Lecture 2

Measurement (2)

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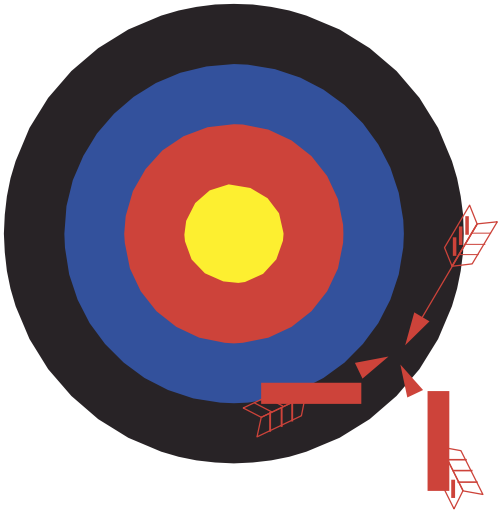
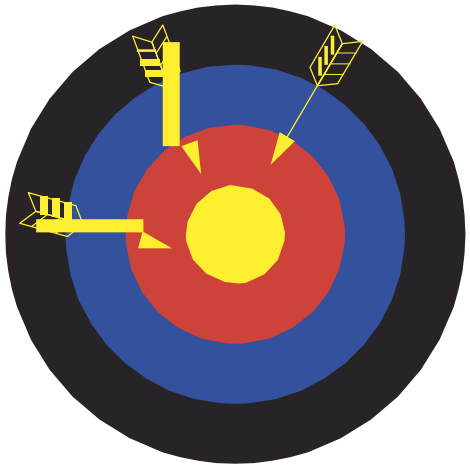
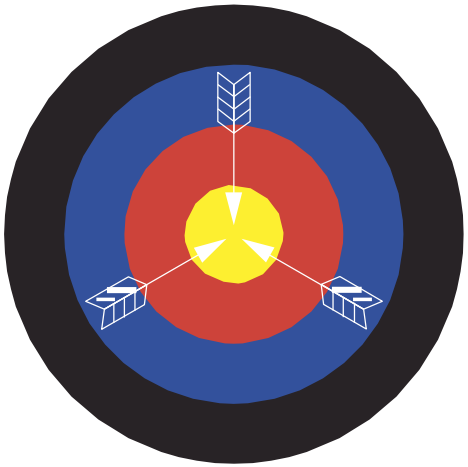
Precision, accuracy and uncertainty



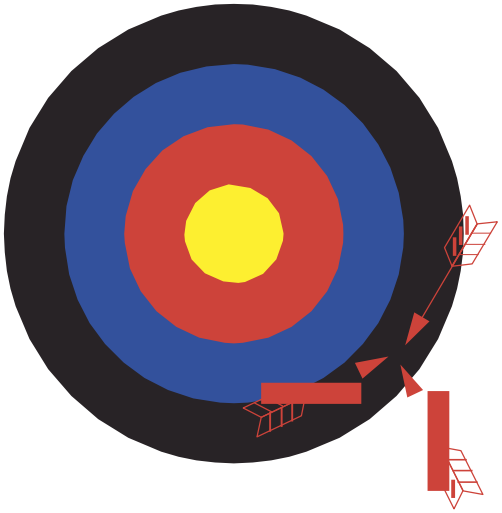




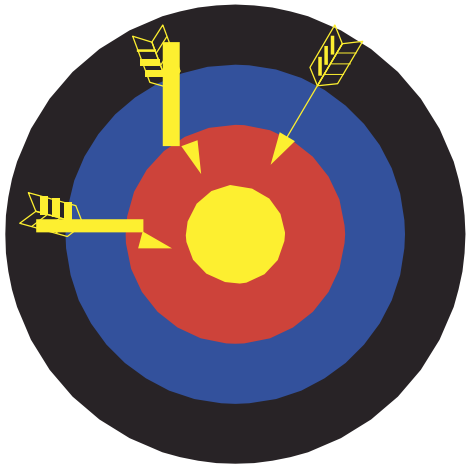
Precision, accuracy and uncertainty

Precision is about how close measurements are to one another.

