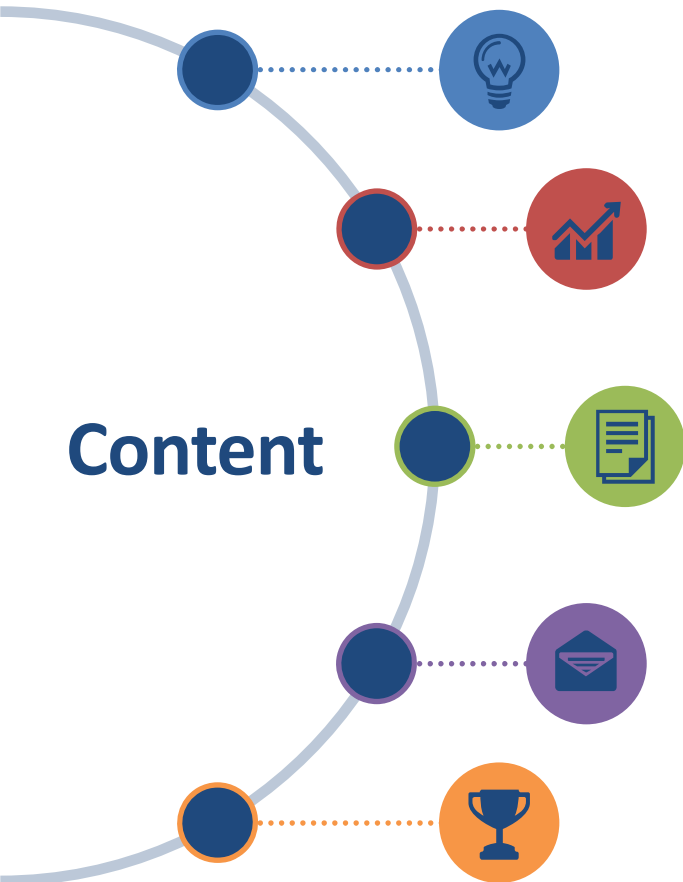




# Laboratory related knowledge

Jing Wang

# Content



Content

Conformity assessment

Product quality Testing/Inspection

Standard and standardization

Traceability

Measurement uncertainty

# Conformity assessment

- **“Conformity assessment procedures:** Any procedure used, directly or indirectly, to determine that relevant requirements in technical regulations or standards are fulfilled. (Annex 1 of TBT Agreement)”
- **Conformity assessment:** Any activity concerned with determining directly or indirectly that relevant requirements are fulfilled. (12.2, ISO/IEC Guide 2)

