability and reproducibility of methods.

It is sometimes assumed that these two approaches are mutually exclusive. However, if the GUM approach is followed it is possible to include all significant component uncertainties. Additional uncertainty sources may be combined, for example those not covered in a method evaluation. The GUM approach should therefore be used as the most general method. The steps that should be taken are:

- review the measurement method and identify potential sources of uncertainty;
- quantify the significant sources of uncertainty;
- combine the uncertainty components and expand to give required level of confidence, the required level of confidence must be 95% using a coverage factor (k) of 1.96;

- report the measurement uncertainty with the measurement result.

The use of the spreadsheets provided by the STA to calculate measurement uncertainty (eg flue gases, particulates, wet chemistry results, calibration gases, Pitot tubes, volumetric flow) is recommended. These are available on the STA website.

## 5.2 The Application of Measurement Uncertainty

In the case of all periodic monitoring, results for measurement uncertainty should be included with the reported result. The following measurement uncertainties are the maximum uncertainties acceptable to the EPA to assess compliance of periodic measurement results against emission limit values specified in EPA licences. If uncertainties are higher, they must be reported as a deviation from the applicable Standard.

**Table 1 - Maximum measurement uncertainties (MU) for periodic monitoring**

Species	Uncertainty (%)	MU source
TPM	± 20	EN 13284-1
TVOC	± 15	Measurement uncertainty half the value given in directives for continuous emissions monitoring systems
HCl	± 30	EN 1911
CO	± 6	EN 15058
NOx	± 10	EN 14792
SO <sub>2</sub>	± 20	EN 14791
SO <sub>2</sub>	± 15	CEN/TS 17021
HF	± 30	Given the same uncertainty as HCl due to similar reactive nature and measurement technique
NH <sub>3</sub>	± 20	EN ISO 21877
Cd and Tl	± 30	Value based on uncertainties applied by monitoring organisations.
Hg	± 20	Value based on uncertainties applied by monitoring organisations.
Dioxins and furans / PCBs	± 30	EN 1948
Speciated VOCs	± 25	Value based on information in CEN/TS 13649 and a review of uncertainties applied by monitoring organisations
Generic wet chemistry methods	± 25	Value based on uncertainties applied by monitoring organisations.
Generic sorbent tube methods	± 25	Given the same value as speciated VOCs because the sampling and analysis is similar.
Generic analyser methods	± 25	Value based on uncertainties applied by monitoring organisations.
O <sub>2</sub>	± 6	EN 14789
H <sub>2</sub> O	± 20	EN 14790
<p><b>Note:</b> These figures are taken from the Environment Agency (England) - Maximum Uncertainty Values for Periodic Monitoring .</p> <p>The values in this Table are the measurement uncertainties on the final result corrected to reference conditions (i.e. the reporting conditions required by the licence). These uncertainties therefore combine both the uncertainty from the measurement method, and any additional uncertainties from associated peripheral measurements used for correcting the result to reference conditions</p>		

Normally the EPA will use the uncertainty values reported by the organisation that carried out the

measurement. However, the quoted uncertainties should not be above these maximum values. MU values that are above the maximum may be accepted where there is an adequate explanation provided. Measurement uncertainty shall be reported, and the calculations should be available for inspection if required.

In the case of waste incineration or large combustion plant, the maximum allowable uncertainty for each parameter is set out in the licence, but this applies to continuous emission monitoring systems (CEMs) only (e.g. 30% uncertainty for particulate measurement, 20% for SO<sub>2</sub> and 40% for HCl). When a large correction is needed to express the emission at reference oxygen conditions then the MU requirements set out in the table above may be difficult to meet.

**Additional sources of information on Measurement Uncertainty.**

- ISO/IEC Guide 98-3:2008 <sup>xi</sup> – Guide to the expression of uncertainty in measurement (GUM);
- EN ISO 14956:2002 <sup>xii</sup> Air Quality – Evaluation of the suitability of a measurement comparison with a required method uncertainty;
- EN ISO 20988:2007 <sup>xiii</sup> Air Quality – Guidelines for estimating measurement uncertainty;
- The Source Testing Association has produced a guidance note for members Guidance on Assessing Measurement Uncertainty in Stack Monitoring with associated excel spreadsheets for calculating uncertainty.

**5.3 Assessing compliance with emission limits.**

Air emission reports tend to report the monitoring result next to the appropriate ELV for comparison purposes. From this it can be determined if the ELV has been exceeded. However, the licensee should also check the ELV in the licence itself, including any technical amendments to the licence, along with any specific interpretation conditions. The results should always be reported (including any required reference corrections, but without any subtraction of the measurement uncertainty). Where the measured value is above the ELV, such occurrences should be reported to the EPA as an incident.

If a reported result is above the ELV, the EPA will assess the results for compliance and may take account of its measurement uncertainty. This is achieved by subtracting the measurement uncertainty from the measured value (as follows).

**Measurement Uncertainty and assessing compliance with ELV.**

1. Determine the measurement uncertainty; the required level of confidence must be 95% using a coverage factor (k) of 1.96:

$$\text{measurement uncertainty} = (\text{measured value} \times \% \text{ uncertainty}) / 100$$

Note: the measured value should be already corrected to the licence reporting conditions.

2. Adjust the measured result by subtracting the measurement uncertainty: Adjusted value = measured value – measurement uncertainty.
3. Compare the adjusted data versus the appropriate emission limit value to assess compliance.

**5.4 Rounding and Significant Figures.**

Emission data should be interpreted to one digit more than the ELV value. For example, an ELV of 20mg/m<sup>3</sup> would need reporting to 20.0mg/m<sup>3</sup> or an ELV of 0.1mg/m<sup>3</sup> would need reporting to at least 0.10mg/m<sup>3</sup>. The need to determine the correct rounded figure is a function of the monitoring programme and is required for all monitoring, but is particularly relevant where the monitoring result is very close to the ELV. Emission limits should be calculated having regard to the least well-defined component of the measurement system, e.g. if the analytical result is quoted as an integer value then it is not appropriate to report the compliance calculation as a decimal value.

**5.5 Reporting when pollutant levels are low**

Where the industrial process has a high-efficiency abatement plant, the concentration of pollutant in the waste gas might be extremely low. The ability of a stack emissions test to detect low levels of pollutant will depend firstly on sampling factors (e.g. sample gas volume), and secondly on the laboratory capability to analyse at low levels.

Laboratory procedures are capable of achieving measurements at very low concentrations (e.g. sub-parts per million). However, while instrumentation may produce a response down to its Limit of Detection (LoD), laboratories will generally quote results to a higher Practical Reporting Limit (PRL) or Limit of Quantitation (LoQ) based on a statistical evaluation of the variation (standard deviation) of blanks and the measurement of standards at known concentrations. The PRL is typically 5 -10 times the LoD or may be the lowest calibration standard used for accredited tests. Uncertainty of measurement increases when levels are below the laboratory PRL. If the sample response is greater than the LoD but less than the PRL then values will generally be reported as “< n” (where n is = PRL). The practice may differ from one laboratory to another and some may seek commercial advantage by advertising low detection capability. There must be clarity in relation to LoD (as outlined below).

**Limits of detection and compliance monitoring.**

It is acceptable to report “less than” results provided that the method limit of detection is stated. The method limit of detection should be calculated using the laboratory LoD.

For compliance monitoring the method limit of detection should be no greater than 10% of the value of the emission limit unless otherwise agreed with the EPA.

## 6 Commonly measured pollutants – an overview

The most frequently occurring pollutant emission limit values that appear in EPA licenses are, in decreasing order, particulates, combustion gases, speciated organics (TA Luft classes), total organic carbon (TVOC as C) and acid gases such as HCl, HF. This section provides a summary description of the techniques commonly employed for the periodic measurement of these pollutants. In each case there are numbered bullet points that highlight the important features of the technique, a consideration of these points may form part of the audit process described in Appendix 1 – On site QA checks in standards for commonly measured pollutants. More detailed descriptions of the techniques can be found among those standard methods that are listed in the [Index of Preferred Methods](#).

### 6.1 Total particulate

The standard reference method for total particulates is EN 13284-1. (Appendix 7) of the Index of Preferred Methods contains further guidance.

Total particulate matter or dust is determined by sampling a measured volume of stack gas through a pre-weighed filter followed by gravimetric analysis. Unlike gaseous pollutants, which are present at a molecular scale, particles are altogether larger entities and they possess a certain momentum when suspended in a gas stream. If the velocity of the gas stream is slowed (for example due to the introduction of an obstruction) then the heaviest particles may “drop out” leaving only those smaller particles that remain in suspension.

**Isokinetic sampling (Particulate and Droplet).**

Pollutants in the form of particulate (or droplet) must be sampled isokinetically, failure to do so will bias the collected sample in favour of a particular size fraction and the collected sample will be unrepresentative of the actual particle size distribution in the stack gas.

Isokinetic sampling employs a carefully engineered sample nozzle through which the sample stream

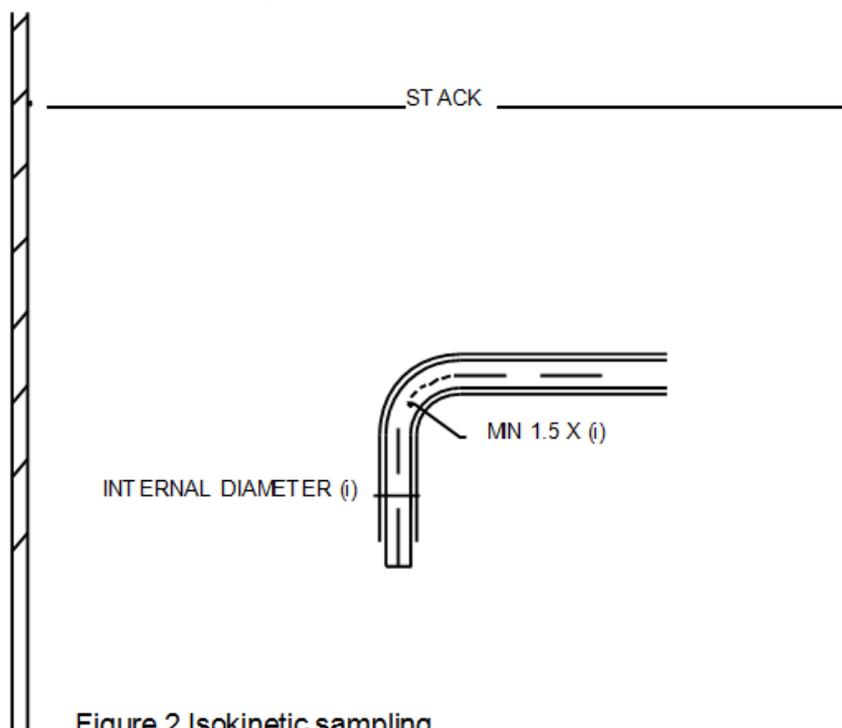


Figure 2 Isokinetic sampling

is drawn at a velocity ( $V_N$ ) equal to the local duct velocity ( $V_a$ ), Figure 2. In order to maintain the proper sampling rate, the duct velocity needs to be checked continuously during the course of the sample run, this can be done either manually or automatically.

While there are many variations of particulate sampling equipment on the market, they all adhere to the same principle. The sampling process is further complicated because the gas velocity across the duct (the measurement plane) may vary – for example, due to friction at the duct wall. In order to achieve a representative sample, the probe nozzle must be positioned for an equal time at a predetermined number of traverse points across the measurement plane, for further detail refer to the standard method. Other points to note regarding total particulate measurement are:

1. The filter for removal of particulate can be positioned in-stack, Figure 3 or out of stack, as in Figure 4. When using the latter configuration, experience has shown that a significant percentage of the particulate can drop out on the inner surface of the sampling apparatus prior to the filter, it is vital therefore to rinse the probe and collect the washing for analysis.

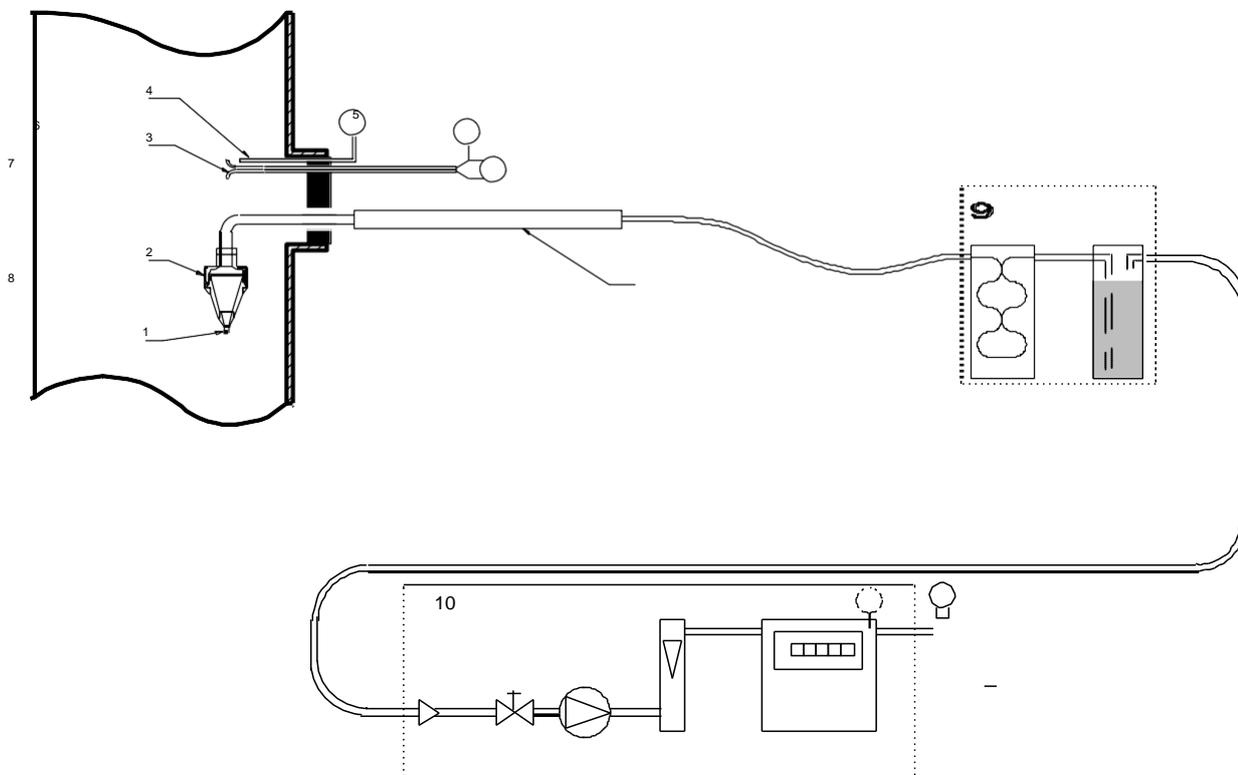


Figure 3 In stack particulate sampling

(1) Nozzle; (2) Filter holder; (3) pitot tube; (4) temperature probe; (5) temperature meter; (6) static pressure meter; (7) differential pressure meter; (8) heated/insulated probe (9) gas drying device; (10) vacuum unit with flow control and gas meter

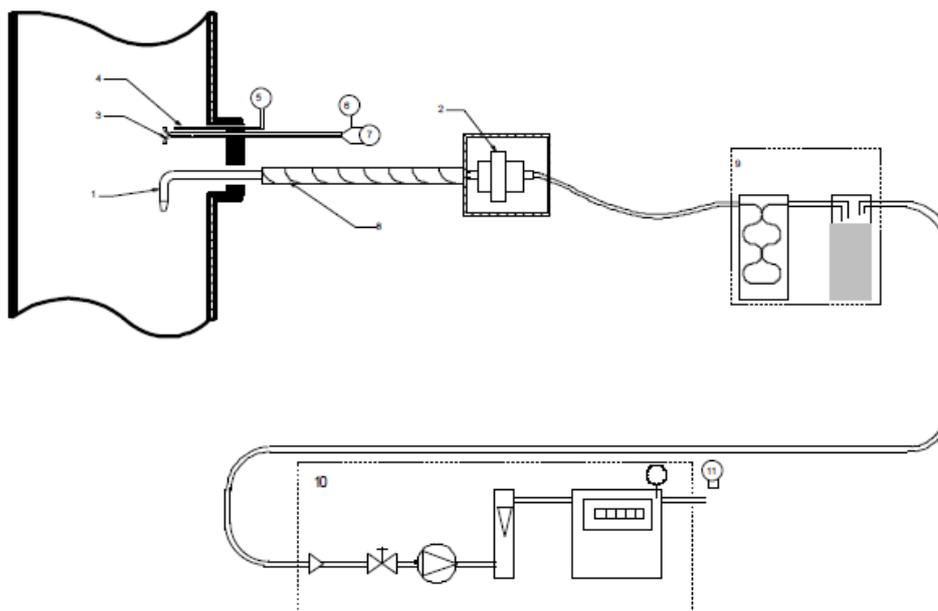


Figure 4 Out of stack particulate sampling

(1) Nozzle; (2) Heated filter holder; (3) pitot tube; (4) temperature probe; (5) temperature meter; (6) static pressure meter; (7) differential pressure meter; (8) heated probe (9) gas drying device; (10) vacuum unit with flow control and gas meter; (11) Barometer

2. Isokinetic sampling equipment can be modified so that gaseous pollutants are trapped in impingers or sorbent traps that are positioned following the filter in the sample train.
3. Isokinetic sampling can only properly be accomplished by personnel with training and experience.
4. The standard method EN 13284 part 1 is suitable for measurement of low-level particulate up to 50mg/m<sup>3</sup>, the method was validated at around 5mg/m<sup>3</sup> There are a number of factors to consider when measuring very low concentration of particulate including;
  - Filter material and filter losses
  - Filter holder design
  - Sample flow rate and nozzle size

Monitoring of low level particulates presents unique challenges as discussed in the [Index of Preferred Methods](#).

## 6.2 Particulate matter, PM<sub>10</sub> and PM<sub>2.5</sub>

Particulate matter present in ambient air is a combination of primary and secondary material. Primary particulate matter is released from stacks as particles, such as ash, dust or rapidly agglomerating aerosols. Secondary particulate matter forms from aerosols and gaseous species in the ambient air, downstream of the source.

Those ranges of particulate with diameters below 10 micron (µm) and 2.5 µm respectively have become the focus for environmental regulation because they can be inhaled into the inner reaches of the lungs and cause a spectrum of health effects. Monitoring of these particulate fractions at industrial sources generally involves the use of sampling apparatus that separates the <10 micron and <2.5-micron particles from larger particles followed by gravimetric analysis. This type of source-monitoring can be used to determine only primary particulate at sizes, and it does not measure particles that are smaller than 1 µm.