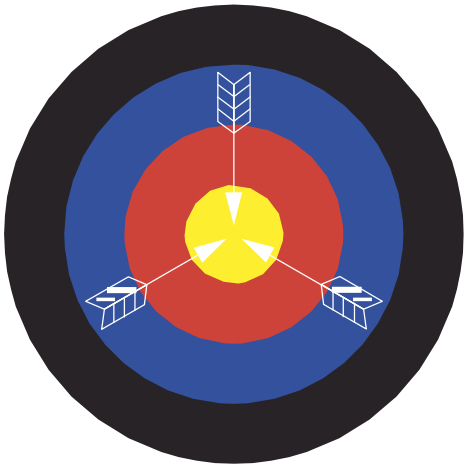
Accuracy is about how close measurements are to the ‘true answer.



Low accuracy, but high precision



Higher accuracy, but low precision



High accuracy and high precision

Precision, accuracy and uncertainty

Accuracy	a qualitative term that describes how close a set of measurements are to the actual (true) value
Precision	describes the spread of these measurements when repeated - a measurement that has high precision has good repeatability
Uncertainty	is the quantification of the doubt about the measurement result and tells us something about its quality
True value	is the value that would be obtained by a theoretically perfect measurement

Precision, accuracy and uncertainty

In practice we are not able to view the target and assess how close to the ‘true answer’ our measurements are. What interests us is the answer to the question "How far from the target could our arrows have fallen?" and we also need to ask "How wrong could we have been?"

Precision, accuracy and uncertainty

Mistakes ⟷ Errors

Precision, accuracy and uncertainty

Error	is the difference between the measured value and the true value of the thing being measured

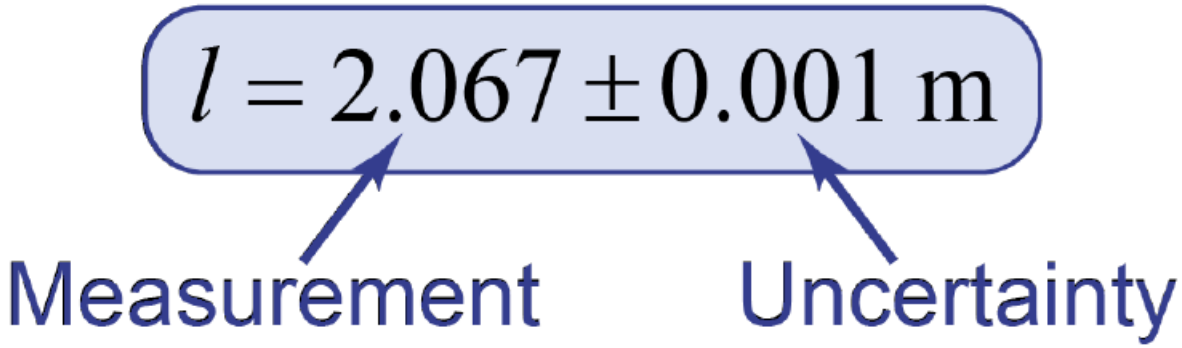
Mistakes ⟷ Errors

‘error’ to specify the difference between an estimate of quantity and its ‘true value’. The word 'error' does not imply that any mistakes have been made.

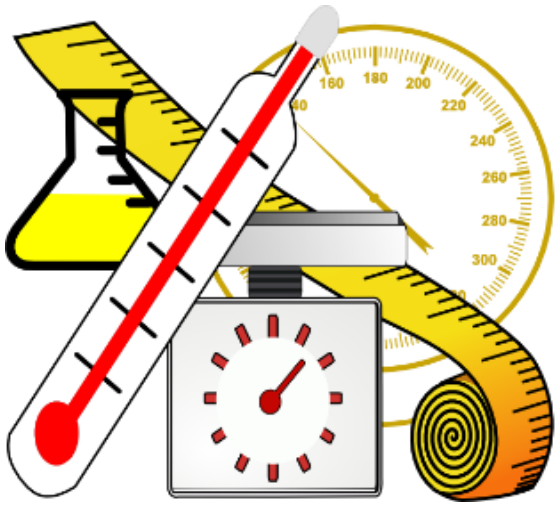
Precision, accuracy and uncertainty

ALL measurements have some uncertainty.

