



Environmental Protection Agency
Office of Environmental Enforcement (OEE)

Air Guidance Note on the Implementation of
I.S. EN 14181 (AG3)

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Preface

The Office of Environmental Enforcement (OEE) is one of the four offices in the Environmental Protection Agency. The OEE's functions include the regulation of activities licensed under the EPA and WMA 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 Guidance Note on the Implementation of I.S. EN 14181 (AG3) is one of a series of guidance notes that the OEE has planned on the general theme of air pollution monitoring. A forerunner to this document is Guidance Note No. 1 Air Emissions Sampling Facilities which describes the facilities that must be provided for the safe and effective monitoring of emissions, and the Air Emission Monitoring Guidance Note (AG2) which is aimed at improving the overall quality of stack emission monitoring by emphasising best practice standards and techniques.

The guidance note is intended for use by all Agency staff involved with Power sector and WID plant (e.g. licensing and enforcement staff), the licensed operator, and test houses that provide an air emissions monitoring service. The document is intended to give clear and practical guidance on how to implement EN14181 in Ireland, which is mainly based on an interpretation of the experiences to date in the rest of Europe. All relevant licensed operators should have had the opportunity to submit questions, which have been incorporated into the guidance note with concise answers.

A CEN standard for the data installation, recording and processing system is currently being addressed as part of WG9. It is currently in a working draft format and should be made available for comment sometime in 2008.

The starting point for an existing AMS is to do a QAL2 and establish a valid range for the AMS. The Agency would consider that within twelve months of the issuing (website or publication) of this Guidance Note (AG3), or by the end of 2008 at the very latest, that the QAL2 should be completed at relevant sites.

MCERTS

The Environment Agency (EA), the competent authority for England and Wales, has stipulated in their M20 Guidance Note, that only test laboratories that are accredited to BS EN ISO/IEC 17025 for the MCERTS performance standards for manual stack-emissions monitoring for the applicable SRM's, may perform the SRM measurements during QAL2 and AST. The test laboratory may be an external third party laboratory or part of the operator's organisation. The EPA (Agency) recognises the many merits of the MCERTS scheme and has encouraged monitoring companies to continue to seek accreditation to MCERTS through UKAS (UK Accreditation Service). The Agency has also encouraged the use of MCERTS certified equipment, (or equivalent) and the personal certification by Irish field technicians through the scheme.

The Agency would now require MCERTS (or equivalent) for personnel and/or contractors who carry out SRM measurements during QAL2 and AST testing procedures for LCPD and WID plant, unless the operator or test house can demonstrate sufficient technical knowledge and experience of the QAL2 and AST testing procedures. Prior to the work being completed, details of any non-certified personnel undertaking the proposed testing and the outline plan will need to be submitted to the Agency for agreement. This requirement will be conditioned in new licences or reviewed licences. For licensed facilities that will be completing QAL2 or AST tests in the short-term, these facilities will be contacted by letter and required to send in an outline test programme prior to carrying out the work.

Revision of this document

This guidance note may be the subject of periodic review and amendment. The most recent version of this note is available on the Agency website: <http://www.epa.ie/downloads/advice/air/emissions/>. If you have any particular queries on this document then please contact Dr. Ian Marnane at i.marnane@epa.ie or Mr. Tony Dolan at t.dolan@epa.ie.

Abbreviations

AMS	Automated Measuring System (sometimes referred to as CEMS especially in the UK)
AST	Annual Surveillance Test
CEMS	Continuous Emissions Measuring System (also AMS)
CEN	European Committee for Standardisation
ISO	International Standards Organisation
ELV	Emissions limit value
LCPD	Large Combustion Plant Directive
MCERTS	Monitoring Certification Scheme
QAL	Quality Assurance Level
SRM	Standard reference method
TUV	German Technical Inspection and Monitoring Union
UBA	German Federal Environment Agency
WID	Waste Incineration Directive
ISO	International Standards Organisation

1. Regulatory Requirements for the International Standards

IS EN 14181, and the related standards IS EN13284-2 for dust monitoring, and IS EN 14854 for mercury monitoring have been developed mainly to support two EU Directives – The European Directive 2000/75/EC on the incineration of waste (WID) and the European Directive 2001/80/EC on the emissions into air from large combustion plant (LCPD) . These Directives must be implemented through national legislation, and the EN standards that support this legislation become mandatory.

1.1 Monitoring Requirements in the WID and the LCPD

These Directives specify performance requirements for Automated Monitoring Systems (AMSs) used to monitor relevant industrial plants. Within this document, the term AMS is used in place of CEMS (continuous emissions measuring system) to be consistent with the terminology used in IS EN 14181.

Firstly, the Directives prescribe that EN Standards must be used for monitoring when AMSs are employed, and that EN Standard Reference Methods must be used for the calibration of the AMSs.

Secondly, these EU Directives specify overall performance requirements for the AMSs (and also discontinuous monitoring devices) to be used for WID and LCPD applications for each species being monitored. These are expressed as measurement uncertainty allowances for the results expressed as a percentage of the emission limit value (ELV[♦]). This measurement uncertainty covers overall requirements for the all parameters that affect it including the precision of the AMS, and this uncertainty is expressed at a confidence level of 95%, in keeping with normal statistical measurement practices.

1.2 The Concept behind EN 14181 and Related Standards

EN 14181 needs to be applied only to those AMSs that are permanently installed at WID or LCPD installations. It does not need to apply to portable AMSs, or to those used as SRMs, or to those used for pollution prevention and control (IPPC)

[♦] ELV refers to the daily or 48 hourly ELV unless otherwise specified.

installations. (The requirements for these are described in other standards (e.g. see annex 1 for EN Standards for SRMs)). It should also be noted that EN 14181 applies to the complete AMS, including all the sampling and sample conditioning system where present, but currently does **not** apply to the data installation, data recording and data processing system used with the AMS. This will be addressed in a future CEN Standard.

EN 14181 specifies requirements for three Quality Assurance Levels (QALs) and an additional annual surveillance test (AST). These are:

QAL1: process by which a suitable AMS is selected as being potentially fit for the applications in terms of its measurement uncertainty capability etc. This requires a procedure to demonstrate that the AMS is potentially suitable for its purpose generally before its sale and installation, by conformance testing (sometimes popularly known as 'type approval') to demonstrate that it can achieve the performance requirements specified in the EU Directives. This procedure is **referred to** in EN 14181, but is **not** described in this standard. Instead, CEN is producing a separate standard for this, which is being published as EN 15267-part3 (Note: reference is also made in EN14181 to ISO standard 14956, which was published before the EN 15267-3 standard, This EN standard supersedes, but is compatible with, the statistical treatments covered in ISO 14956).

QAL2: The procedure for calibrating the AMS against the appropriate SRM (see Annex 1) once the specific AMS has been installed at the WID or the LCPD plant. The SRM is deemed to provide the correct results within certain tolerances. The calibration process also verifies that this specific AMS meets the measurement uncertainty requirements, once installed.

QAL3: A procedure for assessing, in an on-going manner, the quality of AMS results when it is operating normally on the plant, in order to demonstrate and maintain the required quality of the results. This is done by checking the readings of the AMS that are obtained when implementing zero and span checks on a regular basis, so as to confirm that the repeatabilities of these checks are consistent with those obtained during the QAL1 conformance tests.

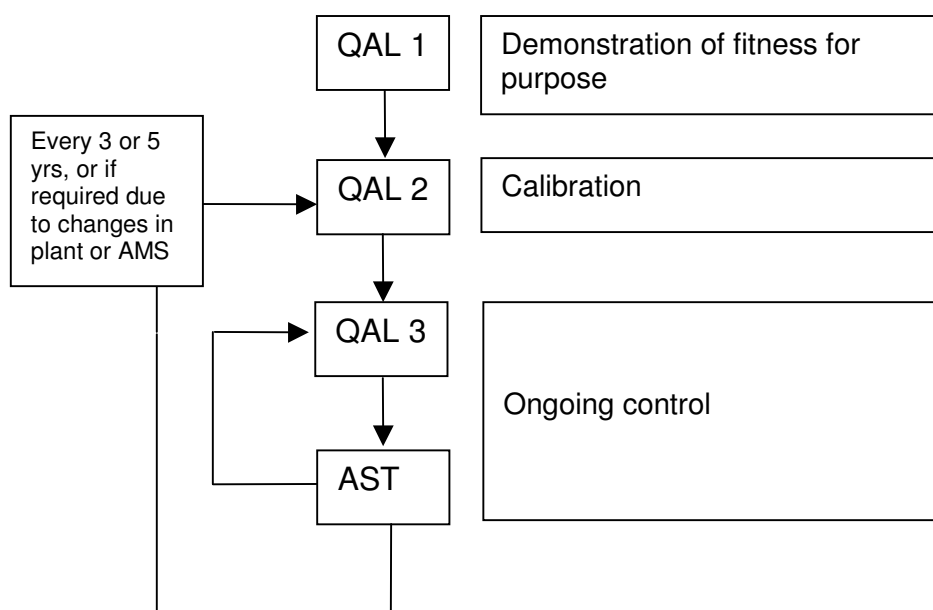
AST: A procedure to evaluate the AMS on a yearly basis to show that it continues to function correctly and the calibration function remains valid by comparison with the results obtained in QAL2.

These quality assurance levels follow a logical sequence and aim to demonstrate the correct selection, installation, calibration, and continuously valid operation of the AMS on the plant. These are shown in Figure 1.

EN standard 13284-2 provides specific requirements for dust monitoring in the context of the more general requirements of EN 14181, and as such is a detailed interpretation of EN14181 for the monitoring of dust under the requirements of the WID and LCPD, where compliance with emission limit values of less than 50mg/m³ under standard conditions is required. The QAL2 procedure for dust must be performed against the SRM specified in EN 13824 –1. Likewise EN 14884 provides a more detailed interpretation of requirements for an AMS used for gaseous mercury monitoring.

Note. Subsequently within this document 'EN 14181' is used to refer generically to the three standards; EN 14181, EN 13284-2 and EN 14884. Where specific reference to an individual standard is required it will be clearly indicated.

Figure 1: The Sequence of Quality Assurance and Quality Control activities covered in EN 14181



2 Overview of QAL1, QAL2, QAL3, AST

The European standards EN 14181, EN 13284 and EN 14884 provide a framework for the Quality Assurance and Quality Control of AMSs for stack emissions monitoring. This framework consists of three Quality Assurance Levels (QALs) and an Annual Surveillance Test (AST).

The stages address;

- the selection of an appropriate AMS (QAL1)
- installation and calibration of the AMS (QAL2)
- the ongoing quality control (QAL3)
- and regular checks of the calibration by performing an AST

It is the legal responsibility of the process operator to ensure the implementation of the requirements of EN 14181. Operators may make use of external contractors to meet these requirements, as described in Figure 3.

The different stages are as follows:

2.1 QAL1 - Initial selection of AMS

QAL1 provides a mechanism for demonstrating the fitness of purpose of an AMS and determining if it is suitable for use on a particular plant. Under QAL1 AMSs are required to have been tested by a laboratory, approved and accredited to ISO/IEC/EN 17025 and for information to be available on a number of performance characteristics.

The testing should be carried out within a conformance testing regime, in which the instrument type is tested; the performance characteristics determined are then valid for all instruments of this type (i.e. for a given manufacturer's model number).

Controls are put in place to require the manufacturer to declare any changes to the design of the instrument that may affect its performance. If changes are made, then retesting by a certified testing laboratory may be required.