PM10/2.5 (further information)

The Environment Agency [Technical Guidance Note M15](#) provides more detailed information on PM<sub>10/2.5</sub>

The standard method for measure of PM<sub>10/2.5</sub> is I.S. [ISO 23210](#).

### 6.3 Combustion gases

The term “combustion gases” in this context means those products of combustion that are frequently specified in EPA licences. Combustion sources include boilers, combined heat and power plant, emergency generators, landfill gas utilisation plant and flares. The most common parameters that require measurement are sulphur dioxide (SO<sub>2</sub>), oxides of nitrogen (NO<sub>x</sub> expressed as NO<sub>2</sub>) and carbon monoxide (CO).

Combustion derived pollutants are commonly measured using portable analysers in conjunction with heated sampling lines and gas conditioning equipment. There is a suite of Standard methods including EN 15058 (carbon monoxide), EN 14792 (Nitrogen oxides) and EN 14789 (oxygen).

Some points to note regarding the measurement of combustion gases are:

1. Being the products of combustion there is generally the need to measure oxygen and sometimes moisture, so as to correct the emission concentrations to reference conditions. The measurement of reference quantities should be simultaneous.
2. The measurement of NO<sub>x</sub> (as NO<sub>2</sub>) is best achieved through the separate determination of both nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>). Some analysers use a converter to reduce NO<sub>2</sub> to NO before analysis. Certain analysers predict NO<sub>2</sub> based on a normal combustion scenario. If predictions are used, it should be stated in the monitoring report.
3. Combustion sources that “cycle” on and off can result in frequent surges of carbon monoxide. These surges can make it difficult to achieve a representative measurement (for example a 30-minute average). The plant shall be operating under stable conditions at a representative even load<sup>b</sup>. A minimum of 30 minutes valid monitoring data should be used to assess licence compliance.
4. A common reason for spurious data is that the combustion process may have actually ceased operation. Oxygen concentration in the region of 20% to 21% is an unequivocal indicator of such an occurrence however care should be exercised to ensure that high oxygen concentrations are not due to leaks within the sampling system itself.

Note: Non-combustion gases may be caused by the direct emissions of process gases arising from a non-fuel origin. These non-combustion gases may include emissions, such as ammonia, formaldehyde, acid gases, or particulates. They are typically corrected only to standard conditions of temperature and pressure.

The measurement of CO<sub>2</sub> is required at combustion processes to determine the air density used in volumetric flow and isokinetic results calculations.

### 6.4 Inorganic gases

The inorganic gases that are most frequently subject to emission monitoring are the individual acid

gases (HCl, HF, etc.), total acids (usually expressed as HCl), and ammonia.

Inorganic gases are typically sampled using impingers (bubblers) that contain an absorbing solution to capture the species of interest. A series of two or three impingers is used, the contents of which are analysed separately to verify the collection efficiency of the sampling system (e.g. the pollutant content in the final impinger should be less than 5%). Sampling train components that are upstream of the front impinger may be rinsed with absorbing/rinsing solution to ensure maximum pollutant collection.

It is important to avoid (or otherwise recover) any condensation in the sampling line because many of these substances dissolve readily in water. Isokinetic sampling must be employed if there is a suspicion that droplets are present in the waste gas stream.

These pollutants can also be measured using more sophisticated portable analysers, like the Fourier Transform Infra-Red (FTIR) spectrometer.

Many of the standard methods employ laboratory analyses that determine the ionic species rather than the molecule of interest directly, for example total chloride ions using ion chromatography rather than HCl itself. All of the commonly measured acid gases are readily ionised in water and this does not generally present a problem, however the presence of inorganic salts can lead to positive bias, e.g. high chloride levels due to sea salt can be recorded at coast locations unless care is taken to filter the gas prior to impingement. It is important that any such distinction is recognised by those responsible for monitoring.

Appendix 7 – Classification of inorganic emissions, (particulate and gaseous) in accordance with TA Luft.. contains further information on testing inorganic gases.

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<sup>b</sup> A Commission Implementing Decision [2012/249/EU](#) establishes rules for determination of start-up and shut-down periods of combustion plant covered by the [Industrial Emissions Directive](#). The decision recognises that emissions from combustion plants during start-up and shut-down periods are generally at elevated concentrations compared to normal operating conditions. The rules provide for transparency of criteria for determining start-up/shut-down, and stable process operation safeguarding health and safety.

## 6.5 Metals and metal species

A number of EPA licenses contain emission limit values for metals and metallic species. The manner in which limit values are expressed varies widely, as do the procedures for their determination. The following are examples of some of the terms that have been used together with the licence stipulated measurement technique [in square brackets];

- *The sum of cadmium (as Cd) and thallium (as Tl), and their compounds. Metals include both gaseous, vapour and particulate phases as well as their compounds (expressed as the metal or total as specified) – [Measurement techniques as updated by EN 14385 standard];*
- *Lead [ICP];*
- *Inorganic dust particles Class III [Filter];*
- *Total lead, arsenic, nickel and antimony [ICP];*
- *Total heavy metals [ICP].*

- *Mercury [ICP}*

**General rule for monitoring metals.**

Standard method EN 14385 is now the most common technique for sampling/analysis. It is suitable for the majority of metal species and monitoring applications.

Metals should always be sampled isokinetically. Particulate-phase metals are collected on a filter and vapour-phase metals are captured in impingers using aggressive absorbing solutions (normally high concentration acid). The filter fraction is digested in the laboratory and analysed along with the impinger fraction using a suitable method such as Inductively Coupled Plasma Spectrometry (ICP). A sample train that excludes the impinger stage will fail to capture vapor-phase metal that passes the filter. It is important that the choice of standard method for monitoring compliance is consistent with the parameter that is the subject of the emission limit value.

Some standard methods include a large number of different metals with their scope. Other methods are specific to one metal (e.g. mercury). The scope of a standard method normally defines the species for which it has been validated. A method may generate data for metal species that are outside its scope which would therefore be invalid. However, Appendix 5 of the Index of Preferred Methods provides information which allows mercury to be sampled along with other metals under some circumstances.

Appendix 7 – Classification of inorganic emissions, (particulate and gaseous) in accordance with TA Luft.. contains further information on testing inorganic particulate.

**6.6 Organic gases (total)**

The Industrial Emissions Directive (IED) sets limit values for Total Organic Carbon emissions from incineration, solvent using and other processes. The EPA recommends the use of standard method EN 12619 for monitoring at Incineration plant, at solvent using and other processes. This method employs a portable Flame Ionisation Detection (FID) based analyser with heated filter and sample line to ensure that a particulate and condensation-free sample is delivered to the analyser. The analyser is calibrated with propane in a balance of synthetic air or nitrogen/oxygen mixture (no other calibration gas is acceptable as span gas) and zeroed with a gas with a TVOC concentration (mg/m<sup>3</sup> as carbon) lower than 0.2 mg/m<sup>3</sup> of carbon or purity 99.998%. Built-in FID carbon filters cannot demonstrate compliance with this requirement and are therefore not accepted for zeroing FID analysers.

**Composite organics – terminology.**

A variety of terms have been employed in EPA licences for the general limitation of summed non-specific gaseous organic emissions. These terms include: total VOCs; total organics; total hydrocarbons, etc.

Furthermore, the IED contains definition for the terms 'organic compound', 'volatile organic compound' and 'organic solvent'.

Unless otherwise agreed with the EPA, the measurement of the composite organic emission should employ portable FID (EN 12619) and the measurement of individual organic species should employ collection and laboratory speciation (see below).

Sample collection on to a sorbent tube and laboratory analysis using Gas Chromatography (GC) is the specified monitoring method in many earlier EPA licences. This sorbent tube method is no longer best practice for total organics, and monitoring should be carried out using EN 12619 (FID method). The licence does permit a change of methodology with the agreement of the EPA, so that the methods recommended above can be adopted.

Experience has shown that data from the tube / GC analysis method rarely matches data from the portable FID method. The principal reason for this is that the GC detector responses of the compounds eluted are required to be compared and quantified against those of a reference compound (usually Toluene). Substances that are not present in the calibration mixture cannot therefore be accurately quantified. In some samples these may represent an appreciable proportion of the total organic species present. Data is presented as  $\mu\text{g}$  of "toluene equivalent" rather than as C. By contrast portable FIDs are often calibrated against propane so it is not surprising that laboratory and on-site measurement differ.

**6.7 Organic gases (speciated)**

The measurement of a discrete organic substance in an emission requires its separation from the other stack gases, its identification and its quantification through the use of calibration standards containing the substance at a range of appropriate concentrations. In practice this process is commonly achieved by sample collection on to a sorbent tube and laboratory analysis by Gas Chromatography (GC) or Gas Chromatography – Mass Spectrometry (GC-MS).

There are many pollutant-specific standard methods that adopt this approach (using a range of sorbent tubes) for the determination of occupational exposure and these methods if properly modified and validated can be used for the measurement of stack gases. There are very few published methods designed specifically for the speciation of organics in stack gases using solid phase traps. Those that are validated tend to be generic and cover a wide range of compounds. A case in point is CEN/TS 13649, which uses collection on charcoal and solvent desorption or thermal desorption.

Difficulties that can arise with this and other sorbent tube based methods are; loss of vapour phase organics by condensation, breakthrough on the tube. Condensation can be addressed through the use of a heated sample line upstream of the sorbent tube, with static or dynamic dilution. Breakthrough can be addressed by correct selection of the solid phase sorbent and use of back-up tubes in series. Temporal variation can be determined through the use of a separate FID survey in real time.

Appendix 8 – Classification of speciated organics (e.g. TALuft) contains further information on testing inorganic gases.

### General rule for monitoring speciated organics

- CEN/TS 13649 is the most commonly adopted method for the measurement of speciated VOCs. The EPA recommends this method unless there are application specific reasons that render another method more suitable.
- The German TA Luft system for classifying organic species remains in use in some licences - refer to Appendix 7–Classification of speciated organics (e.g. TA Luft);
- That part of the IED that relates to installations and activities using organic solvents sets one emission limit value for VOCs that are assigned hazard statements H340, H350, H350i, H360D or H360F and another emission limit value for halogenated VOC's that are assigned hazard statements H341 or H351. To establish the hazard statement for a given organic substance one must consult [Regulation \(EC\) No 1272/2008 on classification, labelling and packaging of substances and mixtures.](#);
- Environment Agency (England) Technical Guidance Note M16 is another useful reference on this subject. Although methane is not classed as a VOC, when speciating VOCs, methods for its measurement are included.

## 6.8 Formaldehyde

The EPA licenses a number of large timber processing facilities that require the measurement of formaldehyde emissions. The EPA has required the use of a method developed and validated for use at these types of emissions by the US National Council for Air and Stream Improvement (NCASI)<sup>xiv</sup>. NCASI is an independent research institute that focuses on environmental topics of interest to the forest products industry.

The method involves impinger train sampling into water and analysis by acetylacetone colorimetry. Trapping efficiency is >90% such that 3 traps will effectively quantify all emissions. Bias due to the presence of other substances such as methyl ethyl ketone (MEK), acetone and acetaldehyde have been evaluated by the EPA and shown to be negligible unless they are present in significant quantities.

Experience has shown the need to avoid (or otherwise recover) any condensation in the sampling line because Formaldehyde dissolves readily in water.

While the EPA deem the NCASI method to be an acceptable method for the measurement of formaldehyde at timber processing facilities, USEPA method 316 may also be used (following agreement with the EPA) and where results are shown to be equivalent to NCASI. All methods must employ isokinetic sampling where droplets are present in the gas stream.

USEPA 316 is the more commonly available method and can be used when measuring formaldehyde at non-timber facilities.

## 6.9 Dioxins

Dioxin is a collective term for the category of 75 Polychlorinated dibenzo-para-dioxins (PCDDs) and

135 polychlorinated dibenzofurans (PCDFs). They arise mainly as by-products of incomplete combustion and from certain chemical processes.

Samples must be collected isokinetically. Thereafter there are a number of sample train configurations that are possible. Dioxin molecules can be immobilised on the filter, in a condensate trap and on absorbent resin. Dioxins are normally present only at very low concentrations and extended sampling periods are employed to lower the methods limit of detection. The IED states that the ELV of 0.1ng/m<sup>3</sup> for dioxins and furans is as an average value measured over the sampling period of a minimum of 6 hours and a maximum of 8 hours. Analysis is by Gas Chromatography (GC) with high resolution Mass Spectrometry. The EPA now requires the use of EN 1948, which supports the monitoring requirements of the Industrial Emissions Directive that relate to waste incineration and waste co-incineration. Further information on EN 1948 can be found in the Index of Preferred Methods

The measurement of dioxins necessitates the use of the standard system of International Toxic Equivalent (I-TEQ) for comparing dioxin toxicities of different samples.

The method measures the 17 PCDD/PCDF congeners necessary to calculate the total I-TEQ (toxic equivalent). The result for each congener is converted to an I-TEQ value and then these 17 values are added to give the total I-TEQ. Where one or more congener is determined at below its limit of detection then for the purpose of the calculation it is assumed to be present in an amount equal to its limit of detection, hence the Total I-TEQ reported for the emission is a worst-case result.

Dioxins become significant when present in the environment even at very low levels. As a consequence, the entire measurement process is one of the most demanding and can only be performed by experienced personnel. Extremely rigorous sampling procedures are required to

Dioxins become significant when present in the environment even at very low levels. The measurement process is demanding, and can only be performed by experienced personnel. Monitoring must always be conducted by accredited organisations.

EPA licences generally require a sampling period of a minimum of 6 hours and a maximum of 8 hours (in line with the Industrial Emission Directive).

EN 1948-3 specifies that the sum of PCDD/PCDF is reported both as worst case (LOQ = LOQ) and best case (LOQ = 0)

avoid contamination or loss of sample.

A key aspect of EN 1948 is the use of <sup>13</sup>C<sub>12</sub>-labelled PCDD/PCDF that is spiked onto the sampling equipment (sampling standards), before extraction (extraction standards) and just before GC injection (syringe standards). This practice allows the recoveries (or losses) of the congeners to be determined. Recovery data should always be provided in the monitoring report.

## 6.10 Flow rate

The determination of volumetric flow rate is important because it is used to calculate mass emission rates, which are an indicator of the load on the environment. Volumetric flow rate is determined through the measurement of the average duct velocity and the internal cross-sectional area of the duct. The most common method for determining velocity is a Pitot tube and differential pressure meter (manometer). A moving gas stream exerts a velocity pressure in the direction of flow, this pressure is detected using the manometer, and it is proportional to the square of the velocity. Duct temperature and pressure must also be measured to permit the correction of the volumetric flow data to Standard Temperature and Pressure (STP). Emissions that are subject to variations in flow rate should be subject to additional monitoring to determine the flow conditions that give rise to the highest load on the environment. Compliance assessment should be conducted when the process is running at, or near to, maximum loading.

#### **Standard method for flow rate measurement.**

A standard method EN ISO 16911<sup>xv</sup> for the measurement of volume flow rate was published in 2013 (available from [ISO website](#)). Further information on EN ISO 16911 can be found in the Index of Preferred Methods. The EPA requires that testing organisations adopt this standard and replace any previous standards which may have been used.

Stack volumetric flow shall be calculated from differential and stack pressure along with stack temperature and stack gas density if principle of differential pressure (Pitot tube) is used. Annex A of BS EN ISO 16911-1:2013 shall be followed at all times. Gas density shall be measured (not estimated) at combustion processes.

The following are some additional points to note in relation to flow rate measurement:

- A common source of error in volumetric flow rate determinations is inaccurate measurement of the internal dimensions of the duct;
- There are standard procedures to identify and deal with cyclonic flow;
- It is necessary to leak check Pitot tubes and lines;
- The thermal limitations of stainless steel can restrict the use of Pitot tubes. The normal Pitot calculations have been validated up to 300°C;
- Volumetric flowrate from combustion plant can also be determined by stoichiometric calculation based on fuel consumption and excess oxygen in the exhaust gas. Should this method be used then a validation exercise must be carried out.
- Volumetric flow rate can be also determined by the transit time tracer gas method.
- The EPA recommends the spreadsheet created by the NPL and circulated by the Source Testing Association (STA) for volumetric flow and uncertainty calculation.
- Where isokinetic parameters (particulates, metals, dioxins, etc.) are in the scope of monitoring, the volumetric flow results shall be calculated from the isokinetic monitoring data. This will provide more representative results than a considerably shorter flow survey.

#### **Annual volumetric flow measurement.**

When a licence does not set any frequency for volumetric flow monitoring, compliance with the Volume Flow ELV should be assessed at least once a year and reported to the Agency in conjunction with their self-monitoring submissions.

## 6.11 Reference quantities

An explanation of reference quantities and the reasons for their use was given in section 3.3. The methods used to measure the oxygen and moisture content of stack gas are described here.

### 6.11.1 Oxygen

The technologies for oxygen measurement are well developed because the control of oxygen in the combustion process is critical to the overall efficiency. The following types of portable oxygen analysers are used for the measurement of stack gases.

- Paramagnetic / Thermomagnetic analysers;
- Zirconium oxide analysers.
- Electrochemical cells;

Standard Reference methods EN 14789 describes how to conduct periodic measurements of oxygen on site.

### 6.11.2 Moisture

The measurement of moisture using EN 14790 is achieved by extractive sampling through a heated line into cooled impingers containing a known volume of de-ionised water, followed by an impinger filled with pre-weighed silica gel. The liquid volume and silica gel weight gain are measured post sampling to determine the increase due to moisture in the stack gas.

## 6.12 Fourier Transform Infra-Red (FTIR).

FTIR instruments are used widely for stack emissions monitoring. The ability to record spectra over a wide wavelength range, and analyse these in real time to identify a number of different pollutants

### FTIR (further information)

The Environment Agency [Technical Guidance Note \(TGN\) M22](#) provides detailed information on the use of FTIR instruments for the measurement of gaseous emissions.

Most organisations that employ FTIR base their procedures on M22 but method [ASTM D6348](#) can also be used.

The technical specification CEN/TS 17337 should be implemented from 31<sup>st</sup> December 2020.

When FTIR is used by an external contractor to assess licence compliance, the testing organisation still needs to meet the EPA minimum criteria for air emissions monitoring (cf: section 2.1) and hold EN ISO/IEC 17025 accreditation for the measurement of the parameter in question using FTIR.

