Measurement and measurement uncertainty

Purpose of this document

The purpose of the document is to generate some discussion about the calibration processes which are to be developed to satisfy the needs of the Ozflux network and to provide some background material which may assist in the decision making process.

Background information

The technical process of making measurements is the first and only thing most people consider when thinking about instrument calibration, however instrumentation is only one part of a much larger picture.

High quality and consistent measurements and instrument calibrations require a management system to support the measurement process. Such management systems provide an administrative framework for the technical processes so that calibration results are accurate and have a known uncertainty i.e. are truly reliable. One such management system is described in the International Standard '*ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories'*. Most of the following discussion points come directly from that standard.

Many laboratories that operate under a system based on ISO/IEC 17025 chose to be accredited so that their expertise is recognised. The Australian body who provides such accreditation services and monitors accredited laboratories is the National Association of Testing Authorities. NATA provides such services to the Australian community under a Memorandum of Understanding with the Commonwealth Government. Given the nature of the Ozflux network and the many different institutions involved, it is unlikely that accreditation of the network could be achieved, even if it was desirable; however the technical and management principles outlined in ISO/IEC 17025 provide a firm basis for excellence in measurement and might allow individual laboratories to be accredited if they chose to be.

Discussion points

1. Measurement uncertainty

    a. What measurement uncertainty is required for the output data from each site so that the results may be useful?

    b. Will different users of the output data require different levels of measurement uncertainty?

    Note that the above uncertainty will, in general, be different to the individual instrument measurement/calibration uncertainty as the instruments are only one part of the measurement chain that produces the output result, which leads to the question:

    c. Is it possible or desirable to calculate a 'site measurement uncertainty' from instrument measurement uncertainties and process uncertainties?

Longitudinal comparison of data collected by each site can only be reliably compared if the overall measurement uncertainty is known.

It is understood that the proposed calibration process be a two-point calibration for zero and span. This raises some interesting questions:

d. Such a calibration assumes perfect measurement linearity. Has the system linearity been assessed and does it show any signs of non-linearity?

e. Is the instrument linearity a function of the measurement technique used by the instrument, or is it internally linearised by some process which may add to measurement uncertainty or instrument drift?

f. Is the linearity stable with respect to time, environmental factors (temperature etc), chemical contamination of sample chamber, etc?

g. How will stability of the span and zero gas be ensured? Small leaks or contamination of the calibration gas through using inappropriate regulators or gas fittings may significantly affect calibration results for a particular laboratory/site and other sites that subsequently use the calibration gases.

h. What if measurements are made above the span gas calibration point? Will that measurement be valid, as technically it is beyond the instruments calibrated range?

2. Traceability

Will, at any time, the measurements made at each, or any, site need to be traceable? In this context traceability means that the calibration of instruments used to make a measurement can be traced back to the relevant primary standard via an unbroken chain of calibrations with decreasing measurement uncertainty. Note that if the result of a measurement depends on a number of inputs, e.g. gas concentration, temperature and barometric pressure; all the input instruments require traceable calibration.

The above requirements for traceability means that all instruments used in the calibration process have traceable calibration and this is usually achieved by having instruments calibrated by a suitably accredited laboratory who can issue endorsed calibration certificates. Depending upon the instruments used, they will require regular and ongoing recalibration to maintain their traceability.

3. The instrument calibration process documentation

To ensure that reliable and accurate measurements and calibrations are performed by each site, a standard process should be followed. This means that a set of ‘work instructions’ that describe the process must be created and this raises some questions:

a. Who will create and control the work instruction documents? This is important for the change control process so that all participating laboratories are always using the *same version* of the work instructions.

b. What training in using the work instructions is required and how will such training be provided? Who will maintain training records?

c. When a set of standardised work instructions are created, it should include a standardised test report which covers all aspects of the calibration process. A standardised test report will assist in compliance monitoring.

d. How will compliance with the work instructions be monitored?

e. Where will calibration records be maintained, by whom and for how long?

f. What happens if an instrument fails calibration? e.g. its calibration uncertainty falls outside the accepted limit, or there is a significant shift in calibration coefficients?

g. What happens to data collected by a suspect or faulty instrument and how is it flagged as possibly being invalid?

h. If, as a result of the items above, corrective action is required, how will that be monitored so that the possibility of repeated faulty data is minimised?

i. Has the calibration procedure been validated? i.e. has it been compared with another method?

4. Competence testing

To ensure that a common and standardised calibration protocol is producing the required results, it will be desirable to undertake competence testing of each site/laboratory. A common practice in the metrology community is sending a sample or artefact around a number of laboratories where it is measured. The testing laboratory does not know the true value of the test item before the competence test. The measurement result and measurement uncertainties from each laboratory are then sent to a central or co-ordinating laboratory where the individual laboratory results are compared with the known or ‘true’ value of the sample or artefact being tested. The combined table of results and measurement uncertainties are then circulated to all laboratories who took part in the ‘round robin’ test.

This process will prove the competence of each laboratory and allow an assessment of the measurement uncertainties of the network of laboratories.