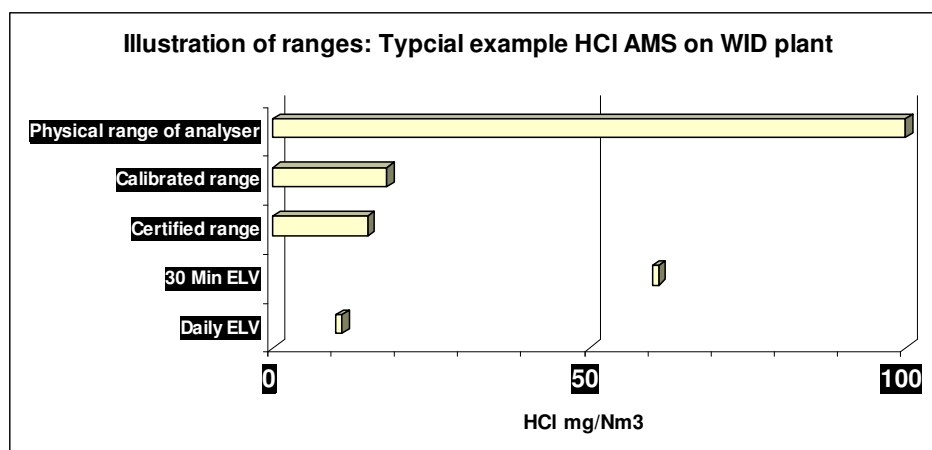
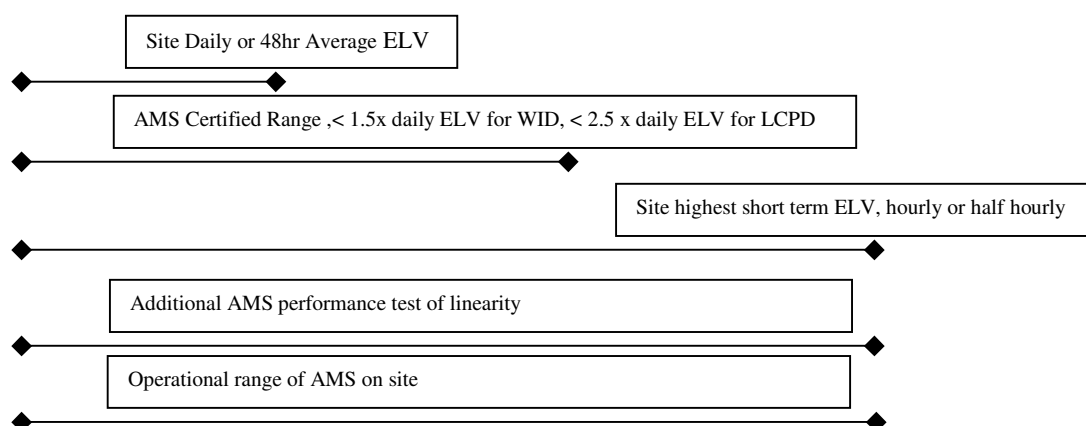
A further aim of QAL1 is to enable the uncertainty of results produced by the AMS to be predicted. Plant specific information, for example interferent levels and external conditions specific to the site can be used during the calculation of measurement uncertainty. The purpose of this is to predict whether the AMS will be able to meet the data quality objectives of the Directives. Currently EN 148181 refers to EN ISO 14956 as the method to use to calculate the measurement uncertainty from the AMS performance data.

CEN has produced a standard EN 15267-3, which provides an implementation of EN 14956 to enable the calculation of the measurement uncertainty of an AMS from performance data. This enables the performance of an AMS in the type approval process to be compared with the data quality requirements of the Directives

It is not the responsibility of the operator to implement QAL1. It is sufficient to ensure that any new analyser purchased has MCERTS, TUV, or other approved certification showing that the instrument is suitable for the intended use. At a minimum the following suitability criteria must be met:

- Instrument field trials must have been carried out on a similar process (e.g. boiler, incinerator, etc.), with a similar stack gas matrix and measuring conditions, to the proposed application;
- Instrument field trials must have been carried out using a gas sampling and conditioning system similar to the proposed application;
- Certified range must be less than 2.5 times the daily or 48-hourly ELV for LCPD plant, and less than 1.5 times the daily or 48-hourly ELV for WID plant;
- The physical measurement range of the instrument must be sufficient to include the highest short-term ELV as well as any higher concentrations that may occur during operation;
- The certificate must provide the uncertainty information required to implement QAL3.

Figure 2, Illustration of ranges appropriate for QAL1 testing.



The calibrated range of the AMS is defined by the range over which the QAL2 is performed. However, the measuring range of the AMS should encompass all expected peaks in emissions.

2.2 QAL2 – Installation and calibration of the AMS

QAL2 covers the installation of the AMS and its calibration by means of parallel measurements against a Standard Reference Method (SRM). QAL2 also includes a set of functional tests to check that the instrument is installed correctly and can achieve the uncertainty required by the appropriate Directive.

The QAL2 procedure is required on installation, and subsequently if:

- The AMS has been repaired or altered in a way, which invalidates the calibration. This may be assessed by using the same calibration function as determined in the most recent QAL2, and if the instrument passes the next QAL3 tests then the calibration is deemed still to be valid.
- Within 5yrs or sooner if legislation requires it (i.e. 3 years for WID plant);
- If there has been a major change to the plant (including a significant change of fuel), See Section 6.3;
- If QAL3 or the AST shows that a new calibration is required.

The standards require at least 15 parallel measurements spread over three days. These three days do not need to be consecutive but must be performed within a period of at most 4 weeks. The calibration procedure needs a good spread of concentrations to provide a reliable calibration function. If this is not possible due to plant conditions, a number of options are available. In general one of three situations will arise;

1. a good spread of data ($> 15\%$ of the ELV), in which case the first procedure for calculating the calibration curve given in EN 14181 ('procedure a') can be followed. See Section 6.4.2 of EN14181.
2. a cluster of points above 30% of the ELV with a spread less than 15% of the ELV, in which case 'procedure b' for establishing the calibration curve in EN 14181 may be used. This relies on at least three points at or near to zero, which may be obtained by the use of surrogates.*
3. a cluster of point near zero, i.e. below 30% of the ELV and with a spread of less than 15%, then the calibration range may be extended by the use of reference materials. Care will be needed to ensure there is consistency between the 'real' data points and those obtained by reference materials, particularly in the presence of interfering compounds in the stack gas matrix. This approach has been adopted in the UK and proposed for the EU guidance. Reference materials may not be available for particulate monitoring instruments, and in this case surrogate materials may be used. These are artefacts designed to reproduce an instrument response equivalent to the required particulate loading, e.g. using optical filters or attenuators.

EN 14181 only allows the extension of the calibration range by a limited amount (10%), however the proposed CEN draft guidance (Draft EN Technical Report of CEN Technical Committee 264, Working Group 9) suggests this can be extended up to the half hourly ELVs if reference materials are used, so long as the results fall within a given confidence interval of the calibration curve based on measured SRM stack data. The value of the confidence interval should be defined by the relevant data quality requirements of the appropriate Directives.

The values given above are flexible, and the most appropriate approach may be adopted, for example if data with 18% spread are scattered such that a linear fit would give an unacceptable R^2 value (say < 0.9) then EN 14181 'procedure b' may be followed. R^2 is a figure of merit for a linear fit, derived from the residuals of the data from the best fit line, and provided as an output from most fitting routines, and while it is not a rigorous measure, it can be used to provide a basic indication of the quality of a fit. In general a fit with an $R^2 > 0.9$ can be considered linear.

EN 13284-2 gives specific guidance for particulate AMSs, where low-level clusters of data are likely, and where the use of surrogate dust material is not possible. In such cases the standard allows for the modification of plant operations to produce higher dust levels. However this may cause problems owing to changes in dust composition (and in particular size distribution) caused by these procedures (i.e. opening a bypass on a bag filter). Certain particulate monitors may be able to use surrogate artefacts that simulate dust changes. In some cases it is proposed that dust monitors used where the concentrations are very low, should be considered indicative, and used to provide verification that emissions remain low. Should emissions subsequently rise then a QAL2 procedure would be required to provide quantification. The Agency should be notified, in advance of the QAL2, of any

* A surrogate is an artefact, supplied by the instrument manufacturer, when a reference material is unavailable.

potential exceedences, but just as a test event. If it is unavoidable to run at high levels to ensure an accurate calibration, it can be allowed, but would not be encouraged except in the case of particulates.

An alternative approach is to vary the plant operation within the range of normal operation. This would include altering the fuel input or waste input as required, but this adjustment should not interfere with any abatement equipment. For parameters other than particulates, it is generally not acceptable to exceed the licence limit(s) except in very exceptional circumstances.

2.3 QAL3 – Ongoing quality assurance

QAL3 addresses the ongoing quality assurance of the AMS in operational use. It requires the operator to ensure that zero and span measurements are carried out periodically. The results of these measurements are used in a control procedure, examples of which are Shewhart or CUSUM control charts, to check that AMS has not drifted out of control and that the precision has not deteriorated. If the AMS goes out of control, then maintenance and a QAL2 will be required.

The CUSUM procedure (see Section 6.4) allows adjustments to be made to the AMS zero and span readings, whereas the Shewhart procedure does not.

Action limits are based on multiples of a standard deviation defined as s_{AMS} in EN 14181. This is determined from QAL1 and QAL2, and may be based on an uncertainty calculation using the QAL1 performance data, or estimated from the ELV multiplied by a factor (as described in the UK Environment Agency's Guidance Note, M20) or as a fraction of the data quality objective defined in the Directives. This latter approach is being proposed by the French standards body, and may be adopted in the CEN guidance, it is also summarised in EA M20.

2.4 AST – Annual surveillance test

The AST is a yearly check that the calibration function of the AMS is still valid and that the instrument is still able to pass the functional tests. The tests comprise a reduced QAL2 test, with fewer parallel SRM tests. The AST also consists of a set of functional tests, and a review of the QAL3 results.

The requirements at each stage are described in detail below.

Figure 3. Summary of requirements and responsibilities of each stage of IS EN 14181

	Stage	Role	Requirement
	Process licensed under LCPD or WID ELVs available Monitoring requirements specified	Process Operator, responsible for implementation of EN 14181. Regulator	Requirements in Directives
Q A L 1	Selection of instrument – based on ELV, species, performance characteristics from type testing, application specific information Ability of instrument to meet QAL2 and QAL3 requirements: <ul style="list-style-type: none"> • Zero and span • Reference materials • Live output 	Process Operator responsible for selecting instrument Instrument manufacturer is responsible for having instrument certificated, and providing information	EN 14181 CEN guidance Test reports from type approval
Q A L 2	Installation Operator to ensure location of instrument meets requirements of relevant standards and sampling locations suitable for parallel SRM testing are available. Instrument manufacturer to install and configure instrument, set up QAL3	Process Operator Instrument manufacturer Advice from test houses	SRM standards Monitoring standards
	Accredited test house – review installation, undertake parallel SRM tests, produce calibration function, review functional tests. Instrument manufacturer may be required for functional tests Instrument manufacturer may be required to implement new calibration function.	Test house - Overall responsibility for QAL2. Instrument manufacturer; See table of responsibilities in Section 3 for functional tests Operator – review report and submit to regulator Regulator – review report	EN 14181 CEN guidance SRM standards
Q A L 3	Operator ensures QAL3 zero and spans are being carried out, either manually or by automatic instrument function. Operator to check control chart and implement any action requirements – maintenance or repeat QAL2	Operator responsible; Manufacturer to ensure instrument capable of carrying out QAL3	EN 14181 CEN guidance
A S T	Accredited test house undertakes AST. Instrument manufacturer may be required for functional tests If fails then instrument may need repair and repeat QAL2 will be required	Certified test house Operator - review report and submit to regulator Regulator – review reports	EN 14181 CEN guidance

2.5 Implementation dates for the Directives

Large combustion plant directive (LCPD)

- 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;
- The requirements for continuous monitoring defined in Annex VIII shall be applied from 27 November 2004 for all relevant plant;
- By 1 January 2008 competent authorities shall ensure all existing and new plants comply with the requirements of the Directive and that limit values for all plant are in line with national emission reduction plans.

Waste incineration directive (WID)

- Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste;
- Applies to new plant after 28 December 2002;
- Applies to existing plant (plant in operation before 28 December 2002 or with licence applications in place before that date, and in operation before 28 Dec 2004) with effect 28 December 2005.

EN 14181 Timescales

The timescales for implementing the different stages of EN 14181 are:

- QAL1 – Before an AMS can be installed on site;
- QAL2 – Within 6 months of any requirement for a QAL2 (i.e. initial installation, changes to plant conditions or maintenance of the AMS);
- QAL3 – Continuously from installation. It is advisable to commence the QAL3 procedures as soon as the instrument is installed, before the initial QAL2 tests.
- AST - Annually.

3 Responsibilities

3.1 QAL1, QAL2, QAL3, AST, Functional Tests

Although responsibilities are given in EN14181, this is an area where experience of the implementation of the standard in the UK has shown there is scope for misinterpretation. This section clearly outlines the responsibilities for carrying out each stage of the process.

The Directives and EN14181 refer to a competent authority; in Ireland this is the EPA.

The following table identifies the responsibilities.

Figure 4. Table of overall responsibilities

Stage	Operator	Regulator	Stack Monitoring Test House	Instrument Supplier
QAL1	Selection of suitable instrument	Definition of ELV for site and issue of licence Regulator to accept type approval schemes		Supply of Certified AMS instrument meeting performance requirements
QAL2	Selection of suitably accredited test house Review of reports Availability of suitable monitoring locations	Review of reports	Delivery of QAL2 tests including overall responsibility for functional tests Review QAL3 reports.	Assist in functional tests if required Ensure instrument is able to use reference materials or surrogates for extension of calibration function if required.
QAL3	Operation of ongoing quality assurance procedures Review of control charts and carrying out any remedial actions	Review of reports		Ensure instruments are able to comply with requirements for QAL3 testing (zero and span measurements)
AST	As QAL2	As QAL2	As QAL2	As QAL2

The test house has overall responsibility for undertaking QAL2 and the AST and for signing them off. However, the functional tests which form part of QAL2 and AST may, for technical reasons, be carried out by instrument manufacturers' instrument engineers. Functional tests are a series of instrument checks listed in Figure 5. The responsibilities for carrying out the functional tests during QAL2 and AST tests are as follows:

Figure 5. Responsibilities for functional tests

Activity	QAL2		AST		Responsibility
	Extractive AMS	In-situ AMS	Extractive AMS	In-situ AMS	
Alignment & cleanliness		✓		✓	Instrument Engineer or Test Laboratory
Sampling system	✓		✓		Instrument Engineer or Test Laboratory
Documentation and records	✓	✓	✓	✓	Test laboratory
Serviceability	✓	✓	✓	✓	Test laboratory
Leak test	✓		✓		Instrument Engineer or Test Laboratory
Zero and span check	✓	✓	✓	✓	Instrument Engineer or Test Laboratory
Linearity	(✓)	(✓)	✓	✓	Instrument Engineer
Interferences			✓	✓	Instrument Engineer
Zero and span drift (audit)			✓	✓	Test laboratory
Response time	✓	✓	✓	✓	Instrument Engineer or Test Laboratory
Report	✓	✓	✓	✓	Test laboratory

(✓) –not required in QAL2 but recommended

4 Existing Guidance/Documentation

The following provides a review of existing (and anticipated) guidance, which relates to the implementation of EN 14181. Summaries of the documents are provided, including information on how they may be used by operators, test houses and regulators. Issues related to the relevance of the existing guidance to specific aspects of the implementation of EN 14181 in Ireland will be identified, and advice provided on how these should be addressed.