CEN/TS 17337 contains performance specifications for FTIR instruments along with on-going QA/QC checks. It also specifies the requirements for on-site setup and checking of the FTIR analyser. For instance, how to conduct a background spectrum, how to use the check gas approach and span gas approach for testing on-site as well as techniques for checking losses and leakage on site.

It is noted that, although there are similarities between TGN M22 and CEN/TS 17337, there are also some significant differences.

in a stack gas makes FTIR a useful technique. In principle, any heteroatomic compound that has an absorption spectrum in the IR region can be measured by FTIR. Determinands that cannot be measured by FTIR are symmetrical diatomic molecules, where there is no dipole change<sup>c</sup> upon vibration, such as oxygen (O<sub>2</sub>) and chlorine (Cl<sub>2</sub>).

### 6.13 Colour indicating tubes

Colour indicating tubes can be used for a wide variety of substances and may be useful if a process requires frequent monitoring (e.g. hourly or daily checks on abatement plant operation, such as ammonia and amines from biofilters). Though proprietary tubes are pre-calibrated to aid quantitation. The results obtained should be regarded as semi-quantitative, because a subjective decision is required to estimate changes in colour, thus they are not considered to be sufficiently robust to demonstrate compliance with licence limits. Where an EN method exists for the parameter being tested, e.g. ammonia, then this should be used if possible

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<sup>c</sup> A criterion for IR absorption is a net change in dipole moment in a molecule as it vibrates or rotates.

Some tube types are subject to interferences so good information is needed on the composition of the gas stream if the results are to be relied upon. In some cases, detection tubes may be acceptable as an alternative technique if a good relationship can be demonstrated with appropriate standards and the emissions are well below the emission limit value. A comparative test using a standard reference method will be required on an annual basis, as a minimum. Further confidence in the operation of detection tubes may also be obtained using calibration gases.

### 6.14 Electrochemical cells

The EPA will no longer accept air monitoring reports prepared using electrochemical cells analysers, unless the process being monitored is a simple process, specifically combustion in natural gas boilers, up to 5MW in size. However, if agreed in advance with the EPA, electrochemical cells can be used at sites where due to safety or equipment integrity reasons other portable flue gas analysers cannot be used. Electrochemical cells get easily poisoned by carbon monoxide and should be avoided for monitoring on low combustion efficiency processes.

Whenever portable analysers fitted with electrochemical cells are used, the same quality controls apply (calibration, leak checks, drift allowance, etc.).

## 7 The Equipment

If the monitoring is to produce good quality data then those items of equipment, (e.g. isokinetic sampling trains and portable analysers), must be fit for purpose. The same applies to peripheral equipment, (e.g. temperature and pressure sensing devices), which have a role in the control of the sampler/analyser or in the measurement of stack conditions.

The licence template states: *Monitoring and analysis equipment shall be operated and maintained as necessary so that monitoring reflects the emission or discharge.*

The following sections discuss the types of monitoring equipment, its management to ensure that it is “fit for purpose”, and the subject of equipment certification.

### 7.1 Types of monitoring equipment

Stack monitoring equipment can be divided into two main types, sampling equipment and on-site continuous analysis equipment, with associated peripheral pieces of equipment that are just as important to the process. The chart in Figure 5 below gives examples of each category.

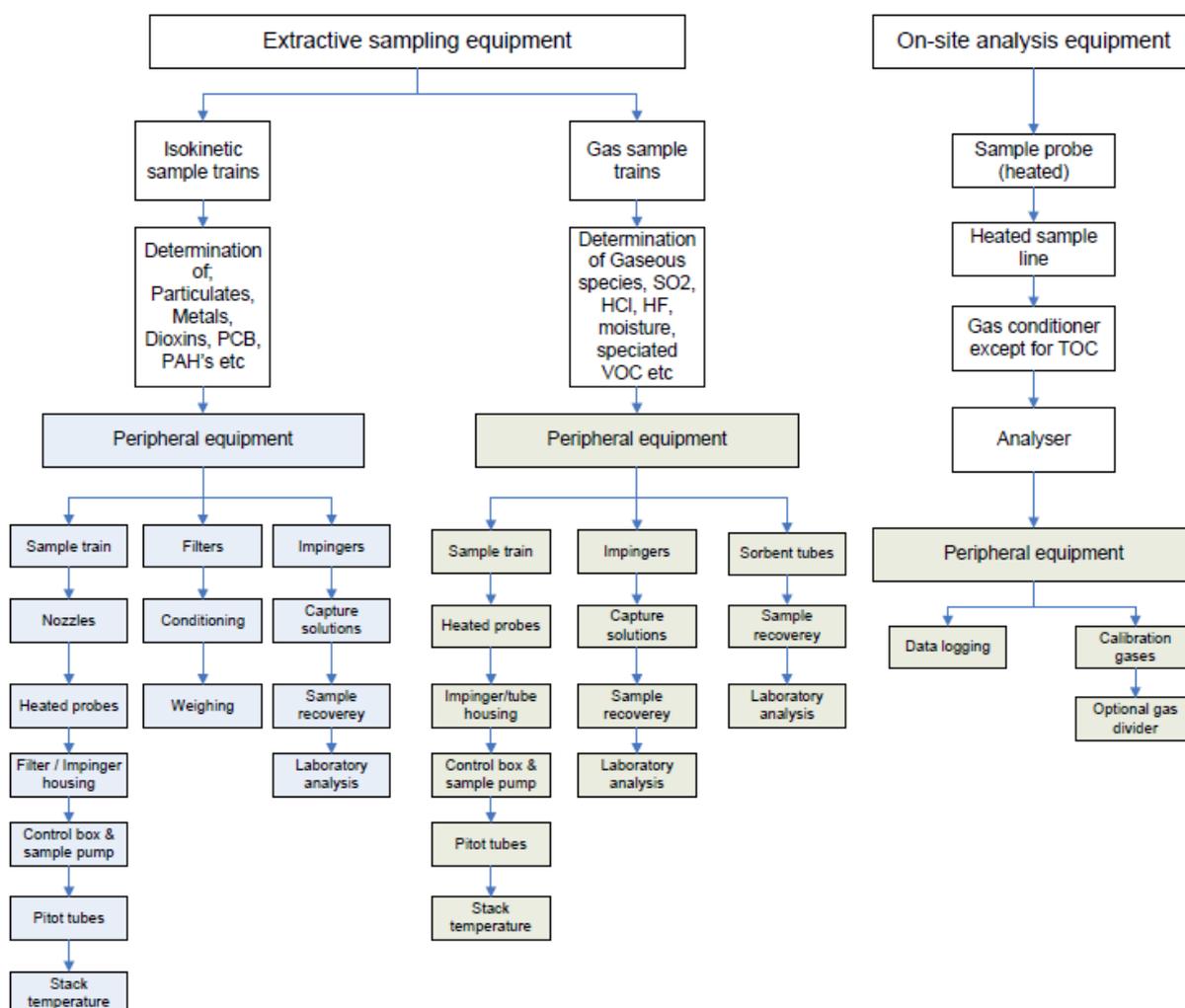


Figure 5 Categories of emissions monitoring equipment

## 7.2 Equipment suitability and fitness for purpose

The test house should be furnished with all items of sampling, measurement and test equipment required for the correct performance of the monitoring task. Schemes for the product certification of stack monitoring equipment exist in the UK ([MCERTS Product Certification](#)) and in Germany ([TUV Approved](#)).

EN 15267-3 defines performance criteria and test procedures for automated measuring systems for monitoring emissions from stationary sources. EN 15267-4 defines performance criteria and test procedures for automated measuring systems for periodic measurements of emissions from stationary sources.

Note the distinction, EN 15267-3 relates to installed analysers used for continuous monitoring of an emission, EN 15267-4 relates to portable analysers used for periodic monitoring.

Equipment and its software used for testing and sampling should be capable of achieving the accuracy required and should comply with specifications relevant to the tests and/or calibrations concerned. The equipment must:

- Be appropriate for use in the field environment in which it will be employed;
- Meet all the criteria specified in the standard method being used;
- Be non-reactive to the pollutant being monitored;
- Not suffer any positive or negative interference, due to the composition or state or condition of the gas stream being monitored;
- For EN 14181 QAL2 and AST parallel reference measurements, analysers shall be certified to EN 15267-3 at the time of purchase (or EN 15267-4) certification of measuring systems, for the appropriate determinands and certification range (ELV multiplier rule);
- For compliance monitoring, if the analyser is not certified to EN 15267-3 (or EN 15267-4) for the appropriate determinands and certification range (ELV multiplier rule) then the user must demonstrate that the minimum performance characteristics specified in the relevant SRM (e.g. EN 12619, EN 14789, EN 14792, EN 15058, CEN/TS 17021 etc.) have been met, together with a demonstration of equivalence to the SRM (if the instrument uses an alternative technique to the SRM) in accordance with CEN/TS 14793.

## 7.3 Equipment calibration

Calibration is a process that either makes a physical adjustment to a device that affects its response to the measurand, or it determines a calibration factor that is used in the calculation of the measurement result. Intermediate checks are used to maintain confidence in the calibration status of an instrument.

Calibration programmes must be established for each piece of equipment that can have a significant effect on the results. Before being placed into service, equipment (including that used for sampling) should be calibrated or checked to establish that it meets the test house's specification requirements, and complies with the relevant standard specifications. Procedures should ensure that equipment transported to site remains in valid calibration, or is otherwise subject to checks or calibration on-site. Zero and span gas checks should be conducted on the entire sampling system to verify its integrity. The SRMs contain detailed requirements for setting up analysers on site.

Equipment calibration must be traceable. The organisation should hold traceable calibration materials (where available) for all aspects of the monitoring process. Where calibrations give rise to a set of correction factors, e.g. Pitot tubes for measuring flow, the test house should have procedures to ensure that copies (e.g. in computer software) are correctly updated and used.

The Irish National Metrology Laboratory provides training and calibration services (details can be found at <https://www.nsai.ie/national-metrology/>).

**Calibration and measurement using portable analysers.**

The following provides details of good practice that can be required when using equipment for periodic measurements:

- Equipment checks should be made prior to beginning measurement and following completion. These should include on-site checks on all instruments that are subject to changes during transport or during measurement. It is not sufficient to reference an equipment check made in the laboratory, prior to bringing the instrument into the field;
- Instruments used to measure physical parameters such as flow meters, should, if appropriate, be checked on-site against a known standard, such as a critical orifice;
- Instrumental analysers are checked using a zero gas and a span gas. It is recommended that the span gas concentration is equivalent to the emission limit value of the substance being measured (unless standard methods or regulatory requirements suggest otherwise).
- The range of instrumental analysers should be selected to ensure that, as far as practicable the upper point of the range for compliance purposes is twice the emission limit value for the substance being measured (unless standard methods or regulatory requirements suggest otherwise).
- The results of the equipment checks should be reported with the data indicating the difference between the analyser's reading and the known value of the calibration gas.
- If the equipment check results in a difference with a known reference material within the limits prescribed by the method, then the measurement results should be reported. However, if the difference exceeds the limits prescribed by the method, the measurement is postponed until a suitable instrument is available or the results are voided and the measurement repeated;
- Sampling lines should be checked to ensure they have been purged adequately before measurement is undertaken. The zero and span gas calibrations should confirm the integrity of the complete sampling system in accordance with the applicable standard method, (it is best practice to introduce span gas through the probe tip to verify the sample line integrity);
- Equipment should undergo operational checks to ensure it is functioning correctly (e.g. correct indicator lights on analyser, heated sample line at correct temperature).

Note: Standard methods such as (EN 14789 (O<sub>2</sub>), EN 14792 (NO<sub>x</sub>), EN 15058 (CO) and EN 12619 (TOC) contain detailed requirements for on-site set-up and calibration of analysers.

Analysers should be set to a logging frequency of no greater than 1 minute, (e.g. a half hour compliance assessment will be calculated as the average of 30 readings).

During the pre and post calibration processes it is important that the analyser is allowed to properly stabilize at the span and zero point. Failure to do so will impede the assessment of drift. It may be helpful to shorten the recording frequency to 15 seconds and/or establish a definition of "a stable reading" which is appropriate to the testing application, (e.g. four successive readings within 1 ppm).

Where the monitoring result is adjusted to take account of equipment drift, the report should quote the raw value and the adjusted for drift value (i.e. before any corrections).

## 7.4 Equipment management

EN ISO/IEC 17205:2017 contains requirements for equipment and all accredited laboratories have to comply with these requirements. These are outlined below.

Equipment should be operated by authorised and competent personnel. Up-to-date instructions on the use and maintenance of equipment (including any relevant manuals provided by the manufacturer of the equipment) should be readily available for use by the appropriate test house personnel.

Each item of equipment should be uniquely identified.

Records should be maintained for each item of equipment and its software significant to the tests performed. The records should include at least the following:

- a) The identity of the item of equipment and its software;
- b) The manufacturer's name, type identification, and serial number or other unique identification;
- c) Checks that equipment complies with the specification;
- d) The current location, where appropriate;
- e) The manufacturer's instructions, if available, or reference to their location;
- f) Dates, results and copies of reports and certificates of all calibrations, adjustments, acceptance criteria, and the due date of next calibration;
- g) The maintenance plan, where appropriate, and maintenance carried out to date;
- h) Any damage, malfunction, modification or repair to the equipment.

Whenever practicable, all equipment under the control of the test house and requiring calibration should be labeled, coded or otherwise identified to indicate the status of calibration, including the date when last calibrated and the date or expiration criteria when recalibration is due.

The test house should have procedures for safe handling, transport, storage, use and planned maintenance of measuring equipment to ensure proper functioning and in order to prevent contamination or deterioration. Procedures should describe the method for cleaning the equipment both before use and between sample runs.

When, for whatever reason, equipment goes outside the direct control of the test house, (e.g. equipment sent for service or rental equipment brought in), the test house should ensure that the function and calibration status of the equipment are checked and shown to be satisfactory before the equipment is returned to service.

## 8 Personal competency

The EPA takes the view that competency of the staff is fundamental to the generation of reliable emission data – the presence of an accredited quality management system, and the use of certified equipment in accordance properly chosen standard methods is of limited value in the absence of competent staff.

A typical condition in EPA licenses states:

*“The licensee shall ensure that personnel performing specifically assigned tasks shall be qualified on the basis of appropriate education, training and experience, as required and shall be aware of the requirements of this licence”*

### 8.1 General Requirements for Competence of Personnel (EN ISO/IEC 17025)

The standard EN ISO/IEC 17025 <sup>xvi</sup> recognizes that competence of personnel plays a key role in determining the correctness and reliability of tests performed by the organisation. It requires that management ensure the competence of staff that are performing tests, evaluating results and signing test reports.

The key clauses of EN ISO/IEC 17025 which cover competence of personnel are reproduced below. These are generic requirements, which apply to all accredited testing laboratories.

*All personnel of the laboratory, either internal or external, that could influence the laboratory activities shall act impartially, be competent and work in accordance with the laboratory's management system.*

*The laboratory shall document the competence requirements for each function influencing the results of laboratory activities, including requirements for education, qualification, training, technical knowledge, skills and experience.*

*The laboratory shall ensure that the personnel have the competence to perform laboratory activities for which they are responsible and to evaluate the significance of deviations.*

*The management of the laboratory shall communicate to personnel their duties, responsibilities and authorities.*

*The laboratory shall have procedure(s) and retain records for:*

- a) determining the competence requirements;*
- b) selection of personnel;*
- c) training of personnel;*
- d) supervision of personnel;*
- e) authorization of personnel;*
- f) monitoring competence of personnel.*

*The laboratory shall authorize personnel to perform specific laboratory activities, including but not limited to, the following:*

- a) *development, modification, verification and validation of methods;*
- b) *analysis of results, including statements of conformity or opinions and interpretations;*
- c) *report, review and authorization of results.*

Management must formulate goals for the individual and have a policy and procedures to identify training needs and provide relevant training. The effectiveness of training must be evaluated. Specific personnel must be authorised to perform particular tasks, operate particular items of equipment and complete the range of tasks necessary for the organisation to provide an accredited service to its customers. The organisation must maintain records of staff competence, qualifications and experience (including contracted personnel).

## **8.2 Competence of Personnel Specific to Emission Testing.**

Although EN ISO/IEC 17025 contains general requirements for competence of personnel, it does not give any *specific* guidance on staff competence in the field of stack emissions monitoring.

Staff should be assessed to ensure they meet physical fitness requirements. Auditors acting on behalf of accreditation bodies may assess competence of personnel - for example during site visits.

The following list of generic criteria for personnel competency are provided as an “informative” example:

- Competence may be defined in terms of levels and based on the persons’ experience and responsibility (e.g. three levels might be technical supervisor, technician and assistant technician).
- Competence can be demonstrated through qualification in university/technical college courses in the natural sciences and engineering, achievement in examinations and skills assessment and though training and work experience records which define the persons’ levels of practical experience.
- General competence criteria could include knowledge and understanding of the following:
  - Measurement objectives;
  - Industrial processes;
  - Health and safety;
  - Sampling location;
  - Method selection and use;
  - Site review;
  - Measurement Plan
  - Operation of equipment;
  - Elaboration of test results and identification of supporting information;
  - Measurement report;
  - Quality Assurance/Quality Control.

Further information on the above topics can be found in Appendix 9 - Example competence criteria for personnel carrying out emission measurements.

The way that a stack testing organisation demonstrates that it meets the requirements of EN ISO/IEC 17025 in relation to staff competency will ultimately be a matter that will be assessed by the accrediting body (e.g. INAB).

*The Environment Agency (England) in the UK has established the MCERTS personnel competency scheme, which Irish staff are able to take part in. This scheme is based on CEN standards, so is an effective way of demonstrating competency.*

## 9 The Organisation

It is the monitoring organisation that must put in place the systems and work practices that ensure personnel, equipment and standard methodologies combine effectively to produce reliable emission data, and that the data is reported in the prescribed manner. The majority of licensed facilities in Ireland contract their emissions monitoring to an external test house and the requirements of this guidance document (AG2) apply. A smaller number of licensed facilities engage in-house staff to conduct emissions monitoring and in these cases the requirements of guidance note AG8 also apply.

### 9.1 License conditions

The EPA's current licensing practice is to impose the following requirement on sampling, analyses and measurements for compliance assessment:

- *Analysis shall be undertaken by competent staff in accordance with documented operating procedures;*
- *Such procedures shall be assessed for their suitability for the test matrix and performance characteristics determined;*
- *Such procedures shall be subject to a programme of Analytical Quality Control using control standards with evaluation of test responses;*
- *Where analysis is sub-contracted it shall be to a competent laboratory;*
- *The licensee shall, within six months of the date of grant of this licence, develop and establish a Data Management System for collation, archiving, assessing and graphically presenting the environmental monitoring data generated as a result of this licence;*
- *Sampling and analysis for all parameters listed in the Schedules of the licence; and any reference measurements for the calibration of automated measurement systems; shall be carried out in accordance with CEN-standards. If CEN standards are not available, ISO, national or international standards that will ensure the provision of data of an equivalent scientific quality shall apply.*

The most important factor in achieving these licence requirements will be the presence, within the monitoring organisation, of an effective Quality Management System.

