



Australian Government

Department of Education, Employment and Workplace Relations

MSL925002A Analyse measurements and estimate uncertainties

Revision Number: 1

MSL925002A Analyse measurements and estimate uncertainties

Modification History

Not applicable.

Unit Descriptor

Unit descriptor	This unit of competency covers the ability to estimate and report measurement uncertainty in accordance with the <i>ISO Guide to the Expression of Uncertainty in Measurement</i> . Personnel are required to review their estimates of measurement uncertainty to assist with making decisions on the fitness for purpose of the measurements.
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Application of the Unit

Application of the unit	This unit of competency is applicable to laboratory personnel who work in calibration and testing facilities and process and interpret data and are required to determine uncertainties using standard methods. The rigour required in estimating uncertainty will depend on the required accuracy of the particular calibration, test or measurement. Industry representatives have provided case studies to illustrate the practical application of this unit of competency and to show its relevance in a workplace setting. These can be found at the end of this unit of competency under the section 'This competency in practice'.
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Licensing/Regulatory Information

Not applicable.

Pre-Requisites

Prerequisite units		
	<i>MSL924001A</i>	<i>Process and interpret data</i>

Employability Skills Information

Employability skills	This unit contains employability skills.
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Elements and Performance Criteria Pre-Content

Elements describe the essential outcomes of a unit of competency.	Performance criteria describe the performance needed to demonstrate achievement of the element. Where bold italicised text is used, further information is detailed in the required skills and knowledge section and the range statement. Assessment of performance is to be consistent with the evidence guide.
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Elements and Performance Criteria

ELEMENT	PERFORMANCE CRITERIA
1. Identify the measured quantity and the uncertainty components	1.1. Specify an equation for the measurement 1.2. List uncertainty components that are associated with each input in the equation
2. Determine the size of each uncertainty component	2.1. Calculate the standard deviations and standard deviation of the mean from the measurement results 2.2. Use calibration reports, manufacturer's specifications, quality control and validation data, and experimental data to collect other available information on the uncertainty components
3. Reduce each uncertainty component to a standard uncertainty	3.1. Allocate an appropriate distribution for each uncertainty component 3.2. Calculate the standard uncertainties
4. Calculate an expanded uncertainty to the required confidence level	4.1. Calculate the sensitivity coefficient for each uncertainty component 4.2. Calculate a combined standard uncertainty 4.3. Determine an appropriate coverage factor based on the degrees of freedom associated with each uncertainty component 4.4. Calculate the expanded uncertainty
5. Report the expanded uncertainty	5.1. Report the result and uncertainty to an appropriate number of significant figures 5.2. Report the confidence level and coverage factor 5.3. Determine the appropriateness of the size of the expanded uncertainty relative to the tolerance or required accuracy of the test 5.4. Determine the fitness for purpose of the expanded uncertainty relative to the use of the measurement result

Required Skills and Knowledge

REQUIRED SKILLS AND KNOWLEDGE

This section describes the skills and knowledge required for this unit.

Required skills

Required skills include:

- gathering information on uncertainty components from calibration reports or reference material report
- making logical assumptions based on experience or experimental data
- calculating sensitivity coefficients either experimentally or by partial differentiation
- calculating a combined standard uncertainty using root-sum-of-squares, accounting for correlations where necessary
- calculating expanded uncertainty
- using spreadsheets to calculate uncertainties
- deciding if the uncertainty is suitable for the accuracy required for the test and establishing whether it is fit for purpose using the tolerance to uncertainty ratio (TUR)

Required knowledge

Required knowledge includes:

- knowledge of the steps in the measurement, test or calibration involved
- evaluation of formulae containing powers, exponents, logarithms functions
- use of scientific notation, correct units and correct number of significant figures
- preparation and interpretation of linear graphs
- mean, standard deviation, standard deviation of the mean and degrees of freedom
- significance tests such as t-test, f-test and analysis of variance (ANOVA), variances, standard deviation of prediction and linear regression (for chemical industry sector)
- the difference between errors, corrections and uncertainties
- uncertainty in the uncertainty estimation process
- uncertainty components that are common to the use of an instrument
- uncertainty components that arise due to the instrument being used under different conditions to those when it was calibrated
- procedures for determining the uncertainty components associated with each of the inputs and whether they are significant and for applying appropriate corrections
- manufacturer's specifications (e.g. instrument drift specification and reference materials)
- procedures for determining uncertainty components from quality control data
- normal, rectangular, triangular distributions and the factors used to reduce each to a standard uncertainty

REQUIRED SKILLS AND KNOWLEDGE

- the concept of degrees of freedom and how to allocate degrees of freedom to each uncertainty component including use of the Welch-Satterthwaite equation
- use of the student's t-table to get a coverage factor for a particular level of confidence
- the characteristics of a valid measurement
- relevant reporting requirements such as the GUM, National Association of Testing Authorities (NATA) or other applicable reference material

Evidence Guide

EVIDENCE GUIDE

The Evidence Guide provides advice on assessment and must be read in conjunction with the performance criteria, required skills and knowledge, range statement and the Assessment Guidelines for the Training Package.