4.1 Directives: LCPD, WID

The Directives define the requirements for monitoring of large combustion plant and waste incineration plant. The directives place requirements on the use of CEN standard methods where these exist. If relevant CEN standards do not exist then a hierarchy of standards may be used, with preference for ISO or other internationally recognised standards, followed by National Standards, such as those produced by BSI, VDI, ASTM or the US EPA, and finally other methods. The directives provide for certain derogations for particular plant, and define both limit values and data quality objectives.

4.2 EN 14181, EN 14884, EN 13284-2

These standards are addressed by this guidance document. EN 14181 primarily covers AMSs which monitor gaseous compounds, EN 13284-2 covers particulate AMSs, and is an extension to EN 14181. EN 14884 is a standard, which covers AMSs that monitor mercury. This standard is based on EN 14181, however it does not address many of the issues which are specific to mercury monitors, and so is somewhat lacking as a full standard for providing quality assurance of mercury AMSs, for example it does not cover issues relating to elemental mercury.

4.3 Standard Reference Methods

Standard reference methods have been developed by CEN and ISO, which address all of the determinants covered by the LCPD and WID. These include

Particulates (Total dust)	
Low levels < 50 mg/m ³	EN 13284-1
High levels > 50 mg/m ³	ISO 9096
Nitrogen oxides	EN 14792
Carbon monoxide	EN 15058
Sulphur dioxide	EN 14791
Total organic carbon	EN 12619
Hydrogen chloride	EN 1911
Hydrogen fluoride	ISO 15713
Oxygen	EN 14789
Water vapour	EN 14790

These methods should be used as the SRMs employed by the test house who carries out the QAL2 and QAL3 procedures. The test houses should be accredited to ISO 17025 for the relevant methods. It is not necessary for the operator to be familiar with these methods, but they should be aware of which SRMs are required for the different determinants required by the directives. This also includes methods for measuring the peripheral parameters required to normalise the stack measurements to standard conditions, including (possibly) water vapour and oxygen.

Where the SRMs are instrumental methods then the equipment used by the test house should be able to be demonstrated to be fit for purpose, within the context of the test house's accreditation to ISO 17025.

The use of other methods as Alternative Reference Methods is addressed by the EN Technical Specification TS 14793, and suitable methods are listed in AG2, Index of Preferred Methods.

4.4 WG9 TS, M20, (& the French equivalent GAX 43/132)

CEN is producing a guidance document for the implementation of EN 14181. It is based on the UK Environment Agency's M20 document, on the French AFNOR document GAX 43/132 and on input from other European experiences in implementing EN 14181, including Danish contributions.

The CEN guidance document is fairly thorough and provides a good set of worked examples and detailed procedures. It is relevant to regulatory bodies, operators instrument manufacturers and test houses. This document is consistent with current draft versions of the CEN guidance document.

4.5 EN 15267-3 (QAL1), EN ISO 14956

These standards provide procedures for the calculation of measurement uncertainty. EN 14181 references EN ISO 14956 to provide a method to calculate the measurement uncertainty of an AMS. EN 15267-3 provides an interpretation of EN ISO 14956 specifically for use in QAL1.

5 Interpretation/Implementation of EN 14181 – Answers to Common Questions

This section provides specific guidance on a number of key areas. The topics are grouped in terms of the different stages, QAL1, QAL2, QAL3 and AST, together with general implementation issues.

The issues covered have been drawn from the questions raised by the EPA, from M20 and the UK implementation, from feedback from operators and test houses, issues raised within European fora, and the areas of concern currently being discussed in the CEN TC264 WG9 sub group drafting guidance for EN 14181.

5.1 General Questions

How do we apply the standard for low use combustion plants or for little used fuels?

The standard should be applied as normal. However, there are a number of exclusions listed in the LCPD/WID directives for low use combustion plants or little used fuels. These decisions would need to be made on a site/process specific basis and this would need to be reviewed in conjunction with the relevant directive and in consultation with the EPA.

What ELV's do we use and what are their accuracy requirements?

The operators should use the ELV values listed in their IPPC licence. The LCPD and WID directives provide data quality objectives. In general when EN 14181 refers to an ELV in assessment criteria, it is referring to the average daily limit value. It is recommended that AMSs have a measurement range which encompasses at least the half hourly ELV. However the maximum QAL1 certification range should be 1.5 times the daily average ELV for WID or 2.5 times the daily average ELV for LCPD. Where clarification is required operators should refer to their IPPC licence or the

EPA for further guidance. The measurement uncertainty requirements are the figures stated on the IPPC licence.

Data quality standards – LCPD

Species	Data Quality Standard
Sulphur Dioxide	20%
Nitrogen Dioxide (NO _x as NO ₂)	20%
Dust	30%

Data quality standards - WID

Species	Data Quality Standard
Sulphur Dioxide	20%
Nitrogen Dioxide (NO _x as NO ₂)	20%
Dust	30%
Total Organic Carbon	30%
Hydrogen Chloride	40%
Hydrogen Fluoride	40%

What do you do if there is no ELV assigned to that species?

The operator should use the general ELV guideline figures from the relevant directive but if no ELV is given to the species then they should refer to their IPPC licence or the EPA for further guidance.

What is the significance of the uncertainty of the SRM?

The SRM uncertainty is not directly taken into account in QAL2 and AST tests. However, the operator should require all SRM results to be reported with their uncertainty in order to assess the validity of the SRM results.

Is all the downtime from EN14181 included in reported downtime as part of WID and LCPD?

The downtime due to the EN 14181 functional tests should be reported, as the instrument will be off line during these tests. QAL3 and auto-calibration procedures will also count as downtime. However downtime resulting from QAL2 and AST testing will be minimal.

5.2 QAL1 Questions

How do I do a QAL1?

QAL1 refers to requirements for an AMS to be certified under a type approval scheme. Currently in Europe this means for example MCERTS in the UK or the UBA/TUV scheme in Germany. CEN is developing a standard, which will define a European certification scheme, defining performance parameters and criteria.

The requirement on the operator in terms of QAL1 is that they should select an AMS which has been certified for use over a relevant certification range for the relevant

process type for the required determinants. It is proposed that suitable certification ranges should be less than 1.5 times the daily average ELV for WID and 2.5 times the daily average ELV for LCPD. This is a guide value, and applies to all pollutant parameters. In addition it is suggested the measurement ranges should encompass likely excursions above the ELV, at least to the half hourly ELVs. The linearity of the AMS should be demonstrated up to the measurement range.

How do I decide if an AMS is suitable for my application?

The AMS chosen should be tested and certified for the determinands (species to be measured) specified in the relevant directive and licence where continuous monitoring is required.

The AMS needs to be certified for a range that is suitable for the operator's application. The operator needs to ensure that specific site conditions do not reduce the performance of the AMS to below the required standards and it is recommended that the intended AMS be proven on comparable installations.

All AMS must have provisions that allow either operators, suppliers or test laboratories to perform zero, span or linearity tests once an AMS has been installed.

When selecting a suitable AMS, the operators shall select an AMS with a certification range which is not more than 1.5 times the ELV daily average for WID installations and not more than 2.5 times the ELV daily average for LCPD installations.

What do you do if your AMS doesn't have QAL1?

For an AMS already installed on site or for the measurement of components not yet assessed (HF for example), since the QAL1 phase cannot be validated, the uncertainty of the values measured can be considered satisfactory if phases QAL2 (variability test) and QAL3 (device can be adjusted if a drift is found) produce satisfactory results. If buying a new AMS, it must have a QAL1 or equivalent certification.

If the AMS does not meet the QAL2 and QAL3 requirements and cannot be adjusted or modified to fulfill the requirements, then the operator will be required to replace them within one year (or as agreed with the Agency) with a suitably approved AMS.

Selection of the range of the AMS?

The range of the AMS should be set at a value which will capture all expected peaks in emissions, yet still meet the uncertainty requirements at the ELV.

The lower limit of the operation range must perform at an acceptable accuracy at the daily emission level, enabling the monitor to measure in accordance with the relevant directive.

Is the AMS approved with the entire sample system included? What do you do if you change it?

The AMS comprises the analyser(s) and additional devices, which includes the sampling system for obtaining a measurement result. It is the complete system, including the sampling system that has been tested and certified.

There are several types of sampling system, such as:

- Simple heated lines coupled to heated analysers that measure gases in a hot, wet form.
- Heated lines and chiller-driers, delivering the sampled gases to the analyser in cooled, dry form.
- Heated lines and permeation-driers, delivering the sampled gases to the analyser in cooled, dry form.
- The stack-mounted probe is coupled directly to a permeation drier, which then passes the cooled, dry sample gas via an unheated line to an analyser.

There are also many variations of these basic forms and as analysers are typically designed for use with specific types of sampling system, testing and subsequent approvals will certify an AMS with a stated type of sampling system.

As industrial processes often differ in their requirements, some flexibility is allowed in the selection of the sampling system with the AMS. However, the installed AMS must not deviate from the type of sampling system specified on the certificate to ensure the AMS is not degraded, such that it no longer meets the required performance specifications.

Allowable variations could include:

- A different length of sampling line to that which was tested.
- A different brand or model of sampling system, so long as there is evidence from third-party testing that the alternative components meet the required performance specifications and have been tested on analogous systems.
- Additional manifolds and heated valves used to allow more than one analyser to share a sampling system.

Any other changes to the system would require a review of the changes by the regulator, and may result in a re-certification of the whole system including the analyser.

How do you work out the uncertainty values?

Two options are proposed :

The use of EN ISO 14956, as specified in EN15367-3, section 14 and Annex D, to calculate the uncertainty from the performance data for the AMS from QAL1 type testing results. Certain manufacturers may supply this data.

Spreadsheets have been developed for the calculating the uncertainty for SRMs in the UK. These are available to download from the NPL website www.npl.co.uk Within EN 14181, values should be reported within data quality objectives.

5.3 QAL2 Questions

When should you do a QAL2

A QAL2 should be carried out: -

- After installation of a new AMS system;
- On existing AMS system(s) that have the relevant accreditation to comply with the standards;
- At least every five years for LCPD installations and three years for WID installations;
- If a QAL3 evaluation demonstrates a need for a QAL2;
- If there is a significant changes, upgrades or repairs to the AMS which will influence and change the results significantly;
- Whenever there is a significant change in plant operation which changes the emissions.

How do we carry out a QAL2 when the emissions are always near zero? (is an AST acceptable?)

Initially carry out a QAL2 on the AMS, and then subsequent QAL2s may be replaced by ASTs if: -

- Daily average gaseous emissions are less than 50% of the ELV in-between QAL2 exercises;
- Daily average particulate emissions are less than 30% of the ELV in-between QAL2 exercises;
- There is no significant change to plant operation or fuel.

What data do you use for a QAL2?

When conducting parallel measurements, the measured signals from the AMS shall be taken directly from the AMS (e.g. expressed as analogue or digital signal) during the QAL2 and AST procedures specified in this standard, by using an independent data collection system provided by the organisation(s) carrying out the QAL2 and AST tests. All data shall be recorded in their uncorrected form (without corrections e.g. for temperature and oxygen). A plant data collection system with ongoing quality control can alternatively be used to collect the measured signal from the AMS. The plant data collection system can be used to record the analogue data but should not be used to normalise the data. In other words, the data collected must be in the uncorrected form. AMS values used should be the values output from the analyser prior to any subsequent corrections/calculations.

How do we extend the calibration range so it covers up to the ELV?

In general, if the data is sufficiently linear to derive a valid calibration function, then:

- The calibration range of AMS monitoring gases may be extended by 10%. The calibration range of particulate monitors may be extended by 100% or up to twice the half-hour ELV, whichever is the higher value.
- The calibration range may be extended further using reference materials so long as the resulting data points are within the 95% confidence intervals of the calibration function.

If greater confidence in the performance of the AMS at ELV is required when the plant is emitting outside its calibration range determined above, reference materials at zero and at a concentration close to ELV shall be used, where available, as part of the calibration procedure to confirm the suitability of the linear extrapolation.

