

## **UNCERTAINTY OF MEASUREMENT – CALIBRATION AND TESTING PROGRAMME**

Pre-course work on a calculation of mean and standard deviation, with full instructions (with delegates using their own calculators) will be sent out to all delegates approximately one week before the course date. Feedback on this work will be the subject of a session on the afternoon of the first day of the course.

### **Day 1**

#### **Introductions and briefing**

**Purpose:** *to set the scene, to introduce the tutors and delegates; to enable tutors and delegates to record their expectations of the course.*

#### **I think we may have dropped one!**

**Purpose:** *A live witnessed test to introduce ideas of validity and of uncertainty and its sources.*

#### **Appreciation of Uncertainty: Individual Exercise in Open Session**

**Purpose:** *to enable delegates to experience and appreciate uncertainty associated with a measurement in a day-to-day situation.*

#### **History and Background**

**Purpose:** *to set the scene and provide a context illustrating the present state of the art in relation to uncertainty of measurement.*

#### **Definition of Metrological Terms**

**Purpose:** *to provide an introduction to the terms used when discussing measurement-related activities, particularly with respect to uncertainty of measurement.*

#### **Traceability, calibration and SI units**

**Purpose:** *to facilitate an understanding of the need for traceability of measurement to SI units and its relevance to assigned values of measurement standards and measuring equipment.*

#### **Classifications of Uncertainty - Type A and Type B**

**Purpose:** *to facilitate an understanding of the types of uncertainty and how they are evaluated.*

#### **Discovering Distributions**

**Purpose:** *Exercise in open session to promote recognition of the different distributions (of data or uncertainty) that may be encountered during an estimation of uncertainty.*

### **Symbols and Equations Part 1**

**Purpose:** *to build on the pre-course work facilitating understanding of the equations that are the 'tools' for calculating uncertainties.*

### **Combination of Uncertainties**

**Purpose:** *to provide an appreciation of the need to quantify and express uncertainties in such a way that they can be combined to produce a meaningful combined uncertainty.*

### **Pre-course Work - De-briefing**

**Purpose:** *to provide an opportunity for delegates to consolidate their understanding of the use of a calculator in statistical mode and to check their pre-course exercise results.*

### **Calculation of Uncertainty for a Measurement**

**Purpose:** *to enable delegates, in their groups, to calculate the expanded uncertainty for a simple measurement.*

### **Report Back on Calculation and Introduction of Forms/Excel for calculating uncertainties.**

**Purpose:** *to allow delegates to report back their results and obtain feedback from the tutors*

## **Day 2**

### **Calculation of Uncertainty for a Measurement**

**Purpose:** *to enable delegates to calculate the expanded uncertainty for a simple calibration, and to consolidate the skills learned the previous day*

### **Example of a test with influence quantities**

**Purpose:** *to demonstrate real uncertainty is appropriate when there is no mathematical model, or numeric result, for the test.*

### **Sources of Uncertainty**

**Purpose:** *to facilitate an understanding of the need to know the test/measurement system in which the delegates work. This presentation includes an open session to draw from delegates possible contributions to uncertainty of a measurement in their specialist area.*

### **Exercise – Uncertain about methods?**

**Purpose:** *to consider the relationship between the method and the associated uncertainties.*

### **Correlated Contributions**

**Purpose:** *to introduce delegates to the concept of correlation and explore ways of dealing with it.*

### **Human Factors**

**Purpose:** *to introduce delegates to the strengths and limitations of the human factors influencing measurement uncertainty*

### **Measurement of Body Mass Index with uncertainty estimate**

**Purpose:** *to apply the principles of uncertainty estimation with functionally related input uncertainties.*

### **Exercise: Calibration of weighing machine**

**Purpose:** *to provide an opportunity to calculate an uncertainty budget and to distinguish between measurements used to estimate the mean of a population and those used to estimate the standard deviation of the population.*

## **Day 3**

### **Pooled Standard Deviations**

**Purpose:** *to introduce the concept of using historical data to improve estimates of uncertainty.*

### **Approaches to Evaluating sources of uncertainty**

**Purpose:** *to enable delegates to consider systematic approaches to linking and quantifying possible uncertainty contributions identified within a measurement system.*

### **Exercise on Sources of Uncertainty and Report Back**

**Purpose:** *to enable delegates, in groups of 4 or 5, to consider their own technical area to identify possible uncertainty contributions; to examine those contributions to see whether they can be (effectively) eliminated, whether they need to be monitored and controlled or could be included in repeatability/reproducibility considerations; where they can be linked; and how they might be quantified. (Note: it would be helpful for delegates from a common employer to have identified suitable measurement areas for this exercise).*

### **Normal or not?**

**Purpose:** *To describe situations where a normal distribution cannot be assumed for the combined uncertainty.*

### **Symbols and Equations Part 2**

**Purpose:** *to introduce the symbols used in equations when the  $t$ -distribution is used for obtaining a coverage factor.*

### **Effective Degrees of Freedom**

**Purpose:** *exercise to provide an opportunity for delegates to assess their own understanding of the  $t$ -distribution and their ability to use it during the calculation of uncertainty.*

### **How Many Measurements?**

**Purpose:** *to demonstrate how the number of measurements made can affect the uncertainty associated with the result.*

### **Stochastic modelling of uncertainty in quantitative measurements**

**Purpose:** *to introduce the possibilities of computer-based stochastic models ('Monte Carlo simulation') for uncertainty estimation, and in areas of non-linear propagation of uncertainty and of multi-variate applications.*

### **Sampling, Destructive Testing, Non-numeric Results**

**Purpose:** *brainstorm to identify challenges in these areas and to facilitate understanding of how to deal with them. This session includes a video example of a destructive test*

### **Statement of Uncertainty and Compliance**

**Purpose:** *to demonstrate how statements of uncertainty can be reported and how uncertainty may affect compliance with specifications.*

### **An introduction to Bayesian Statistics**

**Purpose:** *to provide an insight into future possibilities.*

### **Open Session, Questions and Clarifications**

**Purpose:** *to provide delegates with any further clarification, consolidation on identification and calculation of uncertainties in their testing areas.*

### **Close of course**