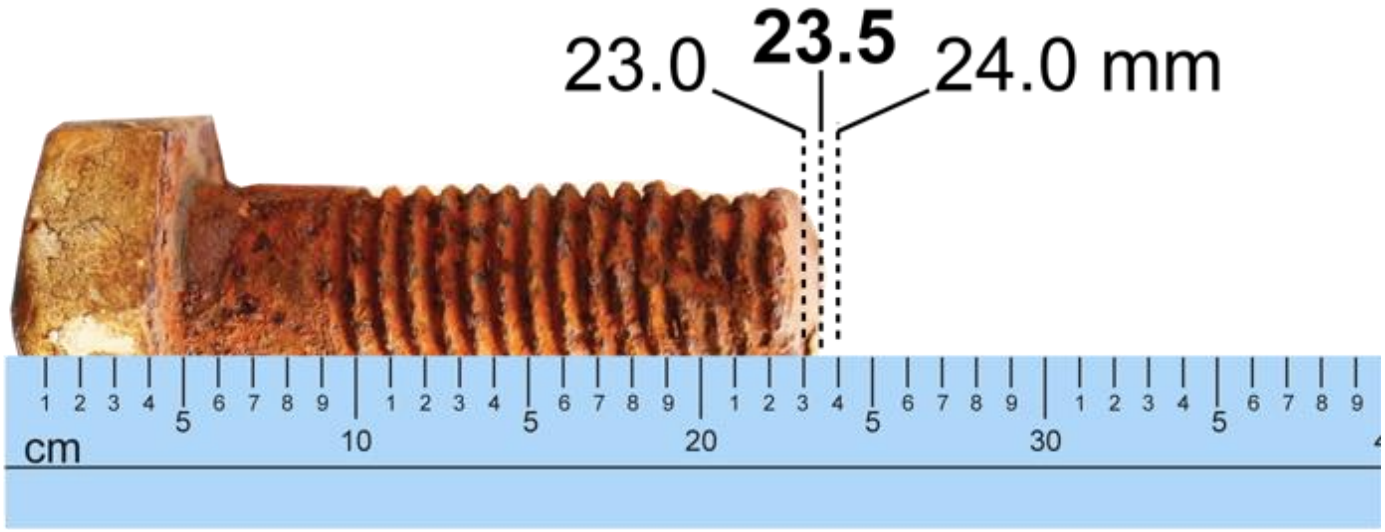
Uncertainty can be expressed in this way:



What affects your measurements?



What affects your measurements?

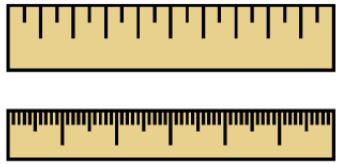


Many factors can reduce accuracy or precision and increase the uncertainty of your measurement result. Some of the most common are:

What affects your measurements?

1- Inferior measuring equipment – equipment which is poorly maintained, damaged or not calibrated will give less reliable results.

The measuring system might be inadequate.

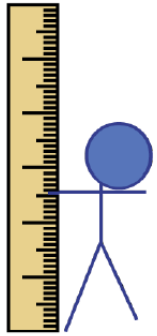


Example: a ruler with gradations that are too large

What affects your measurements?

2- Poor measuring techniques – having consistent procedures for your measurements is vital.

The measuring procedure might have shortcomings.

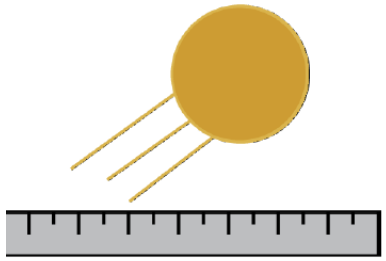


Example: trying to measure a wiggling child

What affects your measurements?

3- Environmental conditions – changes in temperature or humidity can expand and contract materials as well as affect the performance of measurement equipment.

The environment causes problems.



Example: a ruler that heats up and expands

What affects your measurements?

4- Inadequate staff training – not knowing how to make the right measurement, not having the confidence to challenge the results and not being willing to seek advice can all have a negative impact.

The operator could make an error.

Example: due to poor eyesight or lack of skill

Golden Rule

Measure twice and cut once.