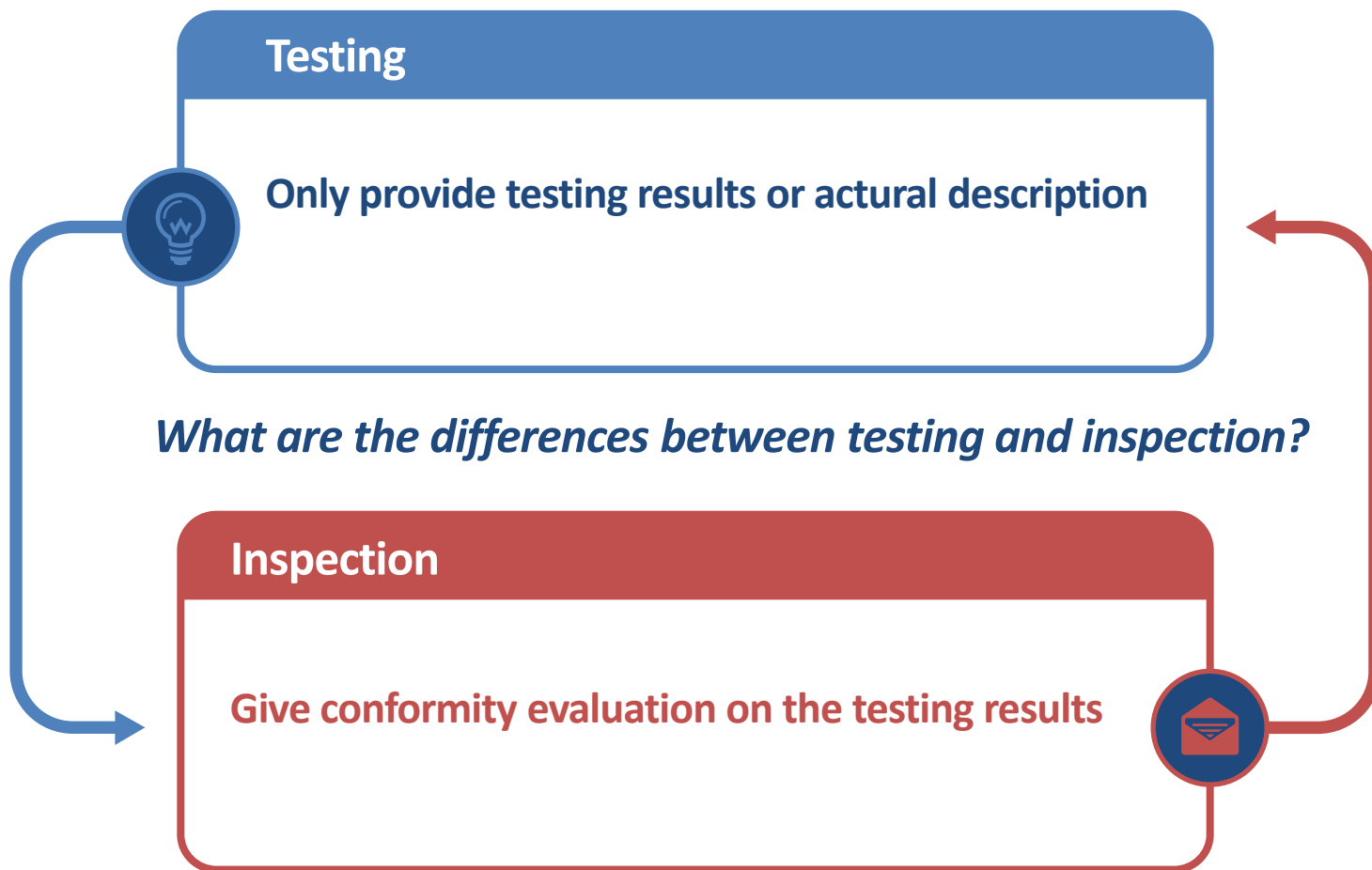
# Conformity assessment

- Conformity assessment procedures include, *inter alia*, procedures for sampling, testing and inspection; evaluation, verification and assurance of conformity; registration, accreditation and approval as well as their combinations. (Footnote 2 of Annex 1, TBT Agreement)
- Conformity assessment is the procedure that WTO uses to evaluate the products and services all over the world.

# Product quality Testing/Inspection

- **Test:** Technical operation that consists of the determination of one or more characteristics of a given product, process or service according to a specified procedure. (13.1, ISO/IEC Guide 2)
- **Testing:** Action of carrying out one or more **tests**. (13.1.1, ISO/IEC Guide 2)
- **Inspection:** Conformity evaluation by observation and judgment accompanied as appropriate by measurement, testing or gauging. (14.2, ISO/IEC Guide 2)

# Product quality Testing/Inspection



# Product quality Testing/Inspection

- The functions of product quality testing/inspection
  - The identification function