In this case, calculate the deviation between the calibrated measured value of the AMS at zero and ELV and the corresponding SRM values. The deviation at ELV should be less than the uncertainty specified by legislation. The deviation at zero should be less than 10% of the ELV.

How to implement the calibration function

The calibration function should be determined by the test house carrying out the QAL2 procedure. It is then provided to the operator to implement. Depending on the analyser, it can either be used to set calibration functions in the analyser, or applied as a correction to the analyser's results in the data handling software.

What happens if the instrument fails a QAL2?

If the instrument fails a QAL2 calibration then the relevant problem e.g. instrument modification or variability test will need to be addressed before carrying out another QAL2 test on the AMS. Failure of the QAL2 test may also be caused by poor quality SRM measurements, and this should be considered when reviewing the possible causes of failure.

How do we avoid cluster effects or what do we do with them, at high levels and at low levels?

The test laboratory must select a set of representative operating conditions that covers as wide a range as possible to avoid cluster effects, without modifying the process to artificially increase emissions. Ideally operators should select a time when the emissions are likely to be their highest and most varied, but the process may not be deliberately varied in order to create higher than normal emissions. For example, this can be carried out when bag filters are replaced, emissions of particulate are temporarily higher and this is an ideal time to measure a wider range of emissions.

For high level clusters three values should be at or near zero, and if the scatter of the data points is not too large, the test laboratory can determine a calibration function using the methodology described in EN 14181 (method B, Section 6.4.2 EN 14181).

For a low level cluster the calibration function is not reliable unless the cluster is highly linear (as indicated by a correlation coefficient of the regression R^2 value of 0.9 or more).

What's the best way to incorporate peripheral measurements as they can have a large effect on the variability test?

AMSs for oxygen and moisture (if used) must be certified to MCERTS/TUV or other approved performance standards. The same applies to SRMs that use instrumental techniques. Functional checks should be performed on the AMSs for oxygen and moisture (if used) although ordinarily a full QAL2 should not be needed for the installation's peripheral measurements. However, if the AMS fails the QAL2 tests using the operator's peripheral measurements, then the SRM peripheral measurements may be used instead. If the AMS then passes the QAL2 tests, then the operator must fix the peripheral monitoring equipment as soon as possible and verify its performance through further QAL2s.

When carrying out the QAL2, it is recommended that the test laboratory plots a graph of the SRM data versus the AMS data for the peripheral measurements.

SRM monitoring for oxygen is required in any event for the QAL2 tests for other determinands, so the 15 sets (or more) of oxygen SRM measurements can then be used to perform a QAL2 for oxygen. When performing the variability test for oxygen and moisture measurements, the following virtual ELVs and uncertainty allowances shall be applied:

- Oxygen: ELV = 21%, Uncertainty = 10%
- Moisture: ELV = 25%, Uncertainty = 30%

If AMS readings for moisture are also found to be erroneous when compared to the reference monitoring and following the variability tests, then the SRM results for moisture shall also be used to perform a full QAL2 exercise on the installation's AMS which measure moisture.

AMS for temperature and pressure shall be cross-calibrated using reference instruments that are traceable to national standards.

How do you correct to reference conditions?

See first worked example in Annex 1.

What triggers a new QAL2?

The QAL2 procedures are repeated, after a major change of plant operation, a failure of the AMS or as required by legislation.

- At least every five years for LCPD installations and at least every three years for WID installations;
- If the QAL3 process demonstrates a need for a QAL2;
- If there is a major changes or repairs to the AMS which will influence and change the results significantly. Significantly can be interpreted as a change, which causes the subsequent QAL3 tests to fail.
- If there is a change of fuel type and significant change of the process.

How do we treat negative numbers from the SRM (&AMS)?

In order to correctly identify offsets which may form part of the calibration function, negative values should be included in the QAL2 process.

Should the sample ports and platform, and AMS location conform with relevant protocols. Are they co-located?

For installation of the AMS the operators should follow the provisions for location and access described in EN 15259 and ISO 10396, in order to determine the optimum location for a representative sample. Spatial variations in temperature, pressure, flow rate and stack-gas concentration should not be greater than 15% across the stack in any plane. Test laboratories should use ISO 10396 when characterising the stack gas conditions and assessing the intended location of the AMS.

Before installing the AMS, the stack gas must be characterised in order to determine whether there are variations across the stack, such that the sampling position will have a significant bias on the readings. It is critical that AMS are not only located at a point where there is access and other provisions for the effective and continued operation of the AMS, but also in a location which complies with the requirements of applicable standards such as EN 13284-1 and ISO 10396. This is because the SRM measurements must be representative, or the bias in the readings will be so great that the AMS may not meet the requirements of QAL2.

Additionally, the AMS must be located at a point where the sample is representative, and the SRM and the AMS (or its sampling location) should be located so that they do not interfere with each other.

The sample ports and platform should conform to the relevant sections in IS EN 13284-1 where isokinetic sampling is required – primarily for particulate measurements. The port dimensions shall allow sufficient space for insertion and withdrawal of the sampling equipment. A minimum diameter of 125 mm or surface areas of 100 mm x 250 mm are recommended, except for small ducts (less than 0.7 m diameter) for which the port size needs to be smaller. This is described in EPA Guidance Note AG1.

When should you do a QAL2 after installation?

The QAL2 is required after installation, however EN 14181 allows 6 months to complete a QAL2 from the time it is required. It is recommended that some time should be allowed for the instrument performance to be assessed using QAL3 procedures, before the initial QAL2 is carried out.

Can you extend the calibration range using reference materials?

The calibration range may be extended further using reference materials so long as the resulting data points are within the 95% confidence intervals of the calibration function.

If greater confidence in the performance of the AMS at ELV is required when the plant is emitting outside its calibration range determined above, reference materials at zero and at a concentration close to ELV shall be used, where available, as part of the calibration procedure to confirm the suitability of the linear extrapolation.

In this case, calculate the deviation between the calibrated measured value of the AMS at zero and ELV and the corresponding SRM values. The deviation at ELV should be less than the uncertainty specified by legislation. The deviation at zero should be less than 10% of the ELV. The reference materials are injected into the

AMS line inlet. The sets of values considered are thus comprised of the calibrated result from the AMS and the expected concentration value for the reference material.

Can you use $R^2 > 0.9$ as a guide? What if it is below that?

The use of R^2 greater than 0.9 provides a reasonable guide that the calibration function is acceptable. When R^2 is less than 0.9, it may still be acceptable to use the calibration function, however there will be a greater risk that the AMS will fail the variability test.

What levels of span gas should be used for the SRM?

The span gas shall have a known concentration of approximately the half-hourly ELV or 50% to 90% of the selected range of the AMS.

What range should be used for the SRM?

The best way of selecting a suitable range for the SRM is to apply range multipliers, whereby the lowest certified range is not more than 1.5 times the daily average ELV for incineration processes and not more than 2.5 times the ELV for large combustion plant and other types of process. As there is a linear relationship between certified ranges and uncertainties, these multipliers provide assurance that SRM with appropriate ranges will meet the uncertainty requirements specified in the WID and LCPD. Therefore, the range is set at a value that will capture all the typical peaks in the emissions, but still maintain the required uncertainty at the ELV.

Should there be a special case for VOCs, which are present in very low concentrations?

There is no special case for speciated VOC measurements, which are addressed as total organic compounds in the WID. These measurements will often need to be treated as low emission cases, and very often will have clusters of results around zero.

How should NO_2 , NO and NO_x measurements be handled?

The QAL2 calibration function should be determined as appropriate to the data, which will be reported under the LCPD and WID and for which the ELVs are prescribed. Where NO and NO_2 are measured separately, the QAL 2 calibration should be performed using the combined NO_x values.

For low level testing, is it possible to change the range to its most sensitive?

The AMS shall also be able to measure instantaneous values over the ranges which are to be expected during all operating conditions. If it is necessary to use more than one range setting of the AMS to achieve this requirement, the AMS shall be verified for monitoring the higher ranges.

What should I do about outliers?

Plotting AMS and SRM data on a graph shows whether data spread is sufficient, whether there are sufficient values close to zero and if there are any obvious outliers. If the test house assesses that a data set is considered invalid then the reasons for this should be noted in the QAL2 report (for example: changing process conditions, error in SRM, failure of instrument). Some data in the experimental values obtained by the operator may appear to be dubious without there being a specific reason found. In this case, the operator can show that they deviate from the other data by

implementing the following procedure. The operator shall, however, use sufficient data so that he ends up with 15 sets of valid measurement data.

The calibration line equation shall be determined by using all the sets of values (x_i, y_i) and the correlation coefficient R^2 .

For each AMS value read x_i , the calibrated value \hat{y}_i is calculated and then the standard uncertainty of the linear regression model s is calculated.

$$s = \sqrt{\frac{\sum_{i=1}^N (y_i - \hat{y}_i)^2}{N - 2}}$$

After determining limits $\hat{y}_i - 2s$ and $\hat{y}_i + 2s$, it shall be checked that all the SRM $y_{i,AMS}$ values expressed in AMS conditions are within these two limits. Any sets of values that do not meet this condition can be eliminated. When a set of values has been eliminated, the calibration line is recalculated with the remaining sets of values. The outlier test shall then be run again. The operator must have 15 sets of valid measurement data and no more than two sets should have been excluded as outliers.

How long should I sample with the SRM?

The timing of each parallel measurement is dependent on the species being monitored, but for each calibration, a minimum of 15 valid parallel measurements shall be made with the plant operating normally. The sampling time for each of the parallel measurements shall be at least 30 min, or at least 4 times the response time of the AMS, including the sampling system (as determined during the response time measurements carried out during QAL1), whichever is the greater. In general the sampling time should equal the shortest averaging time, which is required by the ELV specification. If the sampling time is shorter than 1 hour, then the time interval between the start of each sample shall be longer than 1 hour. These measurements shall be uniformly spread both over at least 3 days and over each of the measuring days of normally 8 hours to 10 hours (e.g. not 5 measurements in the morning and none in the afternoon) and be performed within a period of four weeks.

5.4 QAL3 Questions

How can QAL3 be applied to older/existing AMSs?

The existing AMS should be able to carry out zero and span checks for QAL3. If the value of s_{AMS} is not available from QAL1 testing, then s_{AMS} may be determined as in the answer to the question “**What is the uncertainty of the AMS to use in the QAL3 procedure?**” below.

The AMS and the data recording systems have to be able to:

- Record both positive and negative values.
- Record any changes in readings from the previous zero and span checks
- Record zero and span data results for greater than one year. This permits auditing of the data at the AST.

The EPA should be consulted if an AMS is unable to perform a QAL3 or AST.

What is the interval between QAL3 measurements?

EN 14181 does not specify how frequently a QAL3 test should be undertaken. This is to be recommended by the instrument supplier, but the Agency would be recommending once a week but no less than once per month, unless otherwise agreed with the Agency. If operators are using CUSUM charts then weekly zero and span checks are recommended. If operators are using Shewhart charts, then the frequency may be based on the maintenance interval determined during testing for MCERTS/TUV or other approved certification, although it is recommended to use shorter intervals until sufficient data is available to lengthen the time between checks.

What happens when the AMS does its own internal zero/span?

There is no difference if the AMS undertakes an automatic zero/span check as the recording system will record the data. Operators have the option to use instruments with either automatic or manual QAL3 checks. The majority of instruments use automatic self-checks since these tests can be conducted without additional work from personnel.

Whilst auto-corrections before the AMS drifts out of the control range are not recommended, such auto-corrections may take place so long as the AMS still meet the type approval specification for zero and span drift.

What are the benefits of using either CUSUM or Shewhart charts?

A CUSUM chart provides enough information on changes in analyser performance to allow adjustment of the zero and span to bring the analyser back under control but it is more complicated to implement than the Shewhart chart.

What do you do with cross-duct systems?

EN 13284-2 provides specific guidance for particulate monitors including cross stack optical instruments. It is the responsibility of the manufacturer to provide the QAL3 procedure.

How do you handle readjustments?

When an AMS drift is found, if a CUSUM chart is being used, the operator can make a zero or span correction to correct for the drift. Other adjustments are not allowed and care should be taken to ensure instruments with direct remote links (i.e. to the manufacturer) are not altered between QAL2 tests.

What do you do if an AMS fails a QAL3?

If a CUSUM approach is used then information on both drift (in zero and span) and changes in precision (noise) is available, and in principle adjustment to bring the analyser back into control is possible. The requirement in EN 14181 when the analyser 'fails' a QAL3 is that intervention is necessary. This will most likely involve the instrument supplier performing maintenance, with subsequent recalibration of the analyser by performing a QAL2 procedure.

When is a QAL3 test said to have failed?

The QAL3 test 'fails' when the process control mechanism being followed (which may be a CUSUM, Shewhart or other approach) identifies that the drift or variance of the AMS has exceeded a predefined action limit. This action limit is defined based upon

the uncertainty of the AMS as discussed below. A check should be made that the failure of the QAL3 is not due to a fault in the zero and span procedure. If this is the case then these data points may be excluded from the QAL 3 calculations and this should be logged on site.

What levels of span gas should I use for QAL3?