Overview of assessment

Critical aspects for assessment and evidence required to demonstrate competency in this unit

Assessors should ensure that candidates can:

- prepare a realistic uncertainty budget that is appropriate for the application
- fully document the uncertainty budget
- report results and uncertainties in the required formats.

Context of and specific resources for assessment

This unit of competency is to be assessed in the workplace or simulated workplace environment.

This unit of competency may be assessed with:

- *MSL904001A Perform standard calibrations*
- *MSL905001A Perform non-standard calibrations.*

Resources may include:

- data sets and records
- test methods and description of test setup
- computer and relevant software or laboratory information system
- relevant workplace procedures.

Method of assessment

The following assessment methods are suggested:

- review of data worksheets, calculations, computer files (such as spreadsheets and databases), statistical analysis, graphs and/or tables prepared by the candidate
- questions to assess understanding of relevant procedures, trends in data and sources of uncertainty
- review of reports prepared by the candidate
- feedback from supervisors and peers regarding the candidate's ability to estimate uncertainty in accordance with enterprise procedures.

In all cases, practical assessment should be supported by questions to assess underpinning knowledge and those aspects of competency which are difficult to

EVIDENCE GUIDE	
	assess directly. Where applicable, reasonable adjustment must be made to work environments and training situations to accommodate ethnicity, age, gender, demographics and disability. Access must be provided to appropriate learning and/or assessment support when required. The language, literacy and numeracy demands of assessment should not be greater than those required to undertake the unit of competency in a work like environment.
This competency in practice	Industry representatives have provided the case studies below to illustrate the practical application of this unit of competency and to show its relevance in a workplace setting. Manufacturing Production workers in a water meter manufacturing company are required to batch test water meters. Twenty meters are connected together and tested at the same time using a test rig that collects the water in a tank that sits on top of a weighing instrument. The company's production technician needs to ensure that each water meter meets its maximum permissible error and that all measurements have a maximum permissible uncertainty that is below that specified by the regulator. The technician needs to consider the calibration uncertainty of the weighing instrument, any drift in it over time, the resolution of the meters under test and other factors relating to the temperature of the water, its effect on its density and the buoyancy correction for the weighing instrument. There are a number of corrections that need to be applied in order to achieve an uncertainty less than the maximum permissible uncertainty. Production workers enter readings from the meters into a palm-held device. This data is then downloaded to a computer which uses a spreadsheet program to make the required corrections, tabulate the readings, calculate the uncertainties and determine compliance of each meter with the regulations and produce a report. Uncertainty components may change for different models of water meters that have different flowrates, readability and minimum deliveries. To cope with this, the technician's

EVIDENCE GUIDE

spreadsheet program has 'look-up' tables for these components according to the water meter model. Once this system was setup there is no ongoing overhead costs for uncertainty estimation. The calibration uncertainty may have to be updated when the weighing instrument is recalibrated. Estimating uncertainties have highlighted which uncertainty components have the biggest effect on the final uncertainty. This tells the technician which components to focus on and which have little effect.

Chemical

A consulting laboratory analyses beef fat for a meat export company to determine the concentration of the pesticide residue Dieldrin prior to export. The maximum residue limit for Dieldrin in beef fat is 0.2 mg/kg. The technician analyses the sample using a validated gas chromatography (GC) method. To estimate the measurement uncertainty of the analysis he/she needs to take into account such things as the:

- uncertainty from the GC calibration
- uncertainty associated with the reference materials used
- homogeneity of the sample
- calibration of the glassware used for the analysis
- the repeatability
- reproducibility of the method
- uncertainty of the method recovery.

The technician calculates a result and uncertainty of 0.19 ± 0.02 mg/kg. The reported uncertainty suggests to the meat export company that the concentration of Dieldrin in the meat products could be above the residue limit. They can now make informed decisions about whether to sell the meat or not and possibly avoid exporting meat with excessive levels of pesticide residue which could cost the exporter millions of dollars in lost revenue.

Calibration

Technicians in a commercial calibration laboratory routinely calibrate digital multimeters -including 3½ digit hand-held multimeters and high accuracy 6½ digit bench mounted multimeters. From experience, they know that there are some uncertainty components

EVIDENCE GUIDE

common to each calibration such as the:

- uncertainty of the calibration of their reference instrument (a calibrator)
- drift over time of their reference which they establish from its yearly calibrations over the last 5 years
- repeatability of their measured results at each test point from which they calculate a standard deviation of the mean
- resolution of the multimeter being calibrated.