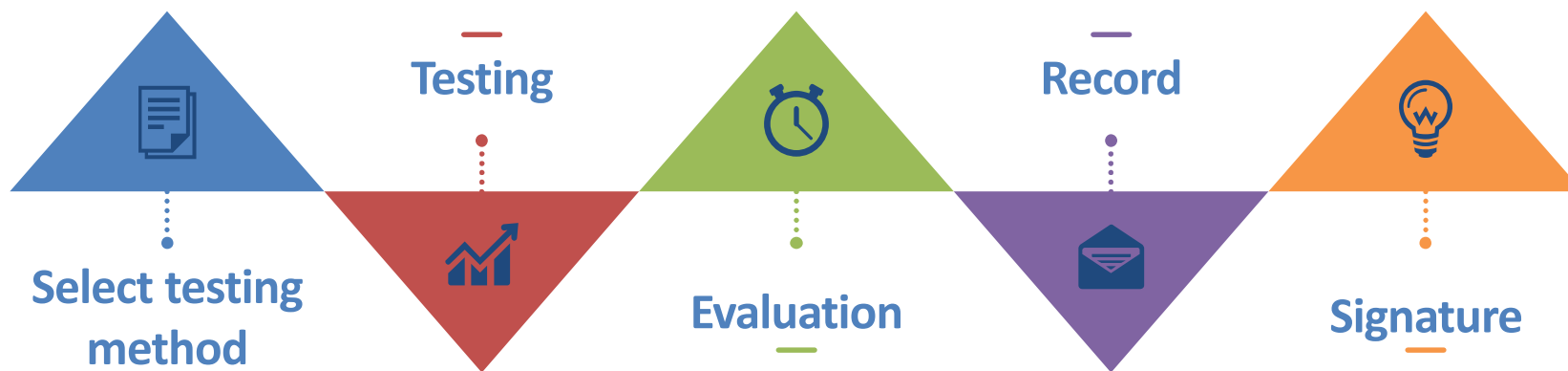
*Determine whether the product quality meets the specified quality characteristics*
  - Check function

*Remove the unqualified products and to be isolated, so that it does not put into production*
  - Decision-making function

*Summarize, collate, analyze and verify the data and information obtained for quality control, quality improvement and provide the proves for quality decision-making*

# Business Mission

- Five steps of product quality testing/inspection.



*Understand the technical requirements*

# Product quality Testing/Inspection

- **Product arbitration inspection:** Commissioned by customer, the product quality inspection agency conducts the specific test on the quality questioned product
  - The purpose of arbitration test is to judge the quality of the product. The object is the product, the result is to issue the inspection report to determine the quality and as a product quality arbitration evidence.
  - Evaluation based on:
    - Laws, regulations or national mandatory standard requirements
    - The standards or relevant quality requirements agreed by the parties
    - The quality requirements specified clearly by the product provider

# Product quality Testing/Inspection

- Sampling inspection: Use the extracted samples to carry out the inspection of the product or process
  - Sampling inspection is in accordance with the provisions of the sampling program, randomly selects part of the products from one batch, for testing. The test results will be compared with the evaluation criteria defined in the sampling program, in order to decide whether the batch of products are qualified

# Standard and standardization

- Standard is the essential basis for all testing and inspection work. A document that obtains the best order within a certain range and provides for a common, reusable rule, guideline, or characteristic of the activity or its results is called a standard.
- The document must be agreed upon and approved by a recognized body, and the development and application of the standards have been carried out in all areas of production and work, particularly in the area of quality inspection.
- Standardization helps to solve problems such as quality, safety, reliability and interchangeability in product exchange. The degree of standardization directly affects the formation and elimination of barriers in trade.

# Standard and standardization

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- By level
  - International standards
  - Regional standards
  - National standards
  - Consortium standards
  - Industry Standards
  - Local standards
  - Enterprise standards

# Standard and standardization

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- By subject of standardization
  - Technical standards
  - Management standards
  - Working standards