Zero and span checks shall be performed using reference materials, such as calibration gases, which are traceable to national standards. For dust, surrogate reference materials are required for performing zero and span checks. Their validity should be assessed during the assessment tests by performing a QAL3 check. The calibration gases used shall be stable for at least one year and the expanded uncertainty associated with the expected concentration shall be less than 2%.

The span value must be made compliant with regulatory requirements of the plant at which each AMS is located. This is, unless specified otherwise, close to the daily (or 48 hr) limit value. When renewing a calibration gas, it is advisable to perform a double QAL3 test to set the new chart with respect to the old one.

What is the uncertainty of the AMS to use in the QAL3 procedure?

QAL3 makes use of a measure of the AMS uncertainty termed s_{AMS} in order to discriminate small random variation in the zero and span readings from a true drift or change in the AMS performance. s_{AMS} is determined from QAL1 and QAL2 data. EN 14181 describes a method for calculating s_{AMS} . However, this method is complicated and is difficult to apply consistently. It is therefore recommended that the following values be used:

	Maximum half confidence interval required by the directives in % for the daily ELV	s_{AMS} in % with respect to the 1 st value read by the AMS when the reference material is injected the first time
CO	10	2
NO _x	20	2
SO ₂	20	2
TVOC	30	3
HCl	40	10
HF	40	20
Dust	30	10

What if reference materials aren't available?

Surrogates for true reference materials will be required for performing zero and span checks on particulate monitoring AMSs and these should be assessed as part of the QAL1 testing for their validity in providing an appropriate QAL3 check.

HCl gas is unstable. How do I do a decent QAL3 for IR HCl analysers?

The accurate labelling of the HCL is very important and such gases used should be traceable to Primary National Standards and should have certificates, which meet the requirements of ISO 4559-4. Suppliers of test gases should also be accredited to BS EN ISO/IEC 17025 to applicable standards such as the ISO 4559 series. The purging of the IR gas cell is important and the long resonance time in the system means that you may not see a stable reading for a considerable time compared to non-reactive

species. It is necessary to establish the transfer efficiency duration and the resonance time of the gas in order to calculate the stabilisation time of the gas.

5.5 AST Questions

Extension of calibration range from QAL2

In general, if the data is sufficiently linear to derive a valid calibration function, then the calibration range of AMS monitoring gases may be extended by 10%. The calibration range of particulate monitors may be extended by 100% or up to twice the half-hour ELV depending on the highest value.

The calibration range may be extended further using reference materials so long as the resulting data points are within the 95% confidence intervals of the calibration function.

If greater confidence in the performance of the AMS at ELV is required when the plant is emitting outside its calibration range determined above, reference materials at zero and at a concentration close to ELV shall be used, where available, as part of the calibration procedure to confirm the suitability of the linear extrapolation.

In this case, calculate the deviation between the calibrated measured value of the AMS at zero and ELV and the corresponding SRM values. The deviation at ELV should be less than the uncertainty specified by legislation. The deviation at zero should be less than 10% of the ELV. The reference materials are injected into the AMS line inlet. The sets of values considered are thus comprised of the calibrated result from the AMS and the expected concentration value for the reference material.

What is the time between parallel measurements?

The timing of each parallel measurement is dependent on the species being monitored but for each calibration a minimum of 5 valid parallel measurements shall be made with the plant operating normally. If the testing laboratory is using instrumental methods for SRMs, then the SRM monitoring system shall be operated continuously over the entire day of the AST. Zero and span checks of the monitoring systems shall take place at least at the start of each day, mid-way through the day and at the end of the day. The sampling time for each of the parallel measurements shall be at least 30 min, or at least 4 times the response time of the AMS, including the sampling system (as determined during the response time measurements carried out during QAL1), whichever is the greater. In general the sampling time should equal the shortest averaging time, which is required by the ELV specification. If the sampling time is shorter than 1 hour, then the time interval between the start of each sample shall be longer than 1 hour. At least five sets of data can then be extracted over any 8 to 10 hours period within the day.

What AMS data should be recorded and used, as the calibration function may have been applied to the data, therefore $y=x$ not $y=mx+c$?

When conducting AST measurements, the measured signals from the AMS shall be taken directly from the AMS system if possible (e.g. expressed as analogue or digital signal) or the plant data collection system with ongoing quality control can additionally be used to collect the measured signal from the AMS.

All data shall be recorded in their uncorrected form (without corrections e.g. for temperature and oxygen).

Can an AST be used to check the single calibration function is valid with new or little used fuel types, rather than a new function QAL2 ?

An AST can be used to check the single calibration function instead of carrying out a QAL2 if the fuel type does not change significantly. Examples are when:

- The operator can demonstrate that the change in process does not affect the emissions profile and the original calibration factor remains valid.
- The thermal input is less than 10% per year for the alternative fuel, and/or
- The change in fuel use can be shown to have no significant effects on emissions, when compared to the original fuel.

If there is a significant change of fuel, then the operator should first perform an AST test. If the results fit within the 95% confidence interval of the calibration function, then no further testing is required. If not, then a full QAL2 is required. A change of fuel is considered significant if:

- The change of fuel is known to result in a change in the emissions profile.
- The change of fuel requires a licence variation.
- The change is from any one of the following types to another – gaseous fuel, liquid fuel, solid fuel - and the alternative fuel is used for more than 10% of the time during a year.
- The change is from a single type of fuel to a mixture of more than one type of fuel (or *vice versa*),

How do you perform calculations for an AST? When should it be done?

An example calculation for an AST is shown in Annex 1.

Typically an AST test is carried out annually after the original QAL2 test. Therefore if a QAL2 test was undertaken in 2006 then an AST will be undertaken in 2007 and then annually after that until a new QAL 2 is required as defined in EN 14181.

5.6 Functional Test Questions

Who does them and when?

A functional test should be undertaken before any QAL2 or AST testing is carried out by the test team. The testing laboratory shall have overall responsibility for the functional tests, although the operator or the equipment supplier may also perform these. In such cases, the tests shall be verified by audit by the testing laboratory and included in their report. The manual zero and span checks shall be performed using the same procedure as for the QAL1 tests - for some (particulate) monitors this will be a condition simulating zero and simulating span measurements. See Figure 5 for more details.

Alignment and cleanliness

A visual inspection, with reference to the AMS manuals, shall be carried out on the following when applicable:

- internal check of the analyser;
- cleanliness of the optical components;
- flushing air supply;
- obstructions in the optical path.

After re-assembly at the measurement location at least the following shall be checked:

- alignment of the measuring system;
- contamination control (internal check of optical surfaces);
- flushing air supply

Sampling system

A visual inspection of the sampling system shall be performed, noting the condition of the following components, when fitted:

- sampling probe;
- gas conditioning systems;
- pumps;
- all connections;
- sample lines;
- power supplies;
- filters.

The sampling system shall be in good condition and free of any visible faults, which may decrease the quality of data.

Documentation and records

The following documentation shall be controlled, readily accessible and up to date:

- a plan of the AMS;
- all manuals (maintenance, users, etc.);
- log books to document possible malfunctions and action taken;
- service reports;
- QAL3 documentation including actions taken as a result of out of control situations;
- management system procedures for maintenance, calibration and training;
- training records;
- maintenance schedules;
- auditing plans and records.

Serviceability

There shall be provisions for the effective management and maintenance of the AMS, in order to ensure the maintenance of the quality of data. Such provisions include at least the following:

- safe and clean working environment with sufficient space and weather protections;
- easy and safe access to the AMS;
- adequate supplies of reference materials, tools and spare parts.

In order to conduct the tests effectively, in addition to the requirements for testing the AMS, and the requirements for the sampling location and the working platform which are required for QAL2 and QAL3, facilities shall be provided to introduce the reference materials, both at the inlet of the sampling line (where present), and at the inlet of the analyser.

Leak test

Leak testing shall be performed according to the AMS manuals. The test shall cover the entire sampling system.

Zero and span check

Reference zero and span materials shall be used to verify the corresponding readings of the AMS. In case of non-extractive AMS, zero and span checks shall be performed using a reference-path free of flue gas before and after readjustment and after re-assembly of the AMS at the measurement location.

Linearity

The linearity of the analyser's response shall be checked using five different reference materials, including a zero concentration.

The reference material with zero concentration, as well as the reference materials with four different concentrations, shall have a verifiable quantity and quality.

In the case of gaseous reference materials, these four reference materials can be obtained from different gas cylinders or can be prepared by means of a calibrated dilution system from one single gas concentration.

The reference material concentrations shall be selected such that the measured values are at approximately 20%, 40%, 60% and 80% of the range of two times the emission limit. It is necessary to know the values of the ratios of their concentrations precisely enough so that an incorrect failure of the linearity test does not occur. The dry test reference material shall be applied to the inlet of the AMS.

The individual analysers are tested using the following concentrations applied in a randomised sequence:

- reference material with zero concentration;
- reference material concentration approximately 20% of 2 times the emission limit;
- reference material concentration approximately 40% of 2 times the emission limit;
- reference material concentration approximately 60% of 2 times the emission limit;
- reference material concentration approximately 80% of 2 times the emission limit;
- reference material with zero concentration.

After each change in concentration, the first instrument reading shall be taken after a time period equal to at least three times the response time of the AMS. At each reference material concentration, at least three readings shall be made. The time period between the start of each of the three readings shall be separated by at least four times the response time.

This procedure means that the quality of the reference material may influence the result of the tests. It should be noted, however, that it is the result that leads to a pass or failure in the test. In some cases, a reference material with a higher quality may change the result from fail to pass.

Special care should be taken, when handling HCl or HF in dry gases. For example, particular surface reactions in tubing can result in very long response time, which is not representative of the response time for humid gases.

Where no other method is possible, the linearity can also be performed with the aid of reference materials such as grating filters or gas filters.

The linearity shall be calculated and tested using the procedure as given in Annex 1. If the AMS does not pass this test, then the problem shall be identified and rectified.

Interferences

A test shall be undertaken if the process gases to be monitored contain components that are known interferences, as identified during QAL1.

Zero & span drift (audit)

The zero point and span drift shall be obtained from and evaluated on the basis of the records of QAL3.

Response time

The response time of the AMS shall be checked. This can be performed, if appropriate, by injecting the reference material into the end of the sampling probe. The response time shall not exceed the measured value that has been identified during QAL1.

Report

The results of the functional test shall be reported. Any faults shall be recorded. If the faults are judged to have an effect on the quality of data, then the operator shall carry out the necessary corrective and preventive actions.

What should a service engineer be doing?

The service engineer should carry out instrument maintenance. In principle the service engineer is the preferred person to carry out the functional tests on the analysers that have been installed. The service engineer should not alter any parameters once a QAL2 or an AST check has been carried out unless the AMS requires major repair. Any other alterations to the AMS could affect the calculated calibration function and would probably mean a repeat QAL2.

6 Worked Examples

A number of specific worked examples are included in Annex 1. In addition where appropriate, example spreadsheets can be found at the web sites detailed below. **The example spreadsheets are for guidance only and users should validate their own calculation procedure.**

The examples cover the following aspects of EN 14181.

Conversion of Data to Normalised Conditions and Useful Equations	Annex 1
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QAL1 Uncertainty of AMS	Annex 1
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QAL2 Flow Chart for QAL2 Calibration of an AMS	Annex 1
Gas Analyser Functional Tests	Annex 1
QAL 2 Example-SO ₂	www.epa.ie
Uncertainty calculation for SRMs	www.npl.co.uk/environment/em.html

AST Flow Chart for Annual Surveillance Test of an AMS	Annex 1
AST Particulates Example	www.epa.ie

QAL3 Shewart Test	www.epa.ie
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7 Bibliography of Relevant European Documents

A summary is provided here of the status of implementation of European Standard EN14181 and related EN standards in certain countries of the European Union in order to give some background to their implementation in Ireland. European and International standards, European Union Directives, and other documentation that are already published or being drafted, referred to in this Guidance Document include:

1. **EN 14181:** Stationary Source Emissions
Quality assurance of automated measuring systems; published 2004
2. **EN 13284-2:** Stationary Source Emissions
Determination of low-range mass concentration of dust – Part 2: Automated measuring systems; published 2004
3. **EN 14884:** Stationary Source Emissions
Determination of total mercury: Automated measuring systems;
4. **A Suite of EN standards prescribing the implementation of Standard Reference Methods (SRMs)**
EN 14789: Stationary source emissions –Determination of volume concentration of oxygen –Reference method;
EN 14790: Stationary source emissions – Determination of water vapour in ducts;
EN 14791: Stationary source emissions –Determination of mass concentration of sulphur dioxide – Reference method;
EN 14792: Stationary source emissions – Determination of mass concentration of nitrogen oxides - Reference method: Chemiluminescence
(see also CEN/TS 14793: stationary source emissions – Intralaboratory validation procedure for an alternative method compared to a reference method)
5. **EN ISO 14956:** Air Quality - Evaluation of the suitability of a measurement procedure by comparison with a required measurement uncertainty
6. **EN 15267-3:** Air Quality – Certification of automated measuring systems: Performance criteria and test procedures
7. **EN ISO/IEC 17025:**
General requirements for the competence of testing and calibration laboratories;
8. **Directive 2000/75/EC:**
On the incineration of waste;
9. **Directive 2001/80/EC:**
On the limitation of emissions of certain pollutants into the air from large combustion plants;
10. **Directive 96/61/EC:**
Concerning integrated pollution prevention and control (IPPC)
11. **ISO 11095:** Linear calibration using reference materials
12. **Draft EN Standard (of CEN Technical Committee 264, Working Group 9)**
TC264 WI264076: Draft Title: Stationary source emissions: Quality assurance of the treatment of AMS outputs, (data processing, data reduction, and data substitution), for monitoring of environmental data;