#### **Mandatory accreditation of stack compliance monitoring QMS.**

From 1 January 2014, the EPA requires that contractors carrying out monitoring of stack gas emissions to atmosphere are accredited to the EN ISO/IEC 17025 standard (including relevant requirements of IS EN 15259) for specified parameters. In the subsequent years of 2015, 2016, and 2019 the required scope of accreditation to be held by these contractors was extended to cover the majority of parameters that are listed in EPA licenses, (c.f.: EPA minimum criteria for air emissions monitoring). The mandatory scope of accreditation was extended in January 2019 to include HF, NH<sub>3</sub> and CO<sub>2</sub>.

### 9.2 The Irish National Accreditation Board (INAB)

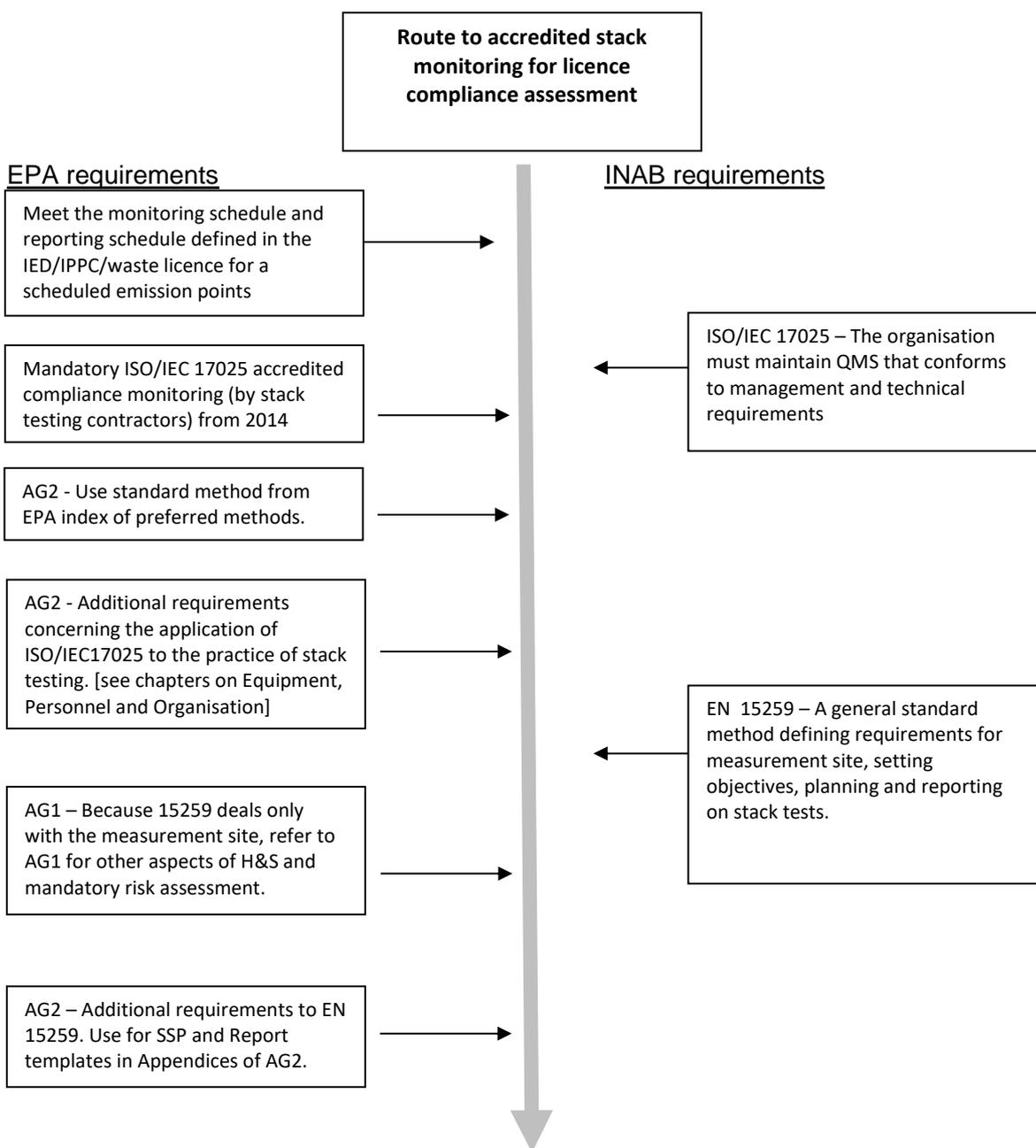
The Irish National Accreditation Board (INAB) provide for the formal accreditation of stack monitoring organisations. An applicant organisation will be assessed for compliance against the current version of the International Standard, EN ISO/IEC 17025. The management system and the technical competence of the laboratory to perform the tests are assessed. The organisation, once assessed successfully, is awarded accreditation for a defined scope of tests (e.g. measurement of a named pollutant in stack gas using a particular standard method). At the time of

publication, there are a number of stack testing contractors that have been accredited by INAB. Details of INAB accredited organisations can be found on the INAB website and on the following [EPA webpage](#).

A number of UK based stack testing contractors provide a service to Irish customers. These organisations are accredited to EN ISO/IEC17025 by The United Kingdom Accreditation Service (UKAS) by the same process to that which applies in Ireland. Many of these UK contractors are also accredited to the MCERTS performance standard for organisations.

### 9.3 Standards that are relevant to the accreditation stack testing organisations.

The following diagram describes the inter-relationship between the EPA function to oversee licence compliance monitoring and the INAB function to accredit commercial stack testing contractors.



## 9.4 EN ISO/IEC 17025 – Quality Management System for testing laboratories

The standard EN ISO/IEC 17025 contains all of the requirements that testing and calibration laboratories have to meet if they wish to demonstrate that they operate a management system, are technically competent, and are able to generate technically valid results. Accreditation bodies such as INAB use EN ISO/IEC 17025 as the basis for their accreditation of test and calibration laboratories.

In general terms, the essential requirements for accreditation to ISO/IEC 17025 include:

- All necessary information shall be documented;
- An organised, functional, structure with clearly defined technical and quality responsibilities, impartiality, integrity and independence;
- Traceable measurement;
- Uncertainty of measurement for all tests and/or calibrations;
- Participation in and achievement of satisfactory results in proficiency testing and inter-laboratory comparison schemes applied scope of accreditation (where available);
- Technically valid procedures.

In more specific terms, the standard is divided into a set of *structural, resource, process* and *management* requirements which must be addressed to the satisfaction of the accrediting body. These criteria have been reproduced in the panels below along with the other sections of the standard [the numbers refer to the section numbers in EN ISO/IEC 17025:2017]

Foreword
Introduction
1. Scope
2. Normative references
3. Terms and definitions
4. General requirements
5. <i>Structural requirements</i>
6. <i>Resource requirements</i>
7. <i>Process requirements</i>
8. <i>Management requirements (with options)</i>
Annex A (Traceability)
Annex B (Management System - options)
Bibliography

## 9.5 The application of EN ISO/IEC 17025 to air emissions testing.

The following section contains information on how the EPA regard EN ISO/IEC 17025 should be applied to the practice of air emissions testing <sup>1</sup>.

### 9.5.1 Resources for air emissions testing

The application of an EN ISO/IEC 17025 Quality Management System to the monitoring of industrial emissions to atmosphere requires a particular suite of resources that are summarised below.

- Personnel – The availability of trained and competent personnel is a key requirement for quality air emissions testing. Refer to earlier chapter 8.
- Facilities and environmental conditions – Equipment and reagents should be protected during the sampling campaign. Sampling platforms should meet the requirements of EN 15259. Possible effects of the environmental conditions on the measurement result should be addressed. Appropriate steps to avoid contamination of samples should be taken.
- Equipment and reagents shall be protected from damage during storage and transportation from a laboratory's permanent site to the location where samples or measurements are to be made at the stationary source. Equipment calibration shall be in accordance with the relevant standard method, (c.f.: 7.3 Equipment calibration)
- Temporary shelter and portable lighting shall be used when appropriate to protect staff and equipment from weather conditions and ensure safe working conditions for the correct performance of the measurement exercise.

NOTE: Methods can advise on the means of protecting the integrity of reagents during storage and transportation. It is good practice to store reagents and samples out of direct sunlight and at a suitable controlled temperature.

- The measurement site should be easily and safely accessible via stairs. To transport measuring instruments, in the case of measurement sites, which are not at ground level, transport means should be provided, for example hoists or lifts.
- When the measurement site is being selected, it should not be in the area of sources that emit unexpectedly, for example rupture disks, overpressure valves or steam discharges. Any hazard should be excluded by structural or organisational measures.
- For safety reasons, it is preferable that the measurement section should not be in a region of positive pressure.
- Suitable measures should ensure that the laboratory personnel carrying out the sampling are informed of any process operating faults which could endanger them.
- It is advantageous to accommodate the working platform or measurement site within the plant building. Particular care should be taken to ensure that the working area is sufficiently protected from heat and dust. Otherwise protective measures, for example weather protection and heating, should be taken to facilitate the necessary environmental conditions for the sampling personnel and the equipment being used.

NOTE: Environmental conditions can affect the measurement result. The ability to follow methods and produce reliable results can be impaired by adverse weather conditions such as wind, rain, snow and inadequate light.

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<sup>1</sup> This content is taken from European Technical Specification CEN/TS 15675. The document was published in 2007 as an application of EN ISO/IEC 17025:2005 to periodic measurement (stack emissions monitoring). As such, it was 'clause-aligned' with EN ISO/IEC 17025:2005 but became obsolete when EN ISO/IEC 17025 was revised in 2017. As a consequence, CEN/TS 15675 was subsequently withdrawn in 2019. Nevertheless, CEN/TS 15675 contained useful information concerning the performance of stack emissions measurements in an accredited context. Some relevant sections are reproduced here. Where possible, they have been linked to the relevant sections of EN ISO/IEC 17025:2017.

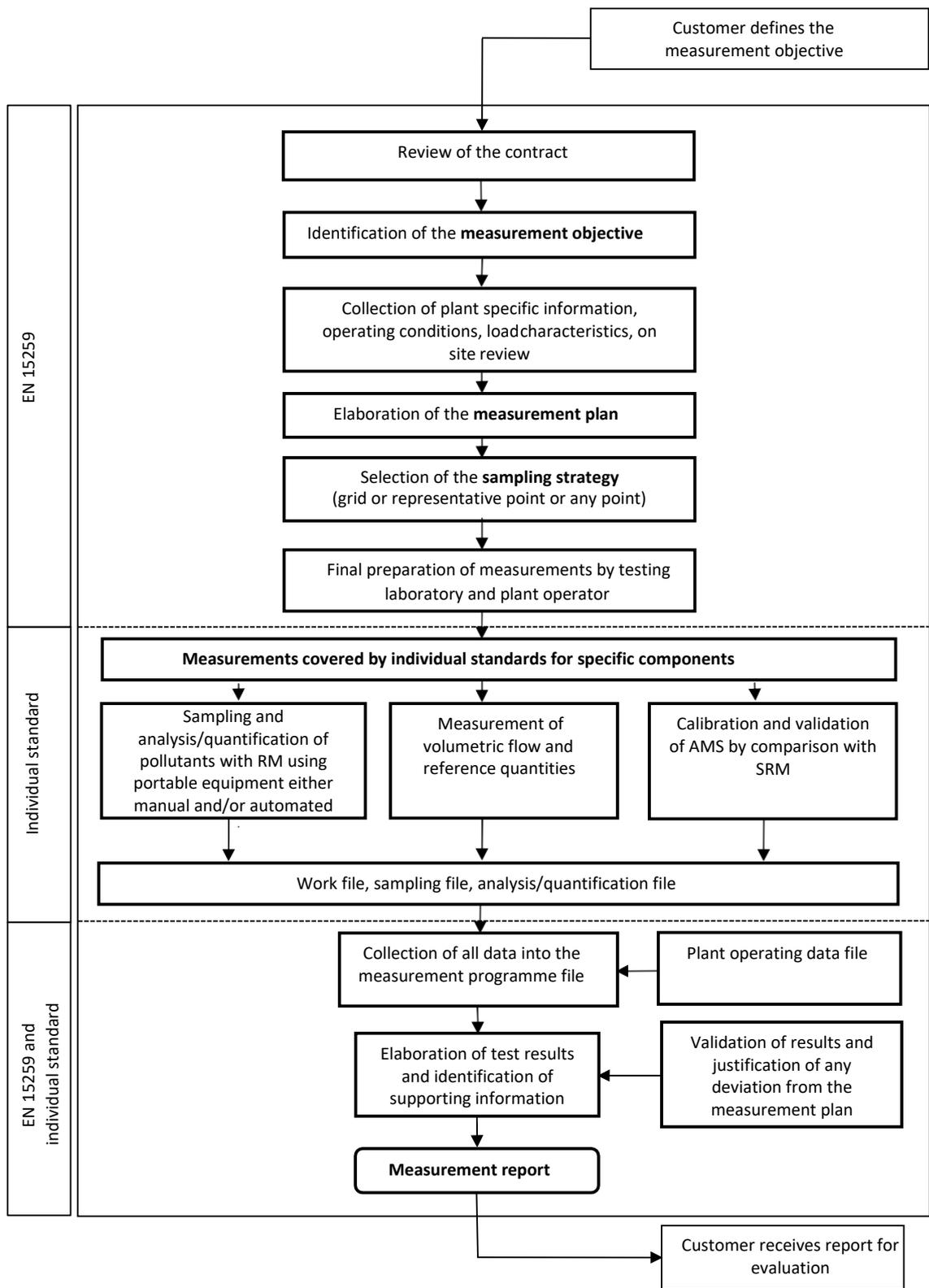
- Service requirements such as electricity supply should also be considered.
- The possible effects of environmental conditions on ambient temperature shall be managed by the following:
  - recording and taking account of the ambient temperature at the measurement site;
  - maintaining the temperature of heated equipment at the operating conditions for the particular method being used;
  - keeping portable analysers at their specified operational temperature range;
  - maintaining a stable and appropriate ambient temperature in mobile laboratories while analysers are operating.
- Emission measurements have a high potential for contamination of samples. The laboratory shall identify and assess the risk of contamination and a clean area shall be available for setting up, recovering and storing equipment and samples.

NOTE: A clean area can be designated in an area close to the place where work is being carried out if the risk of contamination is low. The use of field blanks indicates (albeit retrospectively) if the sample is contaminated.

- Access to and use of areas affecting the quality of the measurements shall be controlled. If necessary, the area for equipment set up and the work area should be cordoned off so that access to the sampling equipment is restricted. If necessary, a mobile laboratory should be manned or otherwise secure, so that access is restricted at all times.
- Equipment – It must be constructed with materials that meet or exceed requirements of the method, (i.e. non-reactive, not cause interference and be robust). All critical items of equipment shall be uniquely identified to aid measurement traceability. Where appropriate, equipment must undergo quality and leak checks prior to measurement (cf: 7.4 above Equipment management)

### **9.5.2 Impact of the Industrial Process on testing strategy.**

- Selection, verification and validation of methods – Methods must be fit for purpose (e.g. suitable to application and limit of detection required). Documents should include operating procedures, a site-specific measurement plan. Tests must be performed in accordance with specified methods. The organisation should estimate the uncertainty if full compliance with the method is not possible;
- The laboratory shall use a method for conducting emission measurements, which is fit for purpose for the process and plant configuration;
- The laboratory shall use written procedures as specified in EN 15259;
- Sampling – Emission measurements consist of planning, sampling, analysis and reporting of results. Figure 6 which illustrates the key stages of the measurement process and the interrelations between the individual measurement standards and the general document EN 15259.



**Figure 6 — Illustration of key stages of periodic measurements of emissions from stationary sources**

- A pre-measurement 'site review' should be undertaken by a responsible person (technical supervisor). The site review should be documented. An example site review checklist is contained Appendix 3;
- A measurement plan (i.e. Site-Specific Protocol) should be generated by a responsible person;
- Further requirements for sampling that relate to a measurement work file (job file), measurement records sheets, field blanks and sample recovery are given below:

### **9.5.3 Site review/ Measurement Plan/Reporting.**

The accepted best practice in air emission monitoring is for the testing organization to adopt the following standardized approach to all projects:

- Conduct a Site Review
- Prepare a Measurement Plan (Site Specific Protocol)
- Maintain a job file (all information/records associated with the project).

#### Site review

Emission measurement personnel need to understand the physical and logistical situation on site before commencing work. Before emission measurements are undertaken a pre-measurement site review shall be undertaken. The review shall provide information essential to determining the appropriate measurement method and development of the measurement plan, which shall be approved prior to conducting the work.

A technically responsible person (technical supervisor) shall conduct the review. Information collected during the visit shall be conveyed to the sampling team prior to commencing work. The review shall include an exchange of information with the plant operator to obtain information relevant to the work.

The site review should be undertaken at an earlier date to the date of sampling so that there is ample time to prepare the Site-Specific Protocol and for any remedial actions to be carried out by the team and/or the operator or regulatory authority.

The site review shall be documented.

In order to prevent any critical items being overlooked, the laboratory shall prepare a checklist of those items that shall be evaluated. An example of items that shall be included in a site review checklist are detailed in Appendix 3 - Site review .

The site review may be abbreviated on repeat visits to the site once the laboratory has full knowledge of the particular site, and the specific requirements of the work in hand.

#### Measurement plan (Site Specific Protocol)

A measurement or sampling plan (EN ISO/IEC 17025 requires a sampling plan) shall be used to address the factors to be controlled to ensure the validity of measurement results.

The term 'Site-Specific Protocol' (SSP) is often used in stack-emission monitoring to describe the measurement or sampling plan. A technical responsible person shall produce a Site-Specific Protocol (SSP). When emission measurements are undertaken for regulatory purposes, the process operator and competent authority prior to commencement of the measurement should

approve the SSP. The laboratory shall retain copies of the SSP.

An example of items that shall be included in an SSP are detailed in Appendix 4 – Template, Site Specific Protocol

#### Measurement Campaign File (Job file)

A file shall be used to record all the details of the emission measurement campaign for an individual site. A measurement campaign file shall contain, as a minimum, the following information:

- scope of work agreed with the customer;
- equipment used;
- reference to equipment history for the measurement campaign;
- reagents and sample media used;
- record of deviations;
- measurement record sheets.