Repeatability, Reproducibility

Repeatability	is the closeness of agreement between repeated measurements of the same thing, carried out in the same place, by the same person, on the same equipment, in the same way, at similar times
Reproducibility	is the closeness of agreement between measurements of the same thing carried out in different circumstances, e.g. by a different person, or a different method, or at a different time
Tolerance	is the maximum acceptable difference between the actual value of a quantity and the value specified for it

Traceability and calibration

When we talk about traceability of measurements, we mean that the measurements can be related to a national standard through a documented unbroken chain of calibrations.

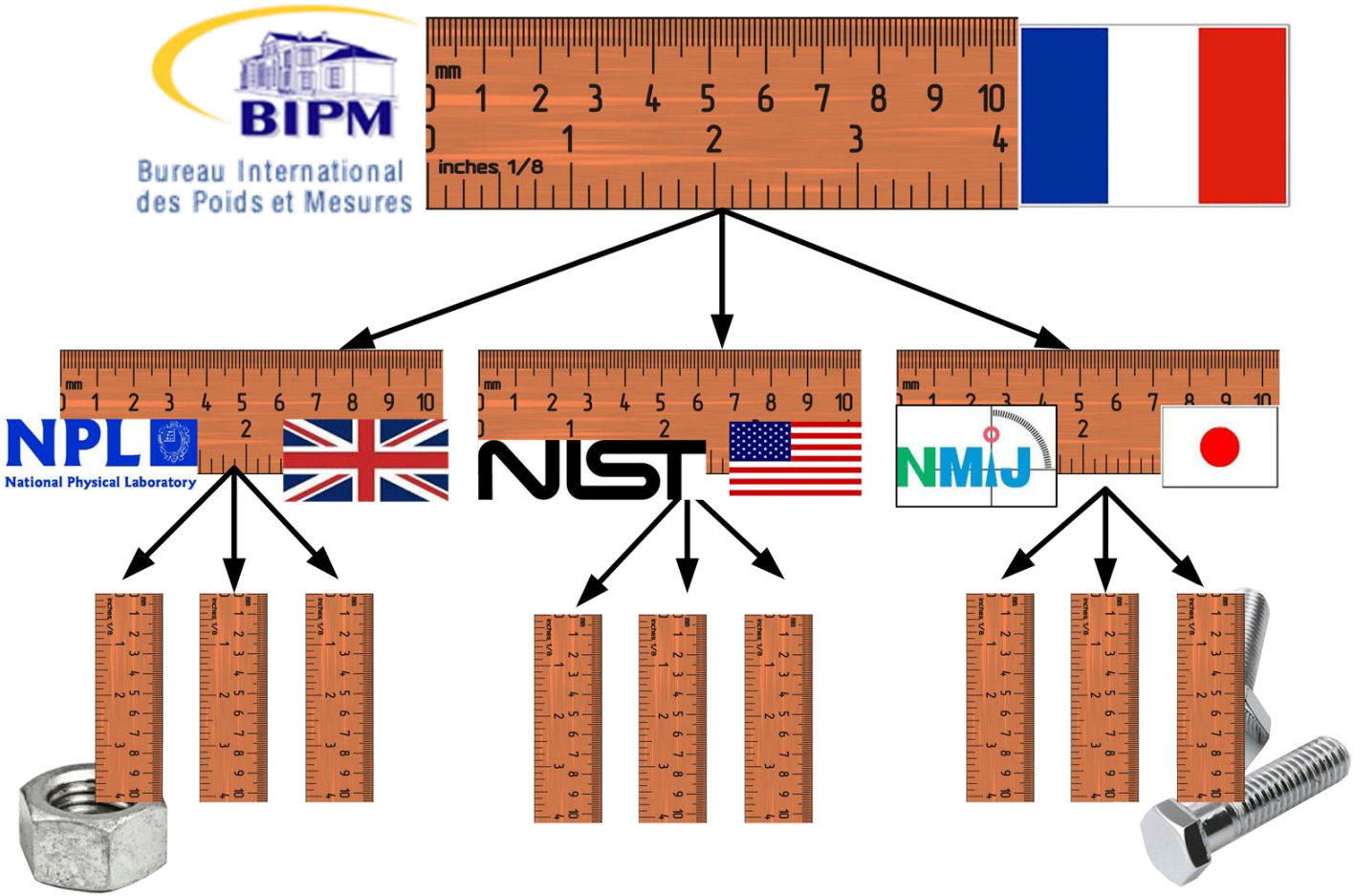
Traceability and calibration

Six of the SI definitions are the procedures needed to 'realise' literally, to make real – the standard or a close approximation of it. This applies to the second, metre, kelvin, ampere, candela and mole.