13. Draft EN Technical Report (of CEN Technical Committee 264, Working Group 9)

New Guidance being drafted on the use of EN 14181 (see Annex 2 Section A2.4)

Annex 1 Worked Examples for EN 14181

Conversion of Data to Normalised Conditions and Useful Equations

Equation 1. Calculating the Concentration of Particulate

$$C_{meas} = \frac{m_{meas}}{V_{meas}}$$

C_{meas} = Concentration of Particulate, (Stack Temperature and Pressure, uncorrected for oxygen, dry gas basis), mg m^{-3}
 m_{meas} = Total mass of Particulate collected on filter, mg
 V_{meas} = Volume of Gas Sampled (Stack Temperature and Pressure, uncorrected for oxygen, dry gas basis), m^3

Equation 2. Conversion of Pollutants from ppm to mg m^{-3}

It is accepted that the main combustion gas species are reported in a mass per volume basis and as many analysers output data on a volume per volume basis (parts per million, ppm), a conversion is required. The following equation is used to convert concentrations in ppm to mg m^{-3}

$$C_{\text{mgm}^{-3}} = C_{\text{ppm}} \times \frac{\text{mol.wt}_{\text{poll}}}{22.414}$$

$C_{\text{mgm}^{-3}}$ = Pollutant Concentration (273.15K, 101.3 kPa)
 C_{ppm} = Pollutants Concentration (output from analyser)
 $\text{mol.wt}_{\text{poll}}$ = molecular weight of the species being measure
 $22.414 \text{ l mol}^{-1}$ = The molar volume of any gas at 273.15K, 101.3 kPa

Table of conversion factors of the major combustion gas species

Species	Molecular Weight	Conversion Factor
Sulphur dioxide (SO_2)	64.0	2.857
Carbon Monoxide (CO)	28.0	1.249
Nitrogen Oxide*	30.0	1.338 (2.052)*
Nitrogen Dioxide	46.0	2.052
Hydrogen Chloride	36.5	1.628
Hydrogen Fluoride	20.0	0.892
Ammonia	17.0	0.759
Methane	15.0	0.669

*Nitrogen oxide when present in ambient air converts quickly to nitrogen dioxide. Therefore, the operating authority asks for all oxides of nitrogen to be reported as NO_2 so 2.052 should be used as the conversion factor for all oxides of nitrogen when reporting data to the operating authority

Equation 3. Converting VOCs (ppm) to VOCs mg (Carbon) m^{-3}

As many VOC analysers are calibrated using a certified hydrocarbon gas standard (normally propane), final data should be reported as a carbon equivalent concentration. The following equation is used to convert the data.

$$C_{mg(C)m^{-3}} = \left(C_{ppmpropane} \times \frac{mol.wt_{C_3H_8}}{22.414} \right) \left(\frac{mass_{carbon}}{mol.wt_{C_3H_8}} \right)$$

$$C_{mg(C)m^{-3}} = C_{ppmpropane} \times \frac{36}{22.414}$$

$$C_{mg(C)m^{-3}} = C_{ppmpropane} \times 1.606$$

Equation 4. Correcting a concentration to Reference Oxygen Conditions

In order to compare concentrations of pollutants from one site to another, the dilution effect of air must be taken into account, as the concentration of the pollutant would vary depending on how much excess air there is in the flue gas. The following equation is used to correct the concentration of the pollutant.

$$C_o = C_{meas} \times \frac{20.9 - O_2 \%reference}{20.9 - O_2 \%measured}$$

C_o	= Pollutant Concentration (corrected for oxygen), $mg\ m^{-3}$
C_{meas}	= Pollutant Concentration, (uncorrected), $mg\ m^{-3}$
$O_2reference$	= Oxygen Correction Factor,
$O_2measured$	= Measured Oxygen Concentration, on a Dry Gas Basis, %Vol

Note 1: when correcting a gas volume for oxygen the above equation is inverted.

Note 2: The operating authority will stipulate which $O_2\%$ reference values shall be used. As a guideline the below values are used:

3% O_2 - Gas/Liquid fired boilers
 6% O_2 - Solid fuel firing boilers
 11% O_2 - Incinerators
 15% O_2 - Gas Turbines

Equation 5. Correcting a Concentration to Dry Gas Basis

In order to compare concentrations of pollutants from one site to another, the dilution effect of water must be taken into account, as the concentration of the chemical would vary depending on how much moisture there is in the flue gas. Therefore, pollutants should be corrected for zero moisture, or dry gas basis, and the following equation is used to correct the pollutant.

$$C_{dry} = C_{meas} \times \frac{100}{(100 - H_2O\%)}$$

C_{dry}	= Pollutant Concentration, (Dry Gas Basis) $mg\ m^{-3}$
C_{meas}	= Pollutant Concentration, (Wet Gas Basis), $mg\ m^{-3}$
$H_2O\%$	= Measured Moisture Concentration, %Vol

Note 1: When correcting a gas volume for water the above equation is inverted

Note 2: In the case of cross-duct Automated Measuring Systems moisture must be included in the peripheral measurements to correct the output of the AMS to reference conditions.

Equation 6. Correcting to Standard Temperature and Pressure

In order to compare concentrations of pollutants from cross duct measurements, the effects of temperature and pressure must be taken into account, as the concentration of the chemical would vary depending on the temperature and pressure in the flue gas. It is normal to correct all concentrations to 273.15 Kelvin and 101.3 kilopascals.

$$C_{ref} = \frac{T}{273} \times \frac{101.3}{P}$$

C_{ref} = Pollutant Concentration (corrected to 273.15K, 101.3 kPa)
 T = Stack Temperature, K
 P = Pressure at the measuring point, kPa

Example Calculation 1. Measurement of particulate and correction to reference conditions.

A cross-duct optical analyser measures an average raw output of 5.5 mg m⁻³ over an hour period. The process is a gas-fired boiler and the peripheral measurements at the time measured the stack conditions of 140°C, 99.8 kPa and 18%Vol moisture and 4.2%Vol oxygen.

To correct this value to reference conditions:

$$C_{corr} = 5.5 \times \left(\frac{273 + 140}{273} \right) K \left(\frac{101.3}{99.8} \right) kPa \left(\frac{20.9 - 3}{20.9 - 4.2} \right) \% O_2 \left(\frac{100}{100 - 18} \right) \% H_2O$$

$C_{corr} = 11.0 \text{ mg Nm}^{-3}$ at 273.15K, 101.3 kPa, 3% O₂, Dry Gas Basis.

Example Calculation 2. Measurement of SO₂ and correction to reference conditions.

A SO₂ NDIR analyser records a reading of 10.2 ppm from an incinerator. The oxygen analyser records a reading of 8.6%Vol. The NDIR analyser is situated at the bottom of the stack after a gas conditioning system.

To correct this value to reference conditions:

$$C_{corr} = 10.2 \times 2.857 \times \left(\frac{20.9 - 11}{20.9 - 8.6} \right) \text{mgNm}^{-3}$$

$C_{corr} = 23.5 \text{ mg Nm}^{-3}$ at 273.15K, 101.3 kPa, 11% O₂, Dry Gas Basis.

Determining the uncertainty of an AMS (QAL1)

BS EN 14181:2004 states:

“An AMS to be used at installations covered by EU directives e.g. [1] and [2], shall have been proven suitable for its measuring task (parameter and composition of the flue gas) by use of the QAL1 procedure, as specified by EN ISO 14956. Using this standard, it shall be proven that the total uncertainty of the results obtained from the AMS meets the specification for uncertainty stated in the applicable regulations. In QAL1 the total uncertainty required by the applicable regulation is calculated by summing in an appropriate manner all the relevant uncertainty components arising from the individual performance characteristics”.

Maximum Allowable Uncertainty of an AMS as required by the Large Combustion Plant Directive (LCPD)

Species	Maximum Uncertainty of the AMS
Sulphur Dioxide	20%
Nitrogen Dioxide (NO _x as NO ₂)	20%
Dust	30%

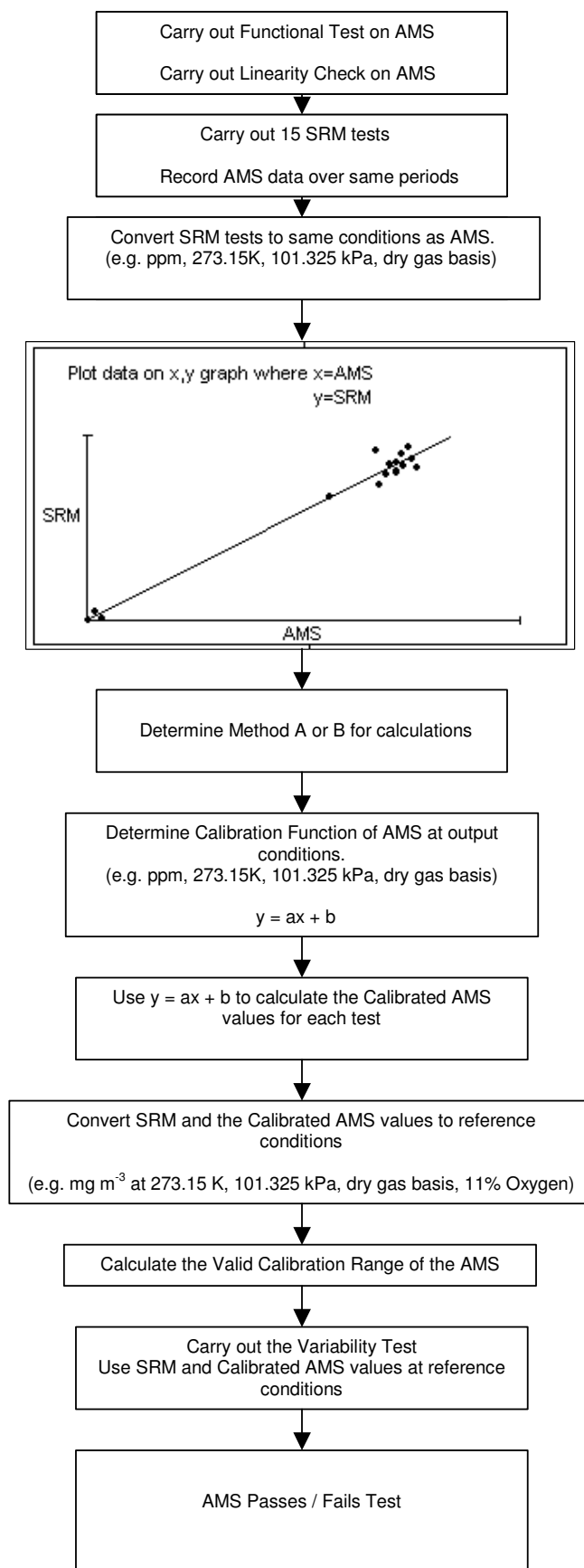
Maximum Allowable Uncertainty of an AMS as laid down by the Waste Incineration Directive (WID)

Species	Maximum Uncertainty of the AMS
Sulphur Dioxide	20%
Nitrogen Dioxide (NO _x as NO ₂)	20%
Dust	30%
Total Organic Carbon	30%
Hydrogen Chloride	40%
Hydrogen Fluoride	40%