The laboratory shall have procedures for recording measurement data and operations relating to the emission measurements. Measurement record sheets shall be used to record this information. These sheets shall be included as part of the final measurement report. Measurement record sheets shall, as a minimum, include the following information:

- date;
- name of the measurement team member making the records;
- measurement method used;
- identification of the equipment;
- sampling location (including diagrams as necessary);
- environmental conditions, e.g. atmospheric pressure;
- details of measurement start and finish times;
- for manual methods, details of sampling, e.g. dry gas metre readings, solution volumes, pressure and temperature readings;
- for instrumental methods, the output or indicated readings of the analyser (including calibration data);
- for manual methods, sample details, e.g. sample bottle or sorbent tube identification label.

#### **9.5.4 Sample care (blanks; recovery; handling).**

##### Field blanks

When measurements are undertaken that require sample analysis to be carried out at a laboratory's permanent facility, sample blanks shall also be analysed and reported. Many standards specify the procedure for blanks. Where the method does not specify the taking of blanks, a field blank shall be produced that meets the following verification and validation requirements:

- the field blank value shall not be subtracted from the measured value;
- the field blank value shall be less than 10% of the measured value or of the limit value to which the measurement result is to be compared;
- if the calculated measured value is less than the associated field blank value, the

reported result of measurement is defined as less or equal to the field blank value.

### Sample recovery

For certain techniques and methods, it is necessary to recover the sample at the end of the sampling period before it is analysed. Sample recovery shall be undertaken in a manner that does not affect the integrity of the result.

NOTE Examples of sample recovery procedures are

- recovery of particulate matter upstream of the filter by rinsing, evaporation and weighing before adding the weight gain to that of the filter and
- rinsing of all non-heated glassware upstream of impingers and combination of the washings with the impinger solution for analysis.

It is usual for sample recovery to be carried out on site rather than after the site visit in the permanent laboratory. On-site sample recovery is essential for extended sampling campaigns with multiple runs. The sample recovery shall be carried out as described in the method of measurement and the laboratory's operating procedures. These shall state the reagents to use (e.g. water, toluene, acetone) and the cleaning technique (e.g. rinsing with wash bottle).

### Handling of test items-

The transport of waste gas from the duct to an analyser or to the analytical laboratory shall not affect the sample result.

Collected samples should be maintained under environmental conditions that do not alter the integrity of the result. A chain of custody record is to be maintained from the collection of samples, to sample storage, through to sample analysis. The record should detail the person, who has possession of the samples, the location of the samples and storage requirements is applicable.

The stack itself is considered to be part of the measurement item and therefore shall be identifiable by a specific reference number or description.

Any deviations from a method caused by measurement sites not conforming to the method requirements (e.g. access restricted to one port) shall be recorded.

## **9.5.5 Interlaboratory comparison**

To ensure the validity of results, appropriate schemes for proficiency testing (PT) by interlaboratory comparisons shall be used, where available. The Agency encourage the use of PT schemes that are accredited to EN ISO/IEC 17043. It is advisable for a test house to consult with their accrediting body before they select a PT scheme and decide on the extent of their involvement. INAB policy on Proficiency Testing can be found [here](#). UKAS policy on Proficiency Testing can be found [here](#).

Schemes for proficiency testing (PT) by interlaboratory comparisons are available for emission measurements. However, they do not cover all aspects relevant to the production of reliable results of known uncertainty. Aspects that are covered include the following:

- analysis of standard gas mixtures;
- use of measurement sites or test rigs with known characteristics;
- weighing of filters and particulate material.

At the time of publication, some providers of PT schemes include; [NPL](#), [Effectech](#) and [VSL](#).

### 9.5.6 Reporting of results

In certain cases, the customer, particularly regulators, can require the use of a specified standard report format. It shall contain an unambiguous identification stacks, process conditions, waste gas characteristics (temperature, pressure, moisture, and oxygen). The EPA reporting requirements are given in Appendix 5 - Stack emission monitoring report.

### 9.5.7 Supplemental QMS requirements – Compliance testing at EPA licensed sites

The EPA also requires that the following technical provisions are satisfied by accredited organisations that are conducting compliance testing at licensed sites.

**Additional EPA requirements relating to the technical aspects of the stack testing organisation.**

Facilities and environmental conditions - Sampling facilities should meet the requirements of EPA Guidance Note AG1. Any deviation from standard method as a result of the sampling facilities should be reported.

**Additional EPA requirements relating to the management of the stack testing organisation.**

If analytical work is subcontracted, it shall be to an organisation that has accreditation to EN ISO/IEC 17025 for the scope of work.

Sub-contracting of any function must only occur within the terms permitted by the accrediting body. A comprehensive monitoring report must provide full transparency in relation to the sampling staff that were employed, the monitoring equipment and analytical laboratory that were used and the management responsibilities with oversight for the project.

Health and safety policy should specifically address the hazards and risks that are associated with stack testing having regard to the EPA Guidance Note AG1. Health and Safety training should be commensurate with that provided by the Source Testing Association or its equivalent.

Selection, verification and validation of methods - Methods employed should be selected from the list of EPA Index of Preferred Methods unless an alternative is agreed. Deviation from a standard method should only occur if technically justified, validated and fully documented. Organisations must prepare an uncertainty budget and estimate the measurement uncertainty in all cases (it is not acceptable to quote the MU stated in the method). The AG2 Index of Preferred Methods provides a valuable source of information on specific standard methods.

Equipment - In methods where detailed leak check procedures are not given, the leak flow shall be below 2 % of the normal flow rate during sampling.

Sampling – A Health and Safety risk assessment should be conducted as part of the site review and must be conducted daily before the commencement of site activities. An example of a measurement plan is given in Appendix 5 – Template, Site Specific Protocol . It is not necessary for the EPA to approve measurement plans (Site Specific Protocols) prior to commencement; it is the responsibility of the licensee to ensure that the plan meets the requirement of the licence for periodic compliance monitoring.

Handling of test items – Licence emission point reference numbers should be used to uniquely identify the stack at which samples were collected or measurements conducted.

Reporting of results – An example of a test report that is acceptable to the EPA is given in Appendix 5, - Stack emission monitoring report

## 9.6 IS EN 15259

### IS EN 15259<sup>xxi</sup>

This standard deals with the location where stack tests are conducted, the measurement plan, and the monitoring report. It is a general standard method as distinct from the many specific standard methods for the determination of individual pollutants, [the numbers refer to the section numbers in EN 15259]:

- 6.0 Measurement section and measurement site – A measurement section and site, preferably created at the plant design stage should be available to enable a representative sample to be taken. Aspects of structural safety of chimneys, construction of working platforms and safety of personnel using them are not treated in this standard. The standard has useful diagrams showing the optimum design for sampling platforms and sample port location;
- 7.0 Measurement objective and measurement plan - The measurement objective specifies the work to be carried out, the plant operating conditions under which measurements are to be taken, any plant or process related information to be collected, working procedures to be used and any associated requirements. The results of these considerations are outlined in the measurement plan (aka Site Specific Protocol (SSP)). Measurements are performed by suitable qualified personnel, under adequate supervision;
- 8.0 Sampling strategy – A key aspect of this section is the requirement to assess homogeneity of gases at the sampling plane. A description is given of how to test for

and calculate the homogeneity (using two sampling trains);

- 9.0 Measurement report - The measurement report shall provide a comprehensive account of the measurements, a description of the measurement objective, and the measurement plan. It shall provide sufficient detail to enable the results to be traced back through the calculations to the collected basic data and process operating conditions;

Further to the requirements of EN 15259, the EPA requires the following provisions are satisfied by accredited organisations that are conducting compliance testing at licensed site.

Additional EPA requirements that relate to the aspects covered in EN 15259.

6.0 Measurement section and measurement site – EPA Guidance note AG1 defines the requirements for sampling facilities at licensed sites. The standard provides a more detailed treatment of these aspects so there are no additional requirements.

7.0 Measurement objective and measurement plan – The EPA requirements tend to simplify the whole area of objectives/planning/strategy. All compliance monitoring campaigns should be preceded by the preparation of a Site Specific Protocol (see example template in Appendix 4 – Template, Site Specific Protocol. The SSP should be agreed with licensee and made available to the EPA on request. The timing of the monitoring should seek to coincide with maximum emission levels.

8.0 Sampling strategy – Refer to above and requirement for SSP to using example template in Appendix 4 – Template, Site Specific Protocol. The EPA consider that while it is best practice to test for homogeneity, it is only required for combustion processes and stacks with an area  $\geq 1.0\text{m}^2$  (equivalent to  $\geq 1.13\text{m}$  diameter for circular ducts). In these instances the duct geometry may result in the inadequate mixing or stratification of pollutants.

9.0 Measurement report - The EPA is legally obliged to provide public access to information in relation to the enforcement of EPA licenses. The licence will also stipulate the reporting frequency, deadlines for submission, requirement for retention of data and notification of non-compliant results. The report must provide the non-technical reader with concise and unambiguous information about the emission points that were tested and their compliance status. It should also provide the licence inspector with both summary information and the supporting technical detail to demonstrate the probity of the measurement process and the reliability of the results. An example of a test report that is acceptable to the EPA is given in Appendix 5, - Stack emission monitoring report

## 10 Standard Methods

Standard reference methods are essential for the effective measurement and control of air pollution. Such standards are developed at international level. The robustness and fitness for purpose of these standards is a function of the accumulated expertise and experience of the people who work together in committee to produce them.

### Guidance on use of standard methods.

The use standard methods are integral to the EPA requirement that licence compliance monitoring is accredited to EN ISO/IEC 17025. This chapter is for informative purposes.

A licence issued by the EPA will typically require: Sampling and analysis of all pollutants as well as reference measurement methods to calibrate automated measurement systems shall be carried out in accordance with CEN-standards. If CEN standards are not available, ISO, national or international standards, which will ensure the provision of data of an equivalent scientific quality, shall apply.

Some licenses will require that monitoring methods are agreed with the EPA subsequent to licence issue, in which case the licensee should select from the hierarchy of standards the method most appropriate to their application and seek approval from their licensing inspector. Licenses may also stipulate the monitoring method in generic terms (e.g. Isokinetic/gravimetric or sorbent tube/GCMS). Such broad definitions reflect the difficulty of prescribing definitive test methods for many parameters due to the limited availability of methods and the complexity of their application.

### 10.1 Irish standards

The National Standards Authority of Ireland (NSAI) is Ireland's National Standards Body. The NSAI represents Irish interests through the formulation of a national input to standards developed at European level by Comité Européen de Normalisation (CEN) and international level by International Standards Organisation (ISO). Both of these Standards bodies work towards the harmonisation of standards and the removal of technical barriers to trade.

The technical committees of CEN/TC 264 (air quality) and ISO TC 146 (air quality) are responsible for the development of new standards and the revision of existing standards in the field of air pollution. Details of these committees and their work programmes can be found at [CEN TC264 web site](#) and [ISO/TC 146 web site](#) respectively. The CEN/TC 264 effort is targeted at those areas where there is a specific or urgent need for specialised standards to support EU legislation. When a CEN standard is produced, NSAI must adopt it and any conflicting Irish Standard (IS) must be withdrawn. ISO standards are not mandatory and are adopted by NSAI on an as needed basis. Irish Standards are available for purchase from the [NSAI web site](#).

The value of these Irish Standard methods is that they are developed by experts through process of international consensus.

### 10.2 Hierarchy of standards

Standards developed by different organisations vary in the degree of validation work carried out as part of their development. Standards developed and published by CEN are generally accepted as being the most robust. However, other standards are still important, as there are substances that are not, as yet, covered by CEN Standards. The selection of method is often dictated by the requirements of the relevant EU Directive, which, for example, makes mandatory the use of the relevant CEN standard. If the selection of method is not dictated by mandatory requirements, then monitoring standards should be used in the following order of priority as given in the European IPC Bureau's Reference Document on the Reference Report on Monitoring of Emissions to Air and

Water from IED installations:

- Comité Européen de Normalisation (CEN);
- International Standardisation Organisation (ISO).

If the substance cannot be monitored using standards covered by the above, then a method can be selected from any one of the following:

- American Society for Testing and Materials (ASTM);
- Verein Deustcher Ingenieure (VDI);
- British Standards Institution (BSI);
- Association Francaise de Normalisation (AFNOR);
- Deutsches Institute fur Normung (DIN);
- United States Environmental Protection Agency (US EPA).

If the substance cannot be monitored using standards covered by the above then the following occupational methods may be developed and validated, following the requirements of CEN/TS 14793<sup>xviii</sup>, for stack-emission monitoring:

- Method for the Determination of Hazardous Substances (MDHS) series published by the Health and Safety Executive (HSE);
- National Institute of Occupational Safety and Health (NIOSH);
- Occupational Safety and Health Administration (OSHA).

Caution is advised against selecting a method solely because it measures a named pollutant. The selection must take account of the scope and applicability of the method to ensure that it can deliver reliable emission data for the stack in question.

Other than in exceptional circumstances, the method selected to monitor a stack emission should be one of those listed in the [Index of Preferred Methods](#). The EPA would consider that the application of the methods listed would give comparable performance/results. However, it is important that the intended application of the method is taken into account. Alternative methods may be acceptable with the agreement of the EPA.

### 10.3 An index of preferred methods

The EPA has also produced an Index of Preferred Methods. This document is complementary to this guidance note.

Rules employed in the compilation of the index. Included on the list:

- All published EN's are listed;
- ISO standards that considered useful due to absence of EN or because the ISO affords greater scope of application;
- Standard methods from other sources that are commonly used in Ireland.
- A series of appendices which provide clarification on a number of standard methods.

Note: Environment Agency (England) produces a series of Methods Implementation Documents (MIDs). Standards may contain various options and approaches, as well as potential ambiguities. Method implementation documents (MIDs) have been produced for several standards to ensure they are applied consistently. MID's are used by contractors who are EN ISO/ISO 17025 accredited by UKAS for the required method(s), subject to compliance with AG2. The information contained in the Appendices to the Index of Preferred Methods is drawn largely from the respective MID.

This is not an exhaustive list of standard methods. If there are technical or other reasons why the listed standard is unsuitable for a particular application, then the hierarchy of standards should be used to select a more suitable method.

#### **10.4 Deviation and validation**

Deviation from standard methods would not normally be acceptable to the EPA, and should only occur if the deviation is technically justified, validated and fully documented (where appropriate).

In conjunction with their testing laboratory any facility or organisation engaged in stack monitoring should validate any non-standard methods, laboratory-designed/developed methods, standard methods used outside their intended scope and modifications of standard methods to confirm that the methods are fit for the intended use. The validation should be as extensive as is necessary to meet the needs of the given application.

Where it is necessary to modify a method, it should be demonstrated to be equivalent to the relevant standard procedure by a process of validation, as specified in CEN/TS 14793:2004<sup>xxiii</sup>. Validation can include procedures for sampling, transportation and analysis. This process of validation consists of:

- Definition of the method and the field of equivalence (range and type of gas matrix);
- Determination of the method and calculation of the overall uncertainty and other characteristics such as limit of detection of the method and selectivity, and where appropriate, check of compliance of the maximum overall uncertainty;
- Check of repeatability and lack of systematic error of the method in the field and, where appropriate, in comparison with the standard reference method (SRM) for the type of matrix defined in the field of equivalence.

#### **10.5 Future standards**

The development of new standards and the revision of existing standards is an on-going process. Standards that have undergone a revision will appear on the [NSAI web site](#) shortly after the ratification process has been completed. A full listing of standards currently in development can be found on [CEN web site](#) and [ISO TC 146 web site](#) respectively.

## **Appendices**

## Appendix 1 – On site QA checks in standards for commonly measured pollutants

### Particulates (EN 13284-1) & Active pharmaceutical ingredients

- In-stack / out-stack: Out of stack testing is required if there are water droplets. Out stack monitoring requires the use of a heated probe and a heated filter heated at least 20°C above stack temperature, or the dew point of the stack gas mix (whichever is greater)
- Sample blank: Observe / check a field blank has been carried out in a similar fashion to sample procedure but without starting the pump and leak checks are performed. The probe should not be inserted into the stack.
- For combustion processes: Prior to isokinetic monitoring, the gas density of the stack gas must be calculated from oxygen, moisture and carbon dioxide measurements. Gas density can be calculated:
  - From direct measurements of O<sub>2</sub>, moisture and CO<sub>2</sub> before isokinetic monitoring
  - From CEMS readings on the day of monitoring (60min average). CEMS must be maintained and within calibration (compliant with EN 14181)
  - From the average results over at least 3 monitoring campaigns provided that results are steady and without significant variations over time (Standard deviation < 20% of the average of results).
  - \* In the case of dry air (<1% humidity) the molar mass may be assumed to be 26 kg/kmol.
  - \* If CEMS readings or average results are used for gas density calculation before isokinetic monitoring, O<sub>2</sub>, moisture and CO<sub>2</sub> still need to be measured for results corrections (if applicable), volumetric flow results, and uncertainty calculations. This could be done during or after isokinetic monitoring.
- The measurement uncertainty of the cross-sectional area of the selected sample nozzle shall be less than 5%. It is, therefore, recommended that, wherever possible, the nozzle diameter should exceed 8 mm.
- Pre and post leak checks: a leak of up to 2% of normal flow rate allowed (this is 2% of the suction flow rate of the sampling pump after selecting the nozzle size). For example, if after measuring the stack velocity and volumetric flow rate and after selecting an 8mm nozzle the suction rate to keep isokinetic conditions is 15 l/min, the maximum leak allowed would be 0.3 l/min.
- Isokinetic rate check calculation: needs to be within 95-115%. If failed, the test is not valid.