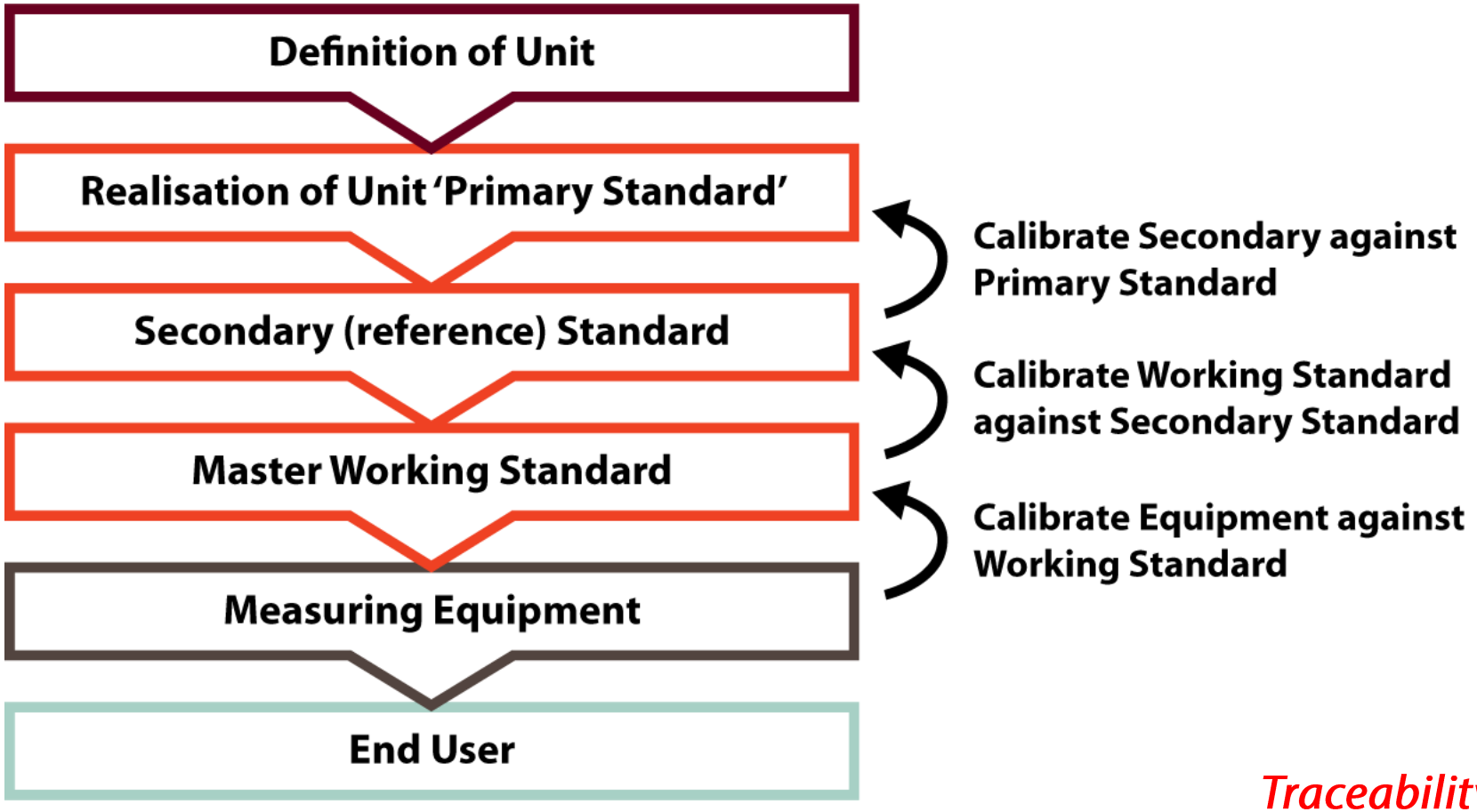
The seventh base unit – the kilogram – is not based on a procedure, but instead on a single physical artefact, a cylinder made up of platinum and iridium metals, which is kept in a safe in the International Bureau of Weights and Measures (BIPM), on the outskirts of Paris, France.