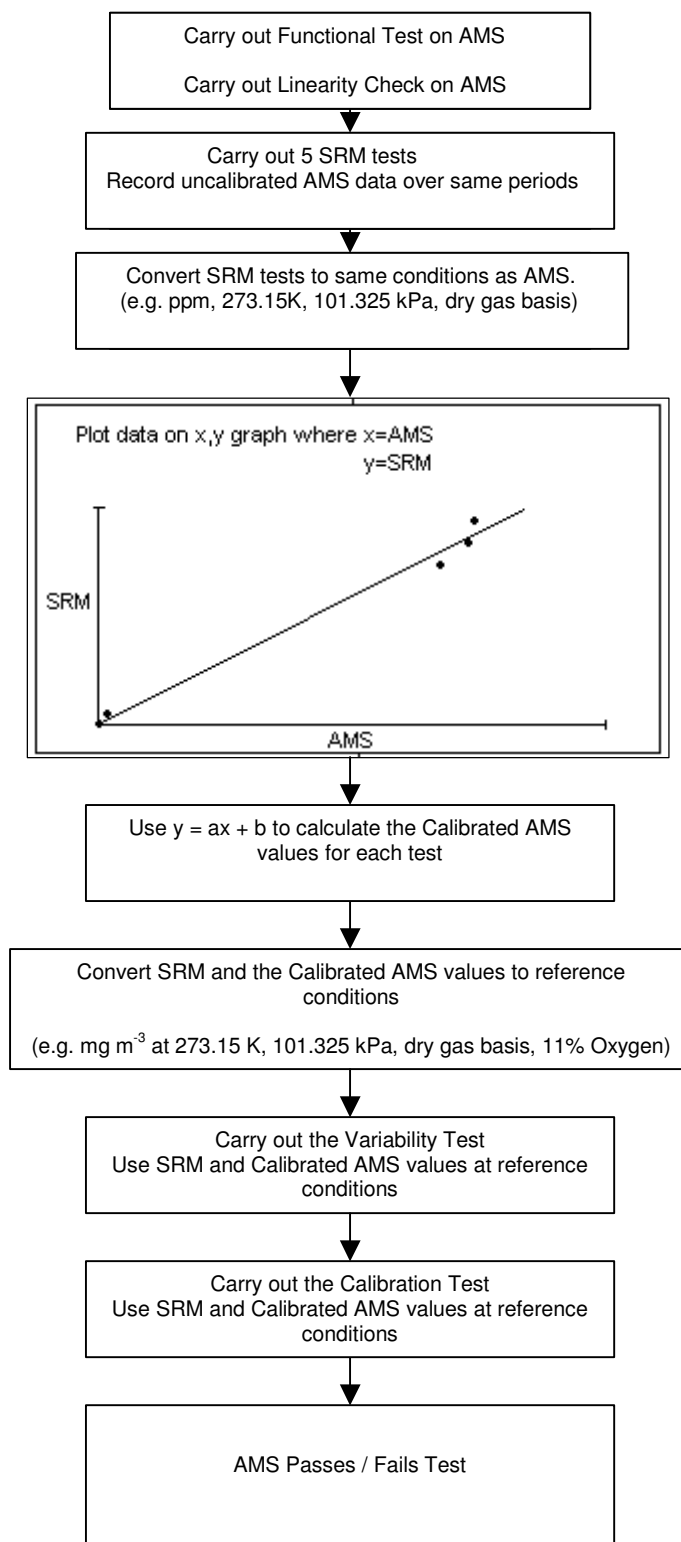
Recommended Maximum Allowable Uncertainty of an AMS measuring Carbon Monoxide

Species	Maximum Uncertainty of the AMS
Carbon Monoxide	20%

Flow Chart for QAL2 Calibration of an AMS



Flow Chart for Annual Surveillance Test of an AMS



Gas Analyser Functional Tests – QAL 2

Alignment and Cleanliness

Visual inspection of the internals of the analyser to be carried out.

Sampling System

Sampling system to be checked for any abnormalities and leak tested as per manufacturer's instruction.

Documents and Records

All relevant documentations to be completed

Zero, Span Checks and Response Times

Required zero and span checks and response times to be completed and documented.

Electrical Circuit tests and Inspection

Earth Continuity and other electrical checks to be carried out

AMS Model and Serial Number :

Sampling system Serial Number:

Other Part Nos, Serial Numbers

Zero and Span Readings Pre/Post Service inc final checking

Gas	HCl	SO ₂	NO	NO ₂	CO	O ₂	H ₂ O	VOC
Units	mg/m ³	mg/m ³	mg/m ³	mg/m ³	mg/m ³	%	ppm	mg/m ³
Zero (pre)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zero (post)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cal Gas Value	150.0	356.6	518.6	44.8	181.9	7.1	N/A	27.5
Span (pre)	152.1	338.8	510.2	56.1	176.1	7.0	N/A	73.4
Span (post)	150.0	356.7	518.8	44.7	182.0	7.1	N/A	27.8
Zero Check	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Span Check	150.0	356.8	518.7	44.8	182.0	7.1	N/A	27.8
90% response time (Sec)	N/A	<60	<60	<60	<60	<60	N/A	<60

Internal Service Parameters

Test	Low Limit	Measured Value	High Limit	Result
Ext 6	N/A	N/A	N/A	N/A
Peltier 2 Stage	600	784	1000	Pass
Peltier	200	N/A	800	N/A
3V-Ref Clamp	-8600	-8974	-10000	Pass
oxygen	N/A	209	N/A	Pass
Ext 5	N/A	2271	N/A	Pass
IR Source	2400	2483	3200	Pass
Flow Rate	N/A	3734	N/A	Pass
A/D	N/A	N/A	N/A	N/A
Pressure	N/A	915	N/A	Pass
Ext Temperature	N/A	310	N/A	Pass
GND	-10	0	10	Pass
-15V	-1425	-1494	-1575	Pass
Int Temperature		498		Pass
+15V	+1425	1497	1575	Pass
+5V	5000	5137	5200	Pass
Motorspeed-6 wheel	1700	N/A	2100	N/A
-10 wheel	1600	N/A	1800	N/A
-16 wheel	1400	1454	1600	Pass

Zero Reference/Filter values

Channel	1	2	3	4	5	6	7	8
Gain	171	171	171	171	171	171	171	171
Signal	29374	31336	12665	8648	29346	21678	19572	30608

Channel	9	10	11	12	13	14	15	16
Gain	171	171	171	171	171		171	171
Signal	15702	33816	22128	49685	25491		34146	20892

Gas Calibration

Gas	Exp Date	Cert No	Target Conc		Calibration Reading		K Factor		Wheel Ratio		Filter Pos	
			ppm	mg/m ³	pre	post	pre	post	pre	post	meas	ref
HCl			92.2	150.0	152.1	150.0	1.005	0.991	152	152	10	11
SO ₂			124.7	356.6	338.8	356.7	1.005	1.058	110	110	6	7
NO			387.0	518.6	510.2	518.8	1.010	1.027	146	146	3	4
CO			145.5	181.9	176.1	182.0	1.020	1.054	194	194	8	9
O ₂			7.1		7.0	7.1	1.000	1.014	N/A	N/A	N/A	N/A
H ₂ O	N/A	N/A	N/A	N/A	N/A	N/A	1.010	1.010	101	101	1	2
NO ₂			21.8	44.8	56.1	44.7	1.010	1.807	163	163	15	16
CO ₂	N/A	N/A	N/A	N/A	N/A	N/A	1.000	1.000	93	93	5	2
C ₃ H ₈												
N ₂ O	N/A	N/A	N/A	N/A	N/A	N/A	1.000	1.000	194	194	12	13

Alarms: ON**Z-Ref Cycle: ON****Dead Time: 240 sec****Calibration Details/Instrument Adjustment**

Calibration Gas	K Span Factor		FID Range	Conc Mg/m ³	Measured Value	Calibration Deviation	Span Gas Cyl No	Valid to
	Old	New						
Propane	3.1558	1.1823	X100	27.5	73.4	45.9		

	Pre Calibration	Post calibration	Final check	Ma Out
Zero	0.0	0.0	0.0	N/A
Span	73.4	27.8	27.8	N/A

MUX Signals

Channel	Test	Lower Limit	Actual	Upper Limit	Test
1	GND	0mv	0	<20mv	Pass
2	T ⁰ INT	100mv	441	600mv	Pass
3	T ⁰ FID	170mv	189	200mv	Pass
4	T ⁰ METH	205mv	N/A	245mv	
5	NC		N/A		
6	NC		N/A		
7	Flame 1	2000mv	9215	9999mv	Pass
8	Flame 2	2000mv	N/A	9999mv	
9	H ₂ /He press	4000mv	6682	8000mv	Pass
10	Air press	2000mv	3627	6000mv	Pass
11	Sample press	1800mv	1872	2200mv	Pass
12	FID 1	50mv	327	9900mv	Pass
13	FID 2	50mv	N/A	9900mv	
14	Purifier T ⁰	380mv	403	420mv	Pass
15	NC		N/A		
16	2.5Vref	2480mv	2498	2520mv	Pass

System Checklist

Description	Checked
Plinth fitted correctly	Yes
Front plates screwed in securely	Yes
Labels/Warning labels fitted	Yes
Panel Switches/Pushbutton secure	Yes
Panel Lamps installed	Yes
Wire colour correct to drawings	Yes
Wire size CSA correct to drawings	Yes
Wires identified at each end to drawing	Yes
Terminal Blocks correctly identified	Yes
Wiring correctly ferruled and pull-tested	Yes
Components correctly laid out and secured	Yes
Mains supply Distribution Rail covered	Yes
Air Conditioner unit Temp set correctly	Yes
Fluidic Material Correct	Yes
Fluidic Piping Size correct	Yes
Cable and Braids checked for wear	Yes
Terminal Common-Links removed	Yes
DC-PSU Voltage regulator set and output correct	Yes
Fuses fitted correctly	Yes
Test Links removed	Yes
Front door fitted correctly	Yes
Rear door fitted correctly	Yes
Side Panels fitted correctly	Yes

Annex 2: European Countries: Implementation of European Standard EN14181 and Related Documents

A summary is provided of the status of the implementation of European standard EN14181 in certain countries of the EU, in order to provide some examples of the different methodologies used, and to give some background to their implementation in Ireland. The standards and related other documentation referred to in this Annex are listed in the bibliography section of this Document.

There are also a number of relevant national standards, guidelines, and other documentation. These are summarised below within the discussion of the country concerned. Section A2.4 below also summarizes some ongoing standardisation work within CEN relevant to this Document.

A2.1 United Kingdom

The regulatory bodies in the United Kingdom responsible for the implementation and application of EN 14181, related standards, and other documentation are:

- The Environment Agency (EA) of England and Wales (supported by the Department of Food, Environment and Rural Affairs – Defra).
- The Scottish Environmental Protection Agency.
- The Environment Agency of Northern Ireland (supported by the Department of Environment in Northern Ireland).

Overviews of the activities of these three organisations related to this Guidance document are given below:

Environment Agency (EA) of England and Wales.

The EA has taken the lead in handling these regulatory issues related to the Waste Incineration and Large Combustion Plant Directives, and BS EN 14181 in the UK. Currently, the status is that:

- Requirements for the application of BS EN 14181 have been included in all industrial licences for plants covered by the Waste Incineration Directive, since the end of 2005.
- Requirements for the application of BS EN 14181, and BS EN 13284-2 are being included in licences for plants covered by the Large Combustion Plant Directive, but these are not complete. The target date for completion is 2008.
- There are requirements by the EA for BS EN 14181 to be applied within certain pollution prevention and control (IPPC) permits in England and Wales, and those are being introduced-up until 2008.

The EA has produced a number of Technical Guidance and related Method Implementation Documents, to support BS EN 14181 and BS EN 13284-2:

- (i) Technical Guidance Note (TGN) M20 (current issue September 2005) is prepared by EA to provide support to its regulatory officers, process operators, and those involved with industrial stack emissions monitoring, in the application of the above standards. It provides guidance on:
 - Monitoring requirements in EU Directives for large combustion and waste incineration plants;

- The selection of AMSs that are capable of meeting the requirements of the two EU Directives.
- The requirement to demonstrate the suitability of the AMS before its incorporation into the plant through product certification using the EA's MCERTS Scheme.
- A method for determining whether the AMS can achieve the measurement uncertainty requirements specified in the above two Directives.
- Requirements for optimally locating the AMS on the stack or duct.
- Functional tests to ensure that the AMS has been installed and is operating correctly.
- Selection of a Standard Reference Method (SRM) and calibration of the AMS.
- On-going surveillance to assure the continued correct operation of the AMS by regular repeated measurement throughout the year.
- Annual surveillance tests for the AMS.

However, it should be noted that:

- M20 makes **no reference** to the use of an AMS on an industrial plant that is **not** certified through product conformance testing to the MCERTS standard, in order to demonstrate its suitability for the selected industrial plant, and to cover the required pollutants and other determinands, and the required certification range(s).
- The scope of M20 **excludes** the data collection and recording system of the AMS, in keeping with standard EN 14181. However, it is anticipated that this will be addressed in future through a new EN standard (see below), and this would then be incorporated into the MCERTS Scheme.

TGN M20 was published, however, before significant operational experiences had been obtained with the EN standards in the UK (or elsewhere in the EU). Therefore, the current guidance was not able to incorporate the large range of experiences obtained following full implementation of EN 14181 for WID and LCPD applications. Therefore, it is intended to revise M20 within the next six months in order to deal with these experiences and other new information, and also to bring M20 into line with the new EN Technical Report currently being drafted (see also below).

(ii) Method Implementation Document (MID 14181) and the associated MID, which is linked to BS EN 13284-2, have been published by the EA. These are published to supplement the European Standards to ensure that organisations carrying out regulatory monitoring implement the standards consistently and rigorously. These MIDs are used together with EA Technical Guidance Notes M1, M2 (see below) and M20, to provide technical details for testing laboratories on how to carry out the QAL2, QAL3 and Annual Surveillance Tests described in EN 14181 and EN13284-2. The two MIDs provide additional details on a number of technical issues, including for example;

- Requirements for the laboratory carrying out the QAL2 and AST tests using SRMs to be accredited to EN ISO/IEC 17025 for the MCERTS performance standards for manual stack monitoring for the applicable SRMs.
- Provision of more specific requirements than EN 14181 as to when a further QAL2 test procedure is required following fuel changes, and when it is acceptable to carry out the more limited AST instead (e.g.