### Metals (EN 14385)

- Sample blank: Observe / check a field blank has been carried out in a similar fashion to sample procedure but without starting the pump and leak checks (before and after) performed.
- If leak pre and post checks failed (>2% as explained above), the test is not valid.
- For combustion processes: Prior to isokinetic monitoring, the gas density of the stack gas must be calculated from oxygen, moisture and carbon dioxide measurements. Gas density

can be calculated:

- From direct measurements of O<sub>2</sub>, moisture and CO<sub>2</sub> before isokinetic monitoring
  - From CEMS readings on the day of monitoring (60min average). CEMS must be maintained and within calibration (compliant with EN 14181)
  - From the average results over at least 3 monitoring campaigns provided that results are steady and without significant variations over time (Standard deviation < 20% of the average of results).
  - \* In the case of dry air (<1% humidity) the molar mass may be assumed to be 26 Kg/kmol
  - \* If CEMS readings or average results are used for gas density calculation before isokinetic monitoring, O<sub>2</sub>, moisture and CO<sub>2</sub> still need to be measured for results corrections (if applicable) and volumetric flow results and uncertainty calculations. This could be done during or after isokinetic monitoring.
- Wherever possible, the nozzle diameter should be over 6mm.
  - Probe & filter temperature: at least 20°C above stack temperature or dew point of the stack gas mix (whichever is greater). Condensation on the filter shall be avoided.
  - Impingers should be kept cold with ice if required (<30°C).
  - All parts coming into contact with the sample are to be made of corrosion resistant and inert material, i.e. borosilicate glass, quartz glass, PTFE, or titanium.
  - Isokinetic rate check calculation: needs to be within 95-115%. If failed the test is not valid.
  - When sampling is complete, rinse the nozzle, probe and filter housing after each measurement with rinsing acid. The rinsing solution becomes part of the sample.
  - No metallic tweezers used for filter assembly and removal.

## Dioxins (EN 1948)

- The method is designed to detect pollutants at very low levels. It is good practice to establish a clean environment (removed from the sampling location if necessary). The clean environment shall be used for sample train preparation and sample recovery operations. The tip of the sample probe should be capped when not sampling to reduce the risk of contamination.
- Observe / check a field blank has been carried out in the same manner as the test but do not insert the probe in the stack or start the pump and leak checks (before and after).
- Leak checks: a leak of up to 5% of normal flow rate is allowed. Leak checks must be carried out before the commencement of the test, when changing the port and at the end of the test. If leak check failed the sample is not valid.
- Filter temperature: <125°C but above sample gas dew point. Condensation on the filter shall be avoided.
- The resin trap temperature must be monitored and kept <20°C during the test (use ice as required).

- For combustion processes: Prior to isokinetic monitoring, the gas density of the stack gas must be calculated from oxygen, moisture and carbon dioxide measurements. Gas density can be calculated:
  - From direct measurements of O<sub>2</sub>, moisture and CO<sub>2</sub> before isokinetic monitoring
  - From CEMS readings on the day of monitoring (60min average). CEMS must be maintained and within calibration (compliant with EN 14181)
  - From the average results over at least 3 monitoring campaigns provided that results are steady and without significant variations over time (Standard deviation < 20% of the average of results).
  - \* In the case of dry air (<1% humidity) the molar mass may be assumed to be 26 Kg/kmol
  - \* If CEMS readings or average results are used for gas density calculation before isokinetic monitoring, O<sub>2</sub>, moisture and CO<sub>2</sub> still need to be measured for results corrections (if applicable) and volumetric flow results and uncertainty calculations. This could be done during or after isokinetic monitoring.
- Isokinetic rate check calculation: needs to be within 95-115%. If failed the test is not valid.
- Wherever possible, the nozzle diameter should be over 6mm.
- The following parameters are required to be periodically recorded (at least every 15 min) to enable the validation of the sampling: velocity in duct, temperature in duct, flow rate through sampling train, filter temperature, adsorbent temperature.
- Inner surfaces of sample train components which are not transferred to the laboratory shall be rinsed with solvents (this normally includes two different solvents, where one of them is miscible with water e.g. acetone and/or methanol followed by toluene). The rinsing solution becomes part of the sample.
- Sample storage: brown glass bottles with screw caps.
- Resin traps and filters may be wrapped in foil to exclude light (good practice). Stored in dark place at <25 °C.

## **SO<sub>2</sub> (EN 14791)**

- Observe / check a field blank has been carried out in the same manner as the test but do not insert the probe in the stack or start the pump and leak checks (before and after).
- If leak pre and post checks failed (>2% as explained above), the test is not valid.
- Probe & filter temperature: at least 20°C above stack temperature or dew point of the stack gas mix (whichever is greater). Condensation on the filter shall be avoided.
- All parts of the sampling equipment upstream of the first absorber shall not react with or adsorb SO<sub>2</sub> (i.e. Borosilicate glass, quartz glass, PTFE or titanium are suitable materials).
- If an unheated gas connector line is used between the heated filter and the first absorber, it shall be thoroughly rinsed with fresh absorption solution after sampling and the rinsing solutions shall be combined with the sample.

- If droplets are present in the flue gases the probe shall be equipped with a nozzle and an isokinetic sampling shall be performed according to EN 13284-1.
- When sampling is complete, rinse thoroughly all the parts of the absorbers, and particularly the fritted glass dividers with absorption solution. The rinsing solution becomes part of the sample
- Adsorption efficiency requirement: >95%.
- The particulate filter shall have a collection efficiency of at least 99.5% for 0.3 µm particles (or 99.9% at 0.6 µm).

## **HCl (EN 1911)**

The standard measures gaseous chloride concentration

- Observe / check a field blank has been carried out in the same manner as the test but do not insert the probe in the stack or start the pump and leak checks (before and after).
- If leak pre and post checks failed (>2% as explained above), the test is not valid.
- Probe & filter temperature: at least 20°C above stack temperature or dew point of the stack gas mix (whichever is greater). Condensation on the filter shall be avoided.
- Absorption solution: chloride-free water (conductivity <100 µS/m).
- A line connecting the heated separator to the absorber is made of borosilicate glass or PTFE. Parts of the line which are not rinsed shall be heated to avoid condensation. This line shall be as short as possible, in order to minimise the residence time of the gas.
- All the parts of the sampling equipment which are in contact with the gases to be analysed upstream of the absorbers, including probe nozzle, seals and flexible connections shall be resistant to corrosion and temperature. They shall not adsorb or react with gaseous chlorides and other compounds in the gases being sampled.
- Borosilicated glass and titanium are convenient, and PTFE may also be used (seals, flexible connections, etc.). Stainless steel shall not be used, since it is known to give gaseous chlorides losses in some cases.
- If droplets are present in the flue gases the probe shall be equipped with a nozzle and an isokinetic sampling shall be performed
- When sampling is complete, rinse the absorbers and the connecting line with the absorption solution and collect the solution into a flask for analysis.
- Adsorption efficiency requirement: >95%.

## **HF (ISO 15713)**

The standard measures gaseous fluoride content

- Observe / check a field blank has been carried out in the same manner as the test but do not insert the probe in the stack or start the pump and leak checks (before and after).
- If leak pre and post checks failed (>2% as explained above), the test is not valid.
- Probe & filter temperature: at least 20°C above dew-point temperature or 150°C (whichever is greater). Condensation on the filter shall be avoided.
- The probe shall be resistant to fluoride attack to avoid sample loss (e.g. Monel<sup>®</sup> or silica).
- Impingers shall be connected to the probe using HF resistant materials (e.g. polypropylene, polyethylene or Viton<sup>®</sup>).
- Absorption solution: 0.1 mol/litre NaOH solution.
- Adsorption efficiency requirement: >95%.
- The particulate filter shall have a collection efficiency of at least 99.5% for 0.3 µm particles. If the amount of particulate fluoride in the sample is <10% of the total, the filter may be omitted.
- If droplets are present in the flue gases the probe shall be equipped with a nozzle and an isokinetic sampling shall be performed

## Ammonia (EN ISO 21877)

- Observe / check a field blank has been carried out in the same manner as the test but do not insert the probe in the stack or start the pump and leak checks (before and after).
- If leak pre and post checks failed (>2% as explained above), the test is not valid.
- The sampling probe shall be heated to a specified temperature that ensures evaporation of droplets (if present) and avoids condensation of water vapour.
- The sampling probe shall be a heated tube with an inlet made of titanium, quartz glass, borosilicate glass or PTFE.
- The particle filter shall be a quartz fibre plane filter, to be heated if used outside the waste gas duct.
- Absorption solution: 0,05 M H<sub>2</sub>SO<sub>4</sub> solution (quality: analytical grade).
- Adsorption efficiency requirement: >95%.
- If droplets are present in the flue gases the probe shall be equipped with a nozzle and an isokinetic sampling shall be performed

## Gas analysers (e.g. NO<sub>x</sub>, CO, TVOC)

- Certification: Check if certified. Check certified range - 1.5 x daily ELV for WID, 2.5 x (daily) ELV for others.
- FID: Check what fuel gas (H<sub>2</sub> or H<sub>2</sub>/He mix) is being used.
- Probe / filter type: Not stainless steel for NO<sub>x</sub> (above 250°C) or HCl.
- TVOCs: It shall have a heated filtering device upstream of the sampling line to trap all particles liable to impair the operation of the apparatus.
- Warm-up time: Have analysers been given enough time to warm up and stabilize as per manufacturer recommendations?
- Analyser calibration: Is the analyser within its calibration period?
- Zero and check gases: T90 response time needed. Wait 3x T90 to take reading (T90 = Time taken to reach 90 % of the value of the check gas).
- Certified gases: Must be traceable to a gas certified as per ISO 17025 Standard requirements. Must have an uncertainty of <2%.
- Calibration: (Zero / Span / Zero) + Line check (Zero / Span) + Post check (Zero / Span). To be carried out only after the instrument provides steady readings. If the pre or post checks are interrupted before reaching stable readings, the instrument drift is not properly checked.
  - Pre-test zeros / span: direct to analyser. The span gas shall have a known concentration of approximately the half-hourly ELV or 50 % to 90 % of the selected range of the analyser. It shall have an inlet for applying zero and span gases.
  - Pre-test leak check: Must check full sample system (tip of the nozzle). Any differences between the readings obtained during the adjustment of the analyser and during the check of the sampling system shall be lower than 5% of the span value.
  - Pre-test zeros / span: Full system check (tip of the nozzle) - Wait 3x T90 before taking reading. Any differences between the readings obtained during the adjustment of the analyser and during the check of the sampling system shall be lower than 5% of the span value.
  - \* Zero / span drift: <2% acceptable. 2% to 5% needs adjusting. > 5% test invalid
- Oxygen synergy / TVOCs: Using zero gas and span gas with similar levels of oxygen as present in the stack gas will give the most accurate results. This is recommended where oxygen levels in the stack gas is around 10%.
- Heated line temperature: 160-180°C.

## FTIR (CEN/TS 17337)

The following provides details that can be required when using FTIR equipment for periodic

measurements. It is based on the requirements of CEN/TS 17337. The reader is advised strongly to ensure compliance with this standard when conducting FTIR work.

- EN 15267-4 (Performance Criteria for Automated Measuring Systems for Periodic Measurements) is relevant throughout CEN/TS 17337. FTIR analysers that had valid certification to EN 15267-3 when newly purchased are acceptable.
- Sampling apparatus shall be heated to at least 180° (if using a hot/wet system).
- The choice of measuring system must take into account stack gas characteristics (e.g. isokinetic sampling might be appropriate if droplets present).
- The FTIR is to be operated via two possible approaches:
  - Check Gas approach
  - Span Gas approach
- The check gas approach involves a sub-set of reference gases, the span gas approach is required for all measurands. The approach cannot be changed from one annual calibration to the next. Specifications for test gases (including zero gas) are contained in CEN/TS 17337.

#### **Tests at the start of the measurement period**

- A background shall be recorded using zero gas. A zero gas check shall also be carried out at least once per day.
- Check Gas approach - zero and check gas is fed direct to the analyser cell, not through the sample inlet probe.
- Zero gas should read no more than 2% of certified range, check gas no more than 5% of certified value.
- Spans Gas approach – a zero check is conducted, and the instrument forced to zero, a zero is also conducted between each span (direct to analyser), each zero should be <2 x repeatability at zero.
- Zero gas shall be passed through the measuring system and a stable reading obtained for each component (<2% of certification range)
- Check for losses and leakage and response time using of a test gas to verify sample system integrity - the deviation between the “direct to analyser” value and the “through the sampling system” value shall not exceed 2%.

Note: CEN/TS also allows the use of alternative approaches such as wet-gas injection and analyte spiking.

A spectral residual test is required once per day.

#### **Tests at the end of the measurement period**

- Zero gas passed through the whole system. The zero reading for each component must be <2% of certified range.
- Drift checks must be performed using the test gas. Pass/fail criteria for drift are the same as

the other EN SRMs for periodic measurements.

CEN/TS 17337 includes mandatory information that shall be included in test reports.

Note: CEN/TS 17337 includes mandatory QA/QC checks such as annual checks of the analyser linearity and annual checks of the conditioning system. For practical reasons, tests at the beginning and at the end of the measurements for reactive gases (HCl, NH<sub>3</sub> and HF) are not required at each campaign but on a quarterly basis in a controlled environment (office/workshop). Evidence of gas certificates and data produced shall be maintained by the testing house and ready for inspection.

## Appendix 2 – Calculations

Calculations have been provided courtesy of the Source Testing Association [www.s-t-a.org](http://www.s-t-a.org). A calculator for Correction of Concentration and Volumetric Flows can be found at the [EPA website](#).

### Calculation of concentrations and mass emissions

To calculate a concentration, the mass of the substance collected during sampling is divided by the volume of stack gas sampled.

1. Concentration = mass of substance / sample volume

A gas sampling pump draws a gas volume of 0.1 m<sup>3</sup> across a filter. Laboratory analysis determines the filter has gained in weight by 25mg due to deposited particulate. The mass concentration of particulate is calculated as follows:

$$\text{mass concentration} = \frac{\text{mass of pollutant}}{\text{volume of gas}} = \frac{25\text{mg}}{0.1\text{m}^3} = 250 \text{ mg} \cdot \text{m}^{-3}$$

*Mass concentration = 250 milligrams per cubic meter*

To convert a concentration to a mass emission it is necessary to know the discharge of gas from the stack.

2. Volume flow rate (m<sup>3</sup>/s) = velocity of gas (m/s) x cross-sectional area of stack (m<sup>2</sup>)

The average velocity of the gas moving through a stack is measured at 8 m/s. The circular stack has a diameter of 1 m, (cross sectional area of 3.14 m<sup>2</sup>). The volumetric flow rate is calculated as follows:

$$\text{Volumetric flow} = \text{gas velocity} \times \text{area} = 8\text{m} \cdot \text{s}^{-1} \times 3.14 \text{ m}^2 = 25.1 \text{ m}^3 \cdot \text{s}^{-1}$$

*Volumetric flow = 25.1 cubic meters per second, or 90,432 cubic meters per hour*

3. Mass emission (e.g. kg/hour) = concentration (mg/m<sup>3</sup>) x volume discharge (m<sup>3</sup>/s) 10<sup>-6</sup> x 3600 The calculation is only valid when the concentration and volume flow terms are in same units of temperature, pressure, moisture content and reference oxygen. To avoid mistakes, it is advisable that data management procedures ensure that the two terms (volume flow and concentration) are available in either of the following formats; (1) fully corrected to reference conditions, or (2) at stack conditions.

The concentration of pollutant in a stack is measured at 250 mg/m<sup>3</sup> (at reference conditions) and the volumetric flow rate is measured at 25.1 m<sup>3</sup>/s (also at reference conditions). The mass flow (or mass emission) rate is calculated as follows:

$$\text{Mass flow} = \text{concentration} \times \text{vol. flow} = 250 \text{ mg} \cdot \text{m}^{-3} \times 25.1 \text{ m}^3 \cdot \text{s}^{-1} = 6,275 \text{ mg} \cdot \text{s}^{-1}$$

$$\text{Mass flow} = 6,275 \text{ milligrams per second, or } 22.6 \text{ kilograms per hour.}$$

### Conversion of concentration units (ppm to mg/m<sup>3</sup>)

To convert ppm to mg/m<sup>3</sup> the following equation is required:

$$4. \text{ Concentration (mg/m}^3\text{)} = \{\text{concentration (ppm)} \times \text{molecular weight (g)}\} / \text{Molar volume(l)}$$

The molar volume is the volume occupied by one-gram mole of a gas at a specific temperature and pressure. The temperature and pressure that concentrations are usually reported at is 273.15K and 101.325 KPa. Under these conditions the molar volume is equal to 22.41 litres.

An analyser designed to measure the concentration of carbon monoxide (molecular weight 28) detects a level of 30ppm in the stack gas. The licence limit is expressed in units of mg/m<sup>3</sup> (at reference conditions). The concentration in mg/m<sup>3</sup> is calculated as follows:

$$\text{Concentration in mg/m}^3 = \frac{\text{ppm} \times \text{Mol. wt}}{\text{molar volume}} = \frac{30 \times 28}{22.4} = 37.5 \text{ mg} \cdot \text{m}^{-3}$$

### Temperature and pressure corrections

To convert the concentration as measured at a temperature of T K to the concentration at 273.15 K, multiply by F<sub>t</sub> where

$$5. \quad F_t = T/273.15$$

To convert the concentration as measured at a pressure of P kPa to the concentration at 101.325 kPa, multiply by F<sub>p</sub> where

$$6. \quad F_p = 101.325/P$$

For concentration measurements, P and T will be the pressure and temperature at the point where the sample volume is metered. Note that the two equations above should only be used to convert mass concentration (e.g. mg/m<sup>3</sup>) and not for volume concentration (e.g. ppm).

When volume flow data is corrected to for temperature and pressure use the reciprocal equations.

## Moisture and oxygen corrections

Emissions of stack gases are usually expressed on a dry gas basis so that variation in the moisture of stack gas does not affect the assessment of the emissions.

To convert a concentration from wet gas to dry gas, the following is used:

$$7. \quad \text{Dry gas concentration} = \text{Wet gas concentration} \times \{100 / (100 - \text{H}_2\text{O}\%)\}$$

To convert a concentration “as measured” to a concentration at reference oxygen level, multiply the concentration by  $F_o$ , the correction factor for oxygen, given by:

$$8. \quad F_o = \{ 20.9 - \text{O}_2\% \text{ reference} \} / \{ 20.9 - \text{O}_2\% \text{ measured} \}$$

Note that when using equation 8 the measured oxygen value should be expressed on a dry gas basis. In situations where the measurement technique has provided oxygen data on a wet basis then the data must be converted to a dry basis using equation 7.

Use the reciprocal equations when volume flow data needs to be corrected for moisture and reference oxygen.