Bureau International des Poids et Mesures

Traceability and calibration

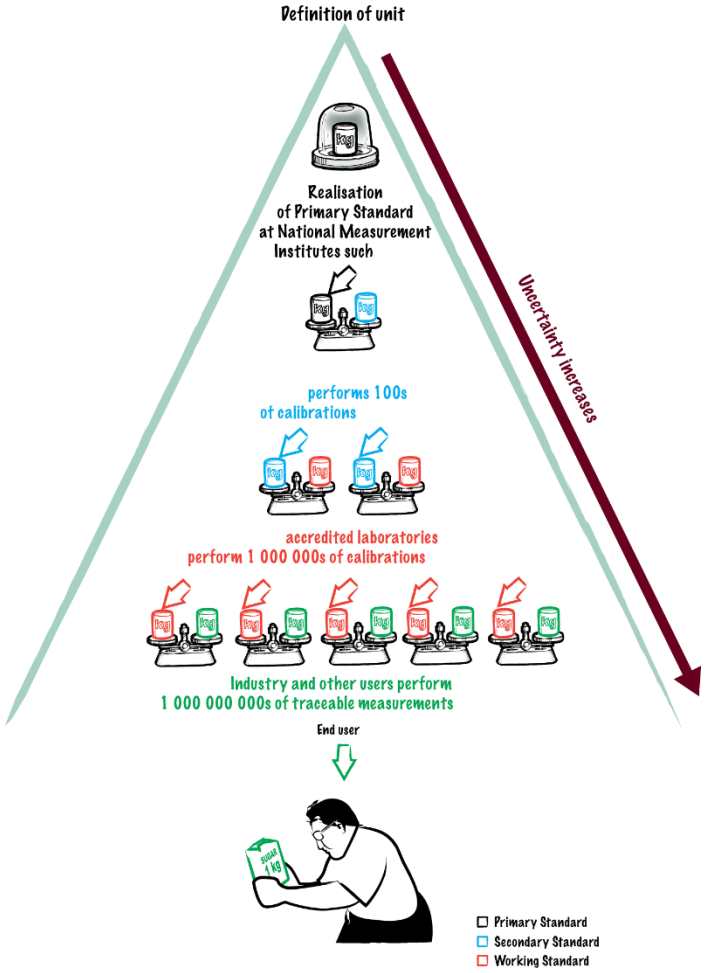


Traceability and calibration



Traceability Chain

Traceability and calibration



Traceability Chain

Traceability and calibration

Calibration	is the comparison of a test instrument or artefact against a more accurate standard
Measurement traceability	refers to the unbroken chain of calibrations linking an instrument or standard to primary standards
Accreditation	means that a calibration laboratory in a specific field has been independently assessed and audited to show that it is competent to carry out specific tests and calibrations in that field.

Traceability and calibration

The internationally agreed procedures that describe how a laboratory should carry out accurate measurements on specific items are called 'International Standards', and the International Organization for Standardization (ISO), based in Geneva, Switzerland, is responsible for publishing and revising them. National standardization bodies such as BSI (British Standards Institution) participate in the preparation of international standards and also prepare standards which address national measurement needs not covered by ISO standards.

ISO 17025, 'General requirements for the competence of testing and calibration laboratories' is the standard that specifies how the national standardization bodies accredit calibration laboratories.

Standards Bodies

American Society for Testing and Materials

American Society for Testing and Material
ASTM

International Organization for Standardization

International Standard Organization
ISO

The American Society for Nondestructive Testing

American Society for Non-Destructive Testing
ASNT

Standards Bodies

German Industrial standard
DIN

American Society Mechanical Engineers
ASME

Institut Marocain de Normalisation
IMANOR

Syrian Arab standards and metrology organization
SASMO

Standards Bodies

International Institute of Welding
IIW

EUROPEAN NORM
EN
European Norm
EN

afnor NORMALISATION
Association Française de Normalisation
AFNOR

BSI British Standards
British Standards
BSI