# Standard and standardization

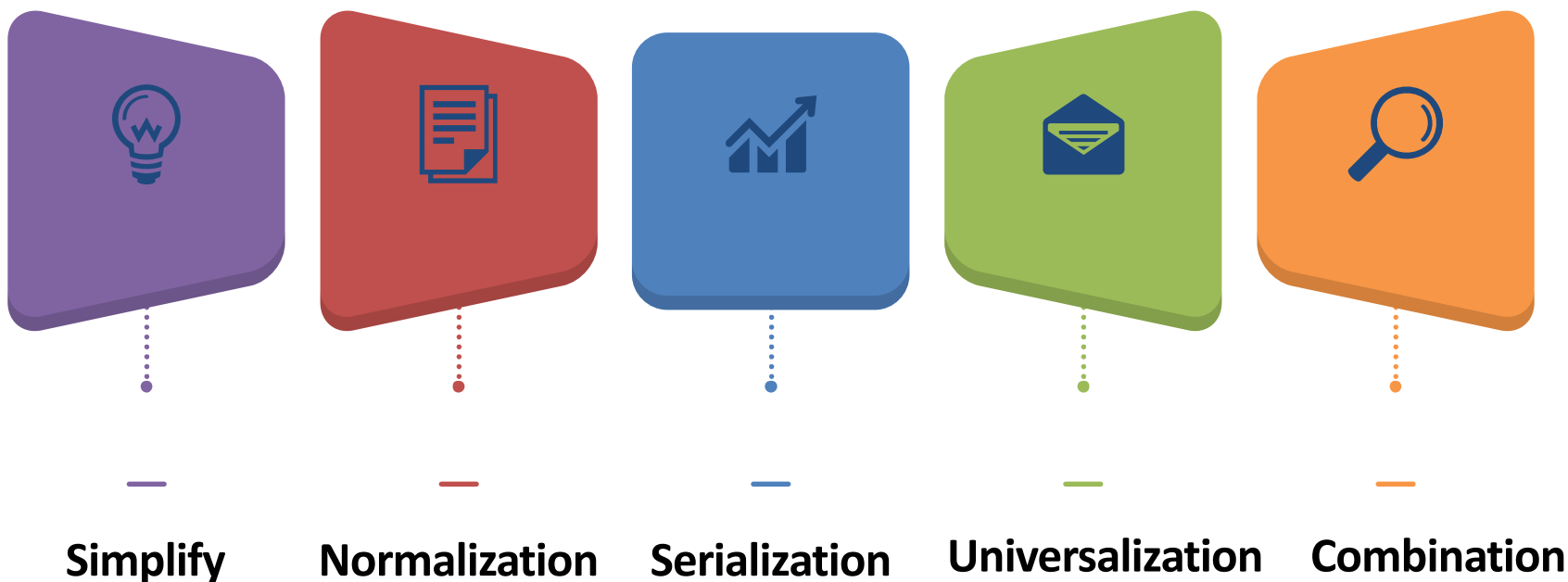
- **Technical standard:** standards made for technology items that are need to be unified, including fundamental technology standards, products standards, test method standard, workman standard, safety, sanitary and environment protection standards.
- **Management standard:** standards made for management items that are need to be unified, including fundamental management standards, technology management standards, economy management standard, administration standard.
- **Working standard:** standards made for responsibility, right, range, quality requirement, procedure, effect, examination methods, evaluation methods. Working standards for department and individual are included.

# Standard and standardization

- By character of standard
  - **Mandatory standards**
  - **Voluntary standards**
  - **Directives**
- Standards concerning protection of human health, personal property and safety and those enforced by laws and administrative regulations are **mandatory standards**, others are **voluntary standards**.  
**Directives:** Documents providing information for standardization which is related to rapid developing technology and providing reference for scientific research, design, manufacture and the management person.

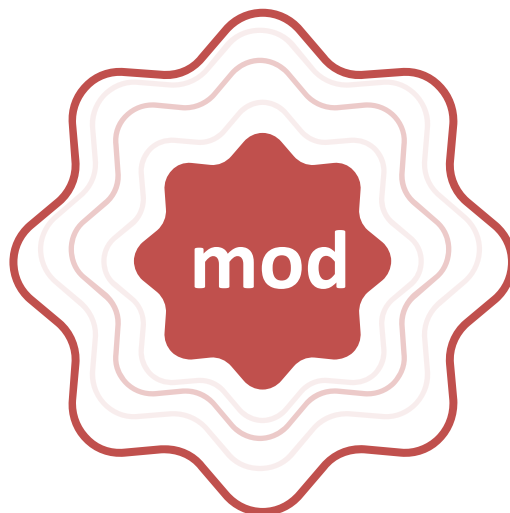
# Standard and standardization

- Standardization form



# Standard and standardization

- Adopting international standards