## Determining the Isokinetic ratio

In order to perform isokinetic sampling, it is necessary to calculate the required sampling flow rate to ensure that the velocity of the gas entering the nozzle is the same as the velocity of the stack gas at the sampling plane. This takes into account the velocity of the gas in the stack at the sampling point and the effective diameter of the sampling nozzle.

$$9. \quad \text{Sampling flow rate} = \text{area of nozzle} \times \text{velocity of gas entering nozzle}$$

By comparing the velocity of the gas at the nozzle with the velocity of the stack gas at the sampling plane the isokinetic ratio is determined.

$$10. \quad \text{Isokinetic ratio (\%)} = \{ \text{velocity at the nozzle} \times 100 \} / \text{velocity of stack gas}$$

It is also possible to check for isokinetic sampling compliance by comparing the required sampling flow rate to the actual sampling flow rate performed during the monitoring.

$$11. \quad \text{Isokinetic ratio (\%)} = \{ \text{actual sampling flow rate} \times 100 \} / \text{required sampling flow rate}$$

I.S. EN 13284-1:2017 for the determination of low range concentration of dust states that, if the mean actual isokinetic ratio during the sampling at the sampling plane differs by more than -5 to +15%, the measurement is not valid.

Note: When expressing gaseous concentration, the notation mg.m-3 is the same as mg/m3, either notation is equally acceptable to the EPA.

## Appendix 3 - Site review

As specified in EN ISO/IEC 17025 a laboratory must have a sampling plan (measurement plan). A site review provides the laboratory with a way to assess what is required in a measurement plan (or Site-Specific Protocol, SSP). When performing a site review, the following information should be included:

- a) plant information:
  - address and contact information;
  - general information about the process and measurements to be conducted;
  - scope of work;
- b) process conditions:
  - process characteristics (material balance, process flow diagrams, feedstock details);
  - expected emissions (mass concentration or mass);
  - expected process variations;
  - site instrumentation relevant to the measurement process;
  - emission control equipment (type, operating mode, instrumentation, control arrangements);
- c) sampling site:
  - access to the duct;
  - adequate work area at the sampling positions;
  - availability of required utilities (electricity, lighting, water);
  - sampling ports (accessibility, correct size, sufficient number, properly located);
  - duct dimensions at the sampling location;
  - a Pitot tube traverse of the velocity profile;
  - temperature and moisture of the waste gas;
  - diagram of the sampling point locations and duct geometry;
  - restrictions on using equipment, e.g. in case of hazardous areas;
  - physical restrictions to using required apparatus;
  - appropriate measurement equipment for the application.

## Appendix 4 – Template, Site Specific Protocol

The following is a list of items that the EPA require to be included in a site-specific protocol. The SSP should be maintained on site and available for inspection.

### Part 1

#### Contact details, monitoring dates and personnel

- licensee name;
- licensee address and contact information;
- licence number (including Technical amendment details where appropriate);
- installation name;
- date and report number of previous monitoring campaign;
- planned date of monitoring campaign;
- name and address of the monitoring organisation;
- the names of sampling team members, their competency and specific responsibility.

Note 1: Part 1 is updated before each monitoring visit

### Part 2

#### Monitoring objectives

- the overall aim of the monitoring campaign.
- the substances to be monitored at each emission point;
  - emission limit value;
  - reference conditions at which the results are expressed;
  - details of monitoring method(s) to be used for each substance;
- the overall uncertainty of the method(s).

#### Process conditions

- the type of process;
- a description of the process;
- if batch process whether the whole of the batch is to be sampled or the details of the part of the batch sampled;
- the fuel type and feedstock ;
- the normal load, throughput or continuous rating of the plant;
- any unusual occurrences that take place during the process;
- what type of abatement system is fitted (if applicable);
- what type of CEM system is installed and details of the data information system (if applicable);

- the process details that need to be collected over the monitoring period.

### **Sample location**

- dimensions of the stack(s) and monitoring facilities;
- a description of the location of the sampling plane for each release point;
- for each sampling plane, a description of the type of sampling port (accessibility, correct size, sufficient number, properly located);
- for each sampling plane, a summary of the number, arrangement and orientation of the sample line(s), and the number of sampling points per line;
- access to the stack;
- adequate work area at the sampling positions;
- availability of required utilities (electrical, lighting, water);
- a Pitot tube traverse of the velocity profile\*;
- temperature and moisture of the stack gas\*;
- homogeneity test\*;
- restrictions on using equipment, e.g. intrinsically safe areas;
- physical restrictions to using required apparatus;
- appropriate measurement equipment for the application;
- for each sampling location, a summary of compliance with IS EN 15259 / AG1 criteria (e.g. flow criteria, homogeneity, access to sample line(s) and sample point(s)).

\*Note 2: Historical information from previous measurement reports may be used. A note of the reports date and ID number shall be included in the site review.

### **Details of monitoring**

- expected emission values;
- the equipment used for each substance monitored;
- the sampling duration and number of samples for each measurement, including blanks;
- for manual methods, the proposed sample flow-rate, volume and minimum sampling times;
- for instrumental methods, the proposed span-gas concentration;
- the measurement concentration range and lower detection limit;
- for manual methods requiring a separate chemical analysis stage, details of the analytical method, the laboratory carrying out the analysis;
- any modifications to the technical procedure, with justifications;
- an explanation why any substance(s) in the monitoring objectives will not be monitored;
- an explanation why any substance(s) will not be monitored in accordance with the monitoring method.

## Appendix 5 - Stack emission monitoring report

### Submission of reports

Monitoring returns for the assessment of compliance with limit values should be submitted with a cover letter in the format specified below. The letter should include the following information referenced at the top of the page:

1. The EPA licence Register No.
2. The company name as per the licence application.
3. The reporting period.
4. Required submission date.
5. Report name as listed in the Schedule on "Recording and Reporting to the Agency" to the EPA licence (Reg. No. XXXX).

In a situation where a number of reports are being submitted together the name of each report should be listed on the cover letter. If there were non-compliances in the reporting period, the following details are required:

1. Date.
2. Parameter.
3. Emission point reference no.
4. Number of non-compliant measurements versus number of measurements during the reporting period.
5. Maximum exceedance versus licence limit.
6. Cause.
7. Corrective action.

### Content of reports

The following is a list of the information that the EPA require to be included in an air emissions monitoring report.

A stack-emission monitoring report should include the following information on each page:

- A unique reference in the following format;
- Licence register number;
- Licence holder and installation name;
- Year of the monitoring visit;
- Sequential number of the visit in the year (if applicable).
- A version number; and
- A page number, which should be written as "page x of y".

The report should contain the following information:

## **Part 1: Executive Summary**

### **Cover Sheet**

- Accreditation logo and registration number of the monitoring organisation (where appropriate);
- Report title;
- Licence register number;
- Licence holder and installation name;
- Dates of the monitoring visit;
- Name and address of the client organisation (if different from licence holder);
- Name and address of the monitoring organisation;
- Date of the report;
- Name and the function of the person approving the report (include qualifications where appropriate);
- Signature of the person approving the report.

### **Contents**

The content sheet should describe the contents of both parts of the report.

### **Monitoring Objectives**

- The overall aim of the monitoring campaign;
- The substances to be monitored at each emission point; and
- Any special requirements.

### **Monitoring Results**

The report shall include a summary table of monitoring campaign with the following information:

- Emission point;
- Date of monitoring;
- Start and end times for the monitoring;
- Substances monitored (including oxygen and blank samples);
- Emission limit value expressed in the terms and units defined in the licence;
- Periodic monitoring result in the same terms as the emission limit value;
- Uncertainty associated with the result at a 95% confidence level;
- Units for the emission limit value, the periodic monitoring result and the uncertainty;
- Reference conditions at which the results are expressed;
- Name and reference number of monitoring method used;
- Accreditation for use of the method, (sampling and analysis).

### **Operating information**

- Process status at the time of monitoring, such as load and feedstock;
- Whether process was continuous or batch process;
- Whether the whole of the batch was sampled or the details of the part of the batch sampled (if applicable);
- Electrical generation (MW) and fuel used in case of power plants;
- Meters per seconds and number of colours in case of printing processes;
- Rate of material processed (tons/hour) for cement, incineration, chemical or pharmaceutical plants;
- Rate of items processed per hour for general manufacturing processes;
- Percentage with regards maximum capacity where appropriate (steam boilers);
- What type of abatement system and whether operating; and
- The periodic monitoring results and the results obtained for the corresponding period by the operator's CEMS, (this should permit a simple and direct comparison between the two values).

### **Monitoring Deviations**

- An explanation why any substance(s) in the monitoring objectives was not monitored;
- An explanation why any substance(s) were not monitored in accordance with the monitoring method stated in this guidance; and
- Any other issues relevant to the monitoring results.

## **Part 2: Supporting Information**

### **Cover sheet**

The cover sheet for Part 2 should contain the same information that is detailed in the Part 1 cover sheet.

### **Contents**

The contents sheet should describe the contents of the whole report.

### **Annex 1**

- The names, functions and qualifications of those persons engaged in the monitoring;
- The substance(s) monitored, the standard method used, and the reference of the operating procedure used by the monitoring organisation;
- A reference to the equipment used and QC checks during the monitoring campaign;
- Unique identification of monitoring equipment in the report for calibration verification including serial numbers for consumables such as charcoal tubes and calibration gases.

### **Further appendices (one for each emission point)**

- Diagrams showing the dimensions of the stack and the monitoring facilities;

- Averages of raw data for all parameters (including O<sub>2</sub>) measured by instrumental techniques (ppm, % or mg/m<sup>3</sup>). This includes final average results and a chart with plotted values;
- Gas measurements, such as oxygen and carbon dioxide;
- Water vapour measurements, this includes impingers weight and sampling volume records for moisture calculation;
- Sampling measurements, such as stack gas temperature or velocity during sampling and sampling volumes (uncorrected and corrected) for manual techniques (particulates, wet chemistry, dioxins, etc.)
- Calibration records [zero-span-zero (instrument adjustment) + span-zero (line check) + span-zero (post cal)] for all parameters measured by instrumental techniques;
- Drift calculations as per Standard (i.e. Annex E of BS EN 15058:2017) and inclusion in the report;
- Instrumental gas analyser results and measuring range of the instrument;
- Analytical laboratory certificates showing the date, result, limit of detection and accreditation for each parameter;
- The manual monitoring method results calculations (could be spreadsheet distributed by the STA), including concentrations and mass emissions; and
- Uncertainty calculations for each reported result, including:
  - - a list of parameters that affect the measurement uncertainty;
  - - uncertainty sources (in order of significance);
  - - combined uncertainty for sources;
  - - expanded total uncertainty as a percentage of the total measurement;
  - - expanded total uncertainty in units of measurement;
  - - expanded total uncertainty as a percentage of the ELV (expressed at a 95% confidence interval).
- Evidence of compliance with all relevant Standards requirements. This would include but not be limited to:
  - a. Blank results requirements;
  - b. Drift requirements;
  - c. Isokinetic conditions;
  - d. Impinger efficiencies;
  - e. Uncertainty requirements;
  - f. Nozzle size;
  - g. Number of ports and sampling plane requirements
- When continuous monitoring is requested in the licence, 1-minute average CEMS results at licence conditions for the periods of monitoring and final overall averages. These results shall be included in the report by the licensee after the report is issued.



## Appendix 6 - Process load details

The onus is on the licensee to provide the following information to the air monitoring contractor to be included in the air monitoring report:

Licensee		Contractor	
Reg number			
Site contact		Contractor's contact	
Role		Role	
Signature		Signature	

Emission point as per Licence			
Type of process	<input type="radio"/> Rotogravure printing	<input type="radio"/> Rotogravure printing	<input type="radio"/> Rotogravure printing
	<input type="radio"/> Cement plant	<input type="radio"/> Cement plant	<input type="radio"/> Cement plant
	<input type="radio"/> Electrical generation	<input type="radio"/> Electrical generation	<input type="radio"/> Electrical generation
	<input type="radio"/> Steam boiler	<input type="radio"/> Steam boiler	<input type="radio"/> Steam boiler
	<input type="radio"/> Other:	<input type="radio"/> Other:	<input type="radio"/> Other:
<b>Load of process</b> <b>Rotogravure printing:</b> the solvent type and content of the ink, the ink delivery rate, the press temperature, the status of abatement plant, printing rate (m/s), etc.; <b>Cement plant:</b> Clinker source and loading rate, fuel source and load rate; <b>Power plant:</b> Electrical generation (MW) and fuel; <b>Cement, chemical or pharmaceutical plants:</b> Rate of material processed (tons/hour); <b>General manufacturing processes:</b> Rate of items processed per hour; <b>Steam boilers:</b> Percentage with regards maximum capacity where appropriate			
Abatement system	<input type="radio"/> Bag filter	<input type="radio"/> Bag filter	<input type="radio"/> Bag filter
	<input type="radio"/> Electrostatic precipitator	<input type="radio"/> Electrostatic precipitator	<input type="radio"/> Electrostatic precipitator
	<input type="radio"/> Cyclone	<input type="radio"/> Cyclone	<input type="radio"/> Cyclone
	<input type="radio"/> Thermal oxidiser	<input type="radio"/> Thermal oxidiser	<input type="radio"/> Thermal oxidiser
	<input type="radio"/> Active carbon bed	<input type="radio"/> Active carbon bed	<input type="radio"/> Active carbon bed
	<input type="radio"/> NSCR	<input type="radio"/> NSCR	<input type="radio"/> NSCR
	<input type="radio"/> SCR	<input type="radio"/> SCR	<input type="radio"/> SCR
	<input type="radio"/> Dry scrubber	<input type="radio"/> Dry scrubber	<input type="radio"/> Dry scrubber
	<input type="radio"/> Wet scrubber	<input type="radio"/> Wet scrubber	<input type="radio"/> Wet scrubber
	<input type="radio"/> Lime injection	<input type="radio"/> Lime injection	<input type="radio"/> Lime injection
	<input type="radio"/> Biofilter	<input type="radio"/> Biofilter	<input type="radio"/> Biofilter
<input type="radio"/> None	<input type="radio"/> None	<input type="radio"/> None	



## Appendix 7 – Classification of inorganic emissions, (particulate and gaseous) in accordance with TA Luft .

Some licenses issued by the Agency employ the German TA Luft system to classify and set limits on Particulate and Gaseous Inorganic substances.

The following approach should be taken when testing for these substances to assess compliance.

### Testing for Inorganic Particulate Substances (ref: Section 5.2.2 of TA Luft)

The following substances are classified across 3 classes.

The following are designated as TA Luft Inorganic Particulate Substances	TAL Class
Mercury	i
Thallium	i
Cobalt	ii
Lead	ii
Nickel	ii
Selenium	ii
Tellurium	ii
Antimony	iii
Chromium	iii
Copper	iii
Manganese	iii
Tin	iii
Vanadium	iii
Easily soluble cyanides (e.g. NaCN) as CN	iii
Easily soluble fluorides (e.g. NaF) as F	iii

The majority of these substances can be tested using IS EN 14385 for metals species. Sampling for particulate should be isokinetic. The metal load on the filter should be tested and reported separately. Impingers shall be used to determine vapour phase metals. Refer to TA Luft section 5.2.2 for further information on the classification of inorganic particulate substances.

**Testing for Inorganic Gaseous Substances.** (ref: Section 5.2.4 of TA Luft)

The following substances are classified across 4 classes.

The following are designated as TA Luft Inorganic Gaseous Substances	TAL Class
Arsine	i
Cyanogen chloride	i
Phosgene	i
Phosphine	i
Bromine and gaseous compounds (as HBr)	ii
Chlorine	ii
Hydrocyanic acid	ii
Fluorine and gaseous compounds (as HF)	ii
Hydrogen sulphide	ii
Ammonia	iii
Gaseous inorganic compounds of chlorine (as HCl)	iii
Sulphur oxides (sulphur dioxide and sulphur trioxide), to be indicated as sulphur dioxide	iv
Nitrogen oxides (nitrogen monoxide and nitrogen dioxide), to be indicated as nitrogen dioxide	iv

Testing for this full list of substances cannot be achieved using a single sampling and analytical technique. The licensee should identify those substances likely to be present in the emission and collaborate with their stack testing contractor to select appropriate methods for the full characterisation of the emission. Where possible select methods from the Index of Preferred Methods, or otherwise use the hierarchy of sources recommended in this guidance.

Refer to TA Luft section 5.2.4 for further information on the classification of inorganic gaseous substances. Methods should be agreed with the Agency in advance.

The introduction of a new raw material or process that could result in the emission of a new substance should cause a review of the agreed methods to determine their continued suitability.

**Reporting of classified inorganic substances**

The above rules ensure that the sampling and analytical methods have full regard for the expected composition of the emission.

When reporting results for a collective parameter like a TA Luft class, the final result along with individual results shall be included in the report, preferably in a table, where the analytical results, the concentration at reference conditions and the mass flow emissions shall be reported. Sampling volume at actual and reference conditions and the laboratory certificates shall be also included in the report.

If any of the individual substances has a result below the limit of detection (LOD), the overall results shall be reported as “<” (less than) the sum of the positive and LOD values and “>” (greater than) the sum of the positive results. The following is a simplified reporting example:

AIR EMISSION MONITORING GUIDANCE NOTE #2

Substance #	COMPOUND	TA luft class	Analytical result (ug)	Volume (l) @ actual Cond	Volume (m <sup>3</sup> ) @ Ref Cond	Concentration (mg/m <sup>3</sup> )
1	Mercury	I	<0.1	70.00722	0.067	<0.001493
2	Thallium	I	1.5	70.00722	0.067	0.022388
3	Cobalt	II	2	70.00722	0.067	0.029851
4	Lead	II	51	70.00722	0.067	0.761194
5	Nickel	II	23	70.00722	0.067	0.343284
6	Selenium	II	1	70.00722	0.067	<0.014925
7	Tellurium	II	10	70.00722	0.067	0.149254
TA Luft class I						<0.023881
TA Luft class II						<1.298507

The final results must be reported as follows:

	ELV	Results (mg/m <sup>3</sup> )	(breakdown)	
TA Luft class I	0.05	>0.022 and <0.024	> (sum of 2) and < (sum of 1+2)	
TA Luft class II	0.5	>1.284 and <1.299	> (sum of 3+4+5+7) and < (sum of 3+4+5+6+7)	exceedance

## Appendix 8 – Classification of speciated organics (e.g. TA Luft)

A licensed emission point can often contain a range of organic species. In such cases the EPA may use one of a number of different classification systems for organic substances. The most common classification system used by the EPA is the German TA Luft regulations <sup>xix</sup> whereby different limit values are set according to the class of organic substance, rather than the specific compound. Another classification system derives from the Solvent Regulations S.I. 565 of 2012 <sup>xx</sup> These systems of classification present advantages when a plant is first being licensed because a single limit value effects control over every substance that is in a particular class (whether they are being used in the plant or not). Note that TA Luft is not exhaustive and contains a finite list of organic species and the class into which they fall. Those substances not appearing on the list can be classified according to the specific set of rules (thus by inference, TA Luft covers every organic substance).