When daily average gaseous emissions are less than 50% of the ELV¹ consistently between the previous and the new QAL2 exercises).

- Requirements for the peripheral AMS measurements on the plant (e.g. oxygen and water vapour), and a procedure on how to handle the results of QAL2 and AST tests when the plant operator's peripheral measurements cause the AMS to fail the variability test in EN 14181.
- Requirements for the spread of data over the calibration range, including near-zero data.
- Specification of the contents of the QAL2 and AST reports to the EA.
- Specification of the functional tests required within the QAL2 and AST procedures and who may carry these out.
- Specification of acceptable SRMs for the tests (and equivalent methods which may be used if these conform to DS TS 14793).

There are also two further EA Technical Guidance Notes that are linked to the implementation and application of EN 14181. These are:

- TGN M1: Sampling requirements for monitoring stack emissions to air from industrial installations.
- TGN M2: Monitoring of stack emissions to air.

These documents, which preceded the publication of EN14181, TGN M20, etc. provide generic technical guidance on the sampling and monitoring of industrial emissions to air, and provide general underpinning to the TGN M20 and MID documents, which specifically support BS EN 14181.

The Scottish Environmental Protection Agency (SEPA)

As noted above, SEPA has been consulted on, and have accepted, all the Guidance documents published by the Environment Agency of England and Wales. SEPA, however, are not advanced as the EA in licensing their waste incineration and large combustion plants that fall under the EU Directives, for conformance with BS EN 14181 monitoring requirements.

The Environment Agency of Northern Ireland / Department of Environment

The Department of Environment of Northern Ireland has issued a draft Guidance document on 'Directive 2000/76/EC on the Incineration of Waste' (Edition 2 January 2007). This document specified what constitutes waste in the context of this EU Directive, and what is covered by other regulations (e.g. IPPC) in Northern Ireland. There is however, no reference to BS EN 14181, although there is close contact between Northern Ireland and the EA on this issue. There are also currently no permits that call for conformance with the requirements of BS EN 14181.

Summary

- (i) The Environment Agency of England and Wales has included the requirements for the procedures in the BS EN 14181 and the BS EN 13284-2 standards (QAL2, QAL3 and AST) in its permits, for plants covered by the Waste Incineration Directive.
- (ii) EA is advanced in the process of permitting all plants covered by the LCPD, with a planned completion date of 2008.
- (iii) The Scottish and Northern Irish regulatory authorities are significantly less advanced in their implementation of the WID, the LCPD, and the requirements to apply the EN 14181 procedures.

¹ Unless otherwise stated the ELV is the daily or 48 hourly ELV

- (iv) The EA has prepared and published one important Technical Guidance Note (M20) and two Method Implementation Documents (covering BS EN 14181 and BS 13284–2), which provide details and clarification of the requirements of these standards.
- (v) Significant experience has been obtained in using the EN 14181 standard in the UK and the rest of Europe, since its publication in 2004. Similarly, there is now experience in the use of TGN M20, (and the related MIDs) since its publication in 2005. These experiences, together with related activated across the EU (see below) will be incorporated in a revision of TGN M20 in the near future.

A2.2 France

Current Status.

The French version of the EN 14181 standard (NF EN 14181) was published in October 2004. The French government ministry responsible for the implementation of WID LCPD etc. is the 'Ministère de l'Ecologie et du Développement Durable'. This ministry issued a formal letter in September 2006 clarifying the timetable and all other requirements for implementing NF EN 14181:

- (i) For industrial installations for the incineration or co-incineration of waste, the first QAL2 procedure shall be completed before 28th December 2008.
- (ii) For installation for combustion within the definition of LCPD, the first QAL2 procedure shall be completed before 6th November 2009. It should be noted, however, that the French authority is requiring implementation of QAL2 for combustion installations that have a thermal power rating of greater than 20 MW, rather than the 50MW requirement in the LCPD.
- (iii) The requirement is also for Annual Surveillance Tests each year following this.
- (iv) There is a requirement for all AMSs to have been certified by an approved body before their use in QAL2.

In France the approved body which carries out the approval tests is ACIME and this provides a 'kite' mark for the instrument. The approval will also assess whether the AMS will fulfil the measurement uncertainty requirements specified in WID and LCPD (e.g. see Annex VIII item 6 of LCPD). This is carried out according to the requirements of EN ISO 14956 (see above) but this standard has been supplemented by a new French Guide (FD) X43-130- see below) which provides more details on how to do this. It is also acceptable in France for the QAL1 procedure to be carried out by acceptable organisations in other EU countries, notably Germany (UBA/TUV) and the UK (MCERTS), but in these cases the determination of the overall measurement uncertainty of the AMS from all the approval tests (according to EN ISO 14956 and FD X45-130) should be evaluated by the accepted French organisation (e.g. ACIME)

- (v) A series of tests of the QAL2 and AST procedures, co-financed by the French government, were carried out on selected industrial plants in 2005 (see below). These identified certain difficulties with the implementation of EN 14181 associated with QAL2 and the AST procedures and, as a result, the French standardisation body has requested revision of this standard. In the meantime, a Guide on the application of NF EN 14181 is being produced, and a draft is now available (see also below).

There are a few industrial sites where this standard has been trialled up until now (see below).

French Documentation Available to Underpin NF EN 14181 and related Standards.

A number of Guidance Documents have been prepared in French to support, amplify and specify in more detail, the requirements of NF EN 14181, NF EN 13284-2, NF 14884, and the WID and LCPD. The main Guides, all published by the French Standardisation AFNOR are:

- (i) Guidance Document GA X43-132, provides support to regulatory officers, industrial process operators, testing laboratories and organisations involved in stack emissions monitoring. The scope, format and coverage of this Guide are the same as the EA TGN M20 – 2005 (indeed most of the text is identical).
- (ii) Guide X43-130 parts 1-7, provides practical and detailed guidance on the estimation of the overall measurement uncertainty of an AMS measuring gaseous components, from the results obtained by QAL1 testing. (This is consistent with EN ISO 14956).
- (iii) Guide NF X06-031 parts 1-4, provides practical and detailed guidance on how to apply the quality control procedures given in QAL3 of EN 14181, and the French guidance covers, Shewhart and CUSUM charts. It also provides a further method involving exponentially-weighted moving-average charts (EWMA), and recommends this method as simple and more efficient on its use of the data, than the other two.
- (iv) The Guidance GA X43-132 also makes recommendations on the use of other EN standards and Technical Specifications:
 - prEN15259 Strategy, planning, reporting and implementation for stack emission measurements at a site;
 - CEN TS 14793 – Intra-laboratory validation procedure for the use of an alternative method compared to the reference method. This allows the use of 'equivalent' methods to SRMs for the QAL2 and AST tests **provided that** they have been demonstrated to be acceptable in performance.

Field Tests Carried Out on the Implementation of the EN 14181 Standard.

These tests involved major exercises in the implementation of the EN 14181 standard in the field by teams of experienced stack emission monitoring personnel:

- two large new generation waste incineration plants in France over a period of 9 months;
- two conventional coal-fired power plants over a period of more than six months in Belgium.

For these tests, the 'best available technologies' were implemented – new generation plant, recently purchased AMSs, carefully selected monitoring locations, experienced accredited testing laboratories using SRMs, high level of preparation for the tests. The test programme identified a number of issues and problems which must, according to the French experts, be considered in the next revision of EN 14181, particularly related to the QAL2 calibration. In the interim, these issues have been incorporated into the French Guidance document (NF X43-132 – see above) and have also been tabled at the first meeting of the CEN TC 264 Working Group 9, which is charged with drafting the CEN Technical Report to incorporate these, and findings from other experiences (see below).

Summary

- (i) The French regulatory authorities have produced a comprehensive infrastructure of Guidance documents to underpin all aspects of the implementation of NF EN 14181 and related standards in all French WID and LCPD plants.

(ii) There are requirements to complete all the QAL2 procedures for WID plants by December 2008, and all LCPD plants by November 2009. Only a few plants have currently completed this.

(iii) There is an assumed requirement that all AMSs that are to be involved in French will be certified to the requirements of QAL1 (i.e. to EN 15267-3) before they are installed, either through the French certification scheme itself, or recognised Schemes in other EU countries (e.g. Germany and the United Kingdom).

A2.3. Germany

Current Status

The Waste Incineration and Large Combustion Plant Directives were enacted into German Federal Emission Control Ordinances 13th BImSchV and 17th BImSchV respectively, and the Directives have hence effectively been in force since November 2004 and December 2005, respectively. The European standard EN 14181 was adopted by the German standardisation body (VDI/DIN) in September 2004. DIN EN 14181 is also applied in Germany to all IPPC installations (through TA Luft Legislation) and these are being required to implement EN14181 between July 2005&2007. Other installations requiring continuous monitoring (e.g. crematoria and combustion plant 20-50 MW) are also included. EN 14181 replaced the previous and less rigorous German Guideline VDI 3950, which covered the installation of the AMS **and** its electronic data collection and processing systems, the annual calibration of the AMS, and reporting requirements.

EN 14181, in combination with the German federal government document (Uniform Practice in Monitoring Emissions, 2005) is applied uniformly as a procedure to all the industrial plants noted above. It is underpinned by the use of Standard Reference Methods specified in VDI Guidelines and DIN Standards, which are now being updated to the published EN standards for SRMs.

It is the German regulatory view that EN 14181 has a number of advantages over the previous VDI 3950 Guidelines, including:

- Requirements for fully independent measured values (over 3 days and in each day);
- A quantitative evaluation of the data quality obtained, through analyses of the measurement uncertainties, etc;
- The valid calibration function has a well-defined and limited range.

It is also stated by German regulators that there were no significant problems in implementing EN 14181 for LCPD and WID applications.

In addition, as is well known, all AMSs for all the above of industrial plant, are required to be tested for suitability before use, by testing and approval, through independent test houses, (these are now required to be accredited for the testing to the EN ISO 17025 standard). The testing is currently as specified in VDI Guideline 4203. In the future, this Guideline will be updated to incorporate the (current draft) EN standard EN 15267–3. This will also include an EN standard currently being drafted on electronic data evaluation systems, covering the whole data path from the raw signals to the validated final measured values, and corrected for the peripheral measurements (water vapour, oxygen, gas pressure and temperature), to replace similar current requirements in VDI 4203.

The VDI 3950 specifications are being revised to include the detailed technical and procedural issues established during the implementation of EN 14181.

It is the German regulatory and their standardisation bodies' view that following the future update of VDI 3950, together with the use of UPME 2005, and with the introduction of the newer SRMs contained in EN standards, there is no need in Germany for further guidance documents to underpin DIN EN14181 etc..

Summary

- (i) Test Procedures were already in place in Germany, which involved AMS 'type approval' before its use, a first calibration of the AMS on the relevant industrial plant, and then annual surveillance test, before the publication of the standard EN 14181. These tests were required by national legislation to be applied to waste incineration and large combustion plants covered by the two EU Directives, and also to certain other plants covered by national integrated pollution prevention and control legislation.
- (ii) These test procedures were contained in several Guidance Documents.
 - VDI Guideline 4203, which covers the testing and type approved to demonstrate the suitability of specific types of AMS before its use – to be replaced by EN 15267-3 when published.
 - VDI Guideline 3950 covers installation of an AMS and its associated data collection and processing system, its first calibration installed at site, and annual surveillance testing.
 - Uniform Practice in Monitoring Emissions (UPME), published by the German Federal Ministry for the Environment,
 - Specification of Standard Reference Methods that are in VDI Guidelines and DIN Standards.
- (iii) As a consequence, the general mechanisms for the revisions of the national practices (mostly in VDI 3950) were already in place and only required modifications to take account of the more rigorous DIN EN 14181 standard.
- (iv) Also as a consequence, the requirements for the EN 14181 standard for waste incineration plant have been in force since December 2005, and the requirements for large combustion plant have been in force since November 2004.
- (v) The German regulatory authorities state that the majority of the above plants are now being tested as specified in EN 14181, and it has been applied to the LCPD and WID plants without problems in most cases.
- (vi) The VDI Guideline 3950 is currently under revision, taking into account certain problems identified up to now, and this will meet all German requirements without further Guidance documents (nevertheless Germany is contributing to the CEN Technical Report covering this).

A2.4 Related Ongoing European Standardisation Activity

As noted previously, there are currently two ongoing CEN activities being carried out by CEN TC 264 WG 9 that are related to the implementation and utilisation of the published standard EN 14181

- (i) Work is beginning on the drafting of a new CEN Technical Report (TR), a CEN Guidance Document that can be published rapidly. This will underpin and support the current standard EN 14181 until its revision (current schedule 2009). A workshop in May 2006 contributed to the content of this TR, which has now been approved, and the Editing Group is beginning a first draft. The context of this TR,

which will incorporate a range of different EU experiences, is compatible with the technical content of this Guidance.

- (ii) As noted, Working Group 9 is now also drafting a new standard (EN 14181-part2) to cover completely the treatment of the data outputs of the AMS. These were not covered by the current version of EN 14181 (see Figure 2 of the standard). A first draft has been prepared and is being reviewed.