Because of the higher accuracy of the 6½ digit multimeter, the technicians know that for these instruments they must also consider additional uncertainty components such as the input impedance of cables together with thermal and capacitive effects. (These components may be insignificant in terms of the accuracy of a 3½ digit multimeter). The uncertainty estimation and the rigour required relates to the accuracy required. The tolerance in electrical calibrations is typically the manufacturer's specification and the uncertainty needs to be smaller than that so that they can decide whether an instrument is within specification. A 4:1 tolerance to uncertainty ratio (TUR) is typical. The technician's thorough understanding of uncertainty estimation enables the laboratory to optimise their measurement effort to ensure they achieve the 4:1 ratio in an efficient manner. The laboratory has NATA accreditation which lists not only what calibrations they can perform, but their best accuracy ('least uncertainties of measurement'). As part of the process of gaining accreditation they need to submit to NATA for review their uncertainty estimations to justify the uncertainties that appear in their scope of accreditation and which they report on appropriate instruments.

Range Statement

RANGE STATEMENT

The range statement relates to the unit of competency as a whole. It allows for different work environments and situations that may affect performance. Bold italicised wording, if used in the performance criteria, is detailed below. Essential operating conditions that may be present with training and assessment (depending on the work situation, needs of the candidate, accessibility of the item, and local industry and regional contexts) may also be included.

Codes of practice

Where reference is made to industry codes of practice, and/or Australian/international standards, it is expected the latest version will be used

Standards, codes, procedures and/or enterprise requirements

Standards, codes, procedures and/or enterprise requirements may include:

- Australian and international standards, such as:
- AS ISO 1000-1998 The international system of units (SI) and its application
- AS ISO 17025-2005 General requirements for the competence of testing and calibration laboratories
- AS/NZS ISO 10005:2006 Quality management systems - Guidelines for quality plans
- AS/NZS ISO 10012:2004 Measurement management systems - Requirements for measurement processes and measuring equipment
- AS/NZS ISO 9000 Set:2008 Quality management systems set
- ISO 5725 Accuracy (trueness and precision) of measurement methods and results
- ISO/IEC Guide 98-3:2008 Uncertainty of measurement-Part 3 Guide to the expression of uncertainty in measurement (GUM)
- Eurachem/CITAC Guide CG4 Quantifying uncertainty in analytical measurement
- Australian code of good manufacturing practice for medicinal products (GMP)
- enterprise quality manual, customer quality plan
- equipment manuals and warranty, supplier catalogues, handbooks
- Eurolab technical report
- NATA Accreditation programs requirements
- principles of good laboratory practice (GLP)

RANGE STATEMENT	
	• NATA Technical notes • national measurement regulations and guidelines • Nordtest guide • sampling and test procedures and standard operating procedures (SOPs)
Data	Data may: • be recorded on worksheets or entered into spreadsheets or databases linked to information management systems • include the results of tests, measurements and analyses
Calculations	Calculations may be performed with or without a calculator or computer software, such as spreadsheets, databases and statistical packages
Statistical analysis	Statistical analysis may include the use of: • standard deviation, standard deviation of the mean, histograms and frequency plots • probability and normal probability plots • control charts • regression methods for calibration, linearity checks and comparing analytical methods • analysis of variance (ANOVA) • data acceptability tests, such as T and F
Records	• Records may include information associated with: • purchase of equipment and materials and service records • manufacturer's datasheets • calibration reports • history of calibration and test results
Uncertainty components	Uncertainty components may include: • calibration uncertainty • instability or drift in the calibrated instrument • repeatability of the results • resolution or readability of the instrument • environmental influences such as temperature, air pressure, humidity, vibration, electrical noise and gravity • reference material uncertainty

RANGE STATEMENT	
	• factors arising from using an instrument under a different operating environment or procedures (e.g. orientation of a transducer and immersion depth of a temperature probe) • reproducibility of quality control data
Confidence level	• The most common confidence level is 95% in accordance with the National Measurement Act, 1960. However, some applications require a higher level of confidence
Occupational health and safety (OHS) and environmental management requirements	OHS and environmental management requirements: • all operations must comply with enterprise OHS and environmental management requirements, which may be imposed through state/territory or federal legislation - these requirements must not be compromised at any time • all operations assume the potentially hazardous nature of samples and require standard precautions to be applied • where relevant, users should access and apply current industry understanding of infection control issued by the National Health and Medical Research Council (NHMRC) and State and Territory Departments of Health

Unit Sector(s)

Unit sector	Data
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Competency field

Competency field	
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Co-requisite units

Co-requisite units		