Despite these advantages, problems can, and do, arise when these sources must be monitored for compliance. A licence requirement to monitor, e.g. for TA Luft class II substances would, if interpreted quite literally, mean the determination of every organic that could be so classed. This is clearly impractical, so the following approach should be taken to make the task manageable:

1. The following list of organics should cover most of applications. This full suite along with other substances emitted in the process shall be tested at every emission point where VOCs, TA Luft Organics I,II,III or Class Organics I,II are included in the scope of monitoring:

Compounds	TA Luft Class	Organics Class
2-Propanol	III	II
Acetone	III	II
Benzene	I	I
Carbon Tetrachloride	I	I
Chloroform	I	I
Cyclohexane	II	II
Cyclohexanone	II	II
Dichloromethane	I	I
Ethanol	III	II
Ethyl Acetate	III	II
Heptane	III	II
Hexane	III	II
m + p- Xylene	II	II
Methyl Ethyl Ketone	III	II
Methyl-iso-butyl Ketone	III	II
o-Xylene	II	II
Tetrachloroethylene	I	I
Tetrahydrofuran	II	II
Toluene	II	II
Trichloroethylene	I	I

2. In addition to above list, all organics expected to be emitted from a particular stack shall be tested for as well
3. Where possible select a standard method from those listed in the [Index of Preferred Methods](#). Otherwise validate and submit one or more methods that will achieve the reliable measurement of all possible emission scenarios. Reliable measurement demands the full quantification of all species present in a sample. Semi-quantitative analysis will only be permitted where it is demonstrated to the satisfaction of the EPA that its use (e.g. toluene) does not underestimate the levels of any species that are present in the emission
4. The introduction of a new raw material or process that could result in the emission of a new substance should cause a review of the agreed methods to determine their continued suitability.
5. Test houses may find it useful to develop and validate a method that covers a suite of organic substances most commonly found in Irish industry.
6. The suite of organic compounds to be tested may be amended with the agreement of the Agency following an evaluation of monitoring results.

The above rules ensure that the sampling and analytical methods have full regard for the expected composition of the emission.

When reporting results for a collective parameter such as VOCs or TA Luft classes, the final result along with individual results shall be included in the report, preferably in a table, where the analytical results, the concentration at reference conditions and the mass flow emissions shall be reported. Sampling volume at actual and reference conditions along with the sampling tube serial number and the laboratory certificates shall be also included in the report.

If any of the individual substances has a result below the limit of detection (LOD), the overall results shall be reported as “<” (less than) the sum of the positive and LOD values and “>” (greater than) the sum of the positive results. The following is a simplified reporting example:

COMPOUND	TA luft class	Analytical result (ug)	Volume (l) @ actual Cond	Volume (m³) @ Ref Cond	Concentration (mg/m³)
Benzene	I	<1	7.00722	0.0067	<0.1492
Carbon Tetrachloride	I	15	7.00722	0.0067	2.2388
Chloroform	I	25	7.00722	0.0067	3.7313
Tetrachloroethylene	II	512	7.00722	0.0067	76.4179
Tetrahydrofuran	II	232	7.00722	0.0067	34.6269
Toluene	II	<10	7.00722	0.0067	<1.4925
Trichloroethylene	II	102	7.00722	0.0067	15.2239
TA Luft class I					<6.1194
TA Luft class II					<127.76119

The final results must be reported as follows:

	ELV	Results (mg/m³)	(breakdown)	
TA Luft class I	20	>5.97 and <6.12	> (sum of 2+3) and < (sum of 1+2+3)	
TA Luft class II	100	>126.27 and <127.76	> (sum of 4+5+7) and < (sum of 4+5+6+7)	exceedance

## Appendix 9 - Example competence criteria for personnel carrying out emission measurements

### Introduction

Due to the many technical and organisational tasks to be managed in preparing for, carrying out, and evaluating emission measurements, a sufficient number of technically qualified personnel is necessary. The personnel should demonstrate competence appropriate to different levels of experience and responsibility.

As an example, there may be defined three levels of competence: a technical supervisor, a technician, and an assistant technician. The assistant technician should undertake measurements under the supervision of a technician. The technical supervisor would be responsible for the measurement plan (SSP), the on-site measurement campaign and producing the measurement report.

The following could be used to demonstrate competence:

- an appropriate course of study in natural sciences or engineering at a university or a technical college or other relevant technical courses;
- evidence of knowledge provided by either presentation of measurement reports, undertaking examinations and assessments of practical skills;
- evidence of experience acquired using training records, which demonstrate a defined minimum amount of work that has provided relevant knowledge and practical experience.

### General competence criteria

#### 1. Measurement objective

The identification of the measurement objective requires

- knowledge of the legislative context within which process operators are required to control their emissions,
- knowledge of the nature of emission limits and
- knowledge of the units of measurement and the importance of standard conditions.

#### 2. Industrial process

The collection of plant specific information requires

- knowledge of the process for the industry sectors that measurements are carried out on, such as  
combustion,  
surface treatment,  
silicate industry,  
oil industry,  
metallurgical processes,  
chemical industry,  
pulp industry,

- waste water treatment plants, or agriculture;
- knowledge of the following process states and the effects they have on sampling strategy:
  - continuous operation with steady state, variable or cyclic load;
  - batch operation;
- knowledge of the importance of obtaining the following process details:
  - typical operation;
  - time-scale of operation;
  - inputs, outlets, mass flows, timing of operations, fluctuations of flow;
  - fuel composition;
  - temperature, pressure and water vapour content of waste gas.

### **3. Health and safety**

Good health and safety practice requires the following:

- ability to carrying out periodic measurements at heights and in difficult working conditions;
- realisation that poor health and safety conditions invariably lead to low quality measurement data;
- competence in the use of and care of personal protective equipment;
- awareness of the following prominent hazards associated with emission measurements:
  - general site hazards: site traffic, fire and emergency procedures, mechanical operations and chemical operations;
  - physical hazards at plant: lifting, falling, burns, electricity, compressed gases;
  - chemical hazards at plant: exposure to chemicals used in monitoring tests, exposure to substances from waste gases;
  - chemical hazards in laboratory: exposure to substances used in equipment and reagent preparation;
  - weather/environment: temperature extremes, wind, rain, lightning, snow and ice, sunburn;
  - welfare: lone working, tiredness; the risk management-based approach to health and safety and the ability to use a risk assessment to identify hazards and implement control measures according to Irish national regulations and site-specific regulation.

### **4. Sampling location**

The selection of sampling locations requires

- knowledge of the standards governing the location of sample points,
- ability to select a sampling location when required to,
- ability to confirm that the sampling location selected conforms to the requirements of the relevant standard and
- awareness that sampling locations that do not meet the requirements of standards have an effect on the uncertainty of the results of measurements.

### **5. Methods selection and use**

The selection and use of measurement methods require

- knowledge of the hierarchy of methods;
- ability to demonstrate knowledge of the appropriate standard methods;

- knowledge of the importance of strict adherence to protocols and standard methods;
- general experience with the main requirements of methods;
- understanding of laboratory analysis.

#### **6. Site review**

The use of a site review requires knowledge as outlined in Appendix 4 – Template, Site Specific Protocol.

#### **7. Measurement plan**

The production of a measurement plan requires the following:

- high level of knowledge and experience in emission measurements;
- knowledge of the reference methods, laboratory techniques, monitoring equipment and process details;
- knowledge of site parameters that affect the measurement plan;
- knowledge of which substances to measure and how frequently to measure them in order to satisfy the relevant requirements of licences.

#### **8. Operation of equipment**

The operation of equipment requires the following:

- knowledge of the general principles of periodic measurements, the importance of representative sampling of gaseous and particulate pollutants and of isokinetic sampling where appropriate (e.g. for particulate matter);
- knowledge of the handling of equipment used in measurement of the physical parameters of volumetric flowrate, humidity, pressure and temperature;
- knowledge of the principles of operation of sampling trains and sufficient information about the practicalities of operation of the equipment to be able to undertake leak-checking of equipment, on-site measurements and sample recovery;
- good practice with sampling equipment and knowledge
- that equipment should be correctly cleaned and kept clean on site to avoid contamination and
- that good laboratory practice applies on site especially when undertaking sample recovery (the importance of avoiding contamination through the use of clean areas for sample recovery and capping sample train inlets where necessary).

#### **9. Elaboration of test results and identification of supporting information**

Elaboration of test results and identification of supporting information requires the following:

- knowledge of data considerations such as
- legislative requirements for compliance limits,
- averaging requirements,
- expression of results from direct reading instrumentation (e.g. percentiles),
- use of data loggers and
- ability to process data manually and using spreadsheets;
- knowledge of the conversion of measured values to relevant standard conditions of temperature, pressure, oxygen and water vapour;
- knowledge of the calculation of results such as volumetric flow rates, concentrations from analytical results,

emission concentration,  
emission rates and  
emission factors.

#### **10. Measurement report**

The production of a comprehensive report as outlined in EN 15259 requires awareness of the uncertainty of measurement including

- the concept of measurement uncertainty,
- the sources of uncertainty,
- the random and systematic components making up combined uncertainty,
- the approaches to quantifying uncertainty and
- the methods to determine uncertainty.

#### **11. Quality assurance and quality control**

Quality assurance and quality control requires

- knowledge of the use of quality management through assurance and control techniques and
- ability to apply these as an essential part of test programme management.

## Appendix 10 - Acronyms in Emissions Monitoring

### Regulatory and Standards Organisations

AFNOR	Association Francaise de Normalisation
ASTM	American Society for Testing and Materials
BSI	British Standards Institution
CEN	Comité Européan de Normalisation (European Committee for Standardisation)
CSA	Canadian Standards Association. CSA Group is parent company of SIRA
DIN	Deutsches Institut für Normung
DIS	Draft International Standard
EA	Environment Agency (England)
EC	European Commission
EN (prEN)	European Standard (draft standard)
EU	European Union
FDIS	Final Draft International Standard
HSA	Health and Safety Authority
IEA	International Energy Agency
INAB	Irish National Accreditation Board
ISO	International Organisation for Standardisation
OSHA	US Occupational Safety and Health Administration
NSAI	National Standards Authority of Ireland
NSAI (NML)	NSAI (National Metrology Laboratory – Ireland)
NIOSH	US National Institute for Occupational Safety and Health
SEPA	Scottish Environment Protection Agency
SIRA	Certification service (operates the Mcerts scheme). Now part of CSA Group.
STA	Source Testing Association
UBA	UmweltBundesAmt , the German Federal Environment Agency
UKAS	United Kingdom Accreditation Service
VDI	Verein Deutscher Ingenieure, Association of German Engineers
TÜV	Technische Überwachungs-Verein , German Technical Inspection Offices
US EPA	US Environment Protection Agency
WHO	World Health Organisation

### Measurement, Monitoring and Data Acquisition

AAS	Atomic Absorption Spectroscopy
AMS	Automated Monitoring System (=CEMS)
CAMS	Continuous Air-quality Monitoring System (ambient)
CEMS	Continuous Emissions Monitoring System (=AMS)
CLD	Chemiluminescence Detector
DAHS	Data Acquisition and Handling System
DCS	Distributed Control System
DOAS	Differential Optical Absorption Spectroscopy
ECD	Electron Capture Detector
FID	Flame Ionisation Detector
FPD	Flame Photometric Detector
FSD	Full Scale Deflection
FTIR	Fourier Transform Infra-Red analyser
FTUV	Fourier Transform Ultra-Violet
GFC	Gas Filter Correlation

GC-MS	Gas Chromatography – Mass Spectrometry (also GC-FID etc)
HPLC	High Performance Liquid Chromatography
ICP	Inductively Coupled Plasma spectroscopy
IMS	Ion Mobility Spectroscopy
IR	Infrared
ISE	Ion-Selective Electrode
MS	Mass Spectroscopy
NDIR(NDUV)	Non-Dispersive Infra Red (Non-Dispersive Ultra Violet)
OES	Optical Emission Spectroscopy
PID	Photo Ionization Detector
SCADA	Supervisory Control and Data Acquisition System
SD	Standard Deviation
SPC	Statistical Process Control
TCD	Thermal Conductivity Detector
TD	Thermal Desorption
TDL	Tunable Diode Laser
TRS	Total Reduced Sulphur
XAD	Trade name for adsorbent resin

### Chemical Names

DCM	Di-Chloro Methane
ITEF	International Toxicity Equivalent Factor
NMVOG	Non-Methane Volatile Organic Compound
PAH	Polycyclic Aromatic Hydrocarbons
PCB	PolyChlorinated Biphenyl
PCDD	PolyChlorinated Dibenzo-Dioxin
PCDF	PolyChlorinated Dibenzo Furans
PCP	Penta-Chloro Phenol
PM <sub>10</sub> , PM <sub>2.5</sub>	Particulate Matter below 10µm or below 2.5µm size fractions
POCP	Photochemical Oxidant Creation Potential
POP	Persistent Organic Pollutants
PTFE	Polytetrafluoroethylene
TCP	Tetra-Chloro Phenol
TEQ, TEF	Toxic Equivalent (Factor) used for total Dioxin and Furan concentrations
TOC	Total Organic Carbon
VOC	Volatile Organic Compound

### Directives, Regulations and Certification

BAT, (BATC)	Best Available Technology (BAT Conclusions)
BAT-AEL	BAT Associated Emissions Levels
BREF	Best Available Technology Reference Document
COSHH	Control of Substances Hazardous to Health
ELV	Emission Limit Value
IED	Industrial Emissions Directive
IPPC	Integrated Pollution Prevention and Control
LCPD	Large Combustion Plant Directive
MCERTS	Monitoring Certification Scheme Environment Agency (Eng)
MDHS	Methods for Determination of Hazardous Substances (UK HSE)
MID	Method Implementation Document (produced by Env. Agency)
OTNOC	Other Than Normal Operating Conditions
SRM	Standard Reference Method

SSP	Site Specific Protocol
TE1, TE2,etc	Technical Endorsements (in the MCERTS Personal Certification Scheme)
TGN	Technical Guidance Note (produced by the Env. Agency, Eng)
TNP	Transitional National Plan (for emissions reduction under IED)
WID	Waste Incineration Directive

### **Pollution Control**

CCGT	Combined Cycle Gas Turbine
ESP	Electrostatic Precipitator
MCR	Maximum Continuous Rating (of a plant)
MSW	Municipal Solid Waste
SCR	Selective Catalytic Reduction for NO <sub>x</sub> control
SNCR	Selective Non-Catalytic Reduction for NO <sub>x</sub> Control

### **Safety, Quality and Instrument Protection**

ALARP	As Low As Reasonably Practicable (In health and safety context)
AST	Annual Surveillance Test within BS EN 14181 standard
ATEX	Atmosphères Explosives – from French title of 1994 directive
IEC	International Electrotechnical Commission
IP	Ingress protection
IS	Intrinsic Safety
LoD	Limit of Detection
MEWP	Mobile Elevated Work Platform
NEMA	US National Electrical Manufacturers Association
PPE	Personal Protective Equipment
QA (QC)	Quality Assurance (Quality Control)
QAL	Quality Assurance Level within BS EN 14181 standard

## References

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- <sup>i</sup> DIRECTIVE 2010/75/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 November 2010 on industrial emissions (integrated pollution prevention and control)
- <sup>ii</sup> SI 7 of 1992 ENVIRONMENTAL PROTECTION AGENCY ACT, 1992
- <sup>iii</sup> SI 27 of 2003 PROTECTION OF THE ENVIRONMENT ACT 2003
- <sup>iv</sup> DIRECTIVE 2001/80/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants
- <sup>v</sup> DIRECTIVE 2000/76/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 December 2000 on the incineration of waste
- <sup>vi</sup> COUNCIL DIRECTIVE 1999/13/EC of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations
- <sup>vii</sup> DIRECTIVE 2008/1/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 January 2008 concerning integrated pollution prevention and control
- <sup>ix</sup> SI 437 of 2004 European Communities (Greenhouse Gas Emissions Trading) Regulations 2004
- <sup>x</sup> SI 374 of 1997 The EPA Act, 1992 (Control of volatile organic compound emissions resulting from the storage of petrol and its distribution) Regulations, 1997
- <sup>xi</sup> ISO/IEC Guide 98-3:2008 Uncertainty of measurement -- Part 3: Guide to the expression of uncertainty in measurement (GUM:1995) [Weblink: [http://www.iso.org/iso/catalogue\\_detail.htm?csnumber=50461](http://www.iso.org/iso/catalogue_detail.htm?csnumber=50461) ]
- <sup>xii</sup> ISO 14956:2002 Air quality -- Evaluation of the suitability of a measurement procedure by comparison with a required measurement uncertainty
- <sup>xiii</sup> ISO 20988:2007 Air quality -- Guidelines for estimating measurement uncertainty
- <sup>xiv</sup> NCASI Method ISS/FP-A105.01 Impinger Source Sampling Method For Selected Aldehydes, Ketones, And Polar Compounds. NCASI Southern Regional Center December 2005
- <sup>xv</sup> ISO 16911-1:2013 Stationary source emissions – Manual and automatic determination of velocity and volume flow rate in ducts – Part 1 Manual reference method. [Weblink: [http://www.iso.org/iso/catalogue\\_detail.htm?csnumber=57947](http://www.iso.org/iso/catalogue_detail.htm?csnumber=57947) ]
- <sup>xvi</sup> EN ISO/IEC 17025:2017 General requirement for the competence of testing and calibration laboratories [Weblink: [http://www.iso.org/iso/catalogue\\_detail.htm?csnumber=39883](http://www.iso.org/iso/catalogue_detail.htm?csnumber=39883) ]
- <sup>xvii</sup> EN 15259 Air quality - Measurement of stationary source emissions - Requirements for measurement sections and sites and for the measurement objective, plan and report [Weblink <http://www.en-standard.eu/csn-en-15259-air-quality-measurement-of-stationary-source-emissions-requirements-for-measurement-sections-and-sites-and-for-the-measurement-objective-plan-and-report/> ]
- <sup>xviii</sup> CEN/TS 14793:2004, *Air Quality – Stationary source emission – Interlaboratory validation procedure for an alternative method compared to a reference method*
- <sup>xix</sup> Technical Instructions on Air Quality Control - TA Luft in accordance with art. 48 of the Federal Immission Control Law (BImSchG) dated 15 March 1974 (BGBl. I p.721). Federal Ministry for Environment, Bonn 1986, including the amendment for Classification of Organic Substances according to section 3.1.7 TA.Luft, published in July 1997.
- <sup>xx</sup> S.I. No 565 of 2012 European Union (installations and activities using organic solvents) regulations 2012 [Weblink: <http://www.irishstatutebook.ie/pdf/2012/en.si.2012.0565.pdf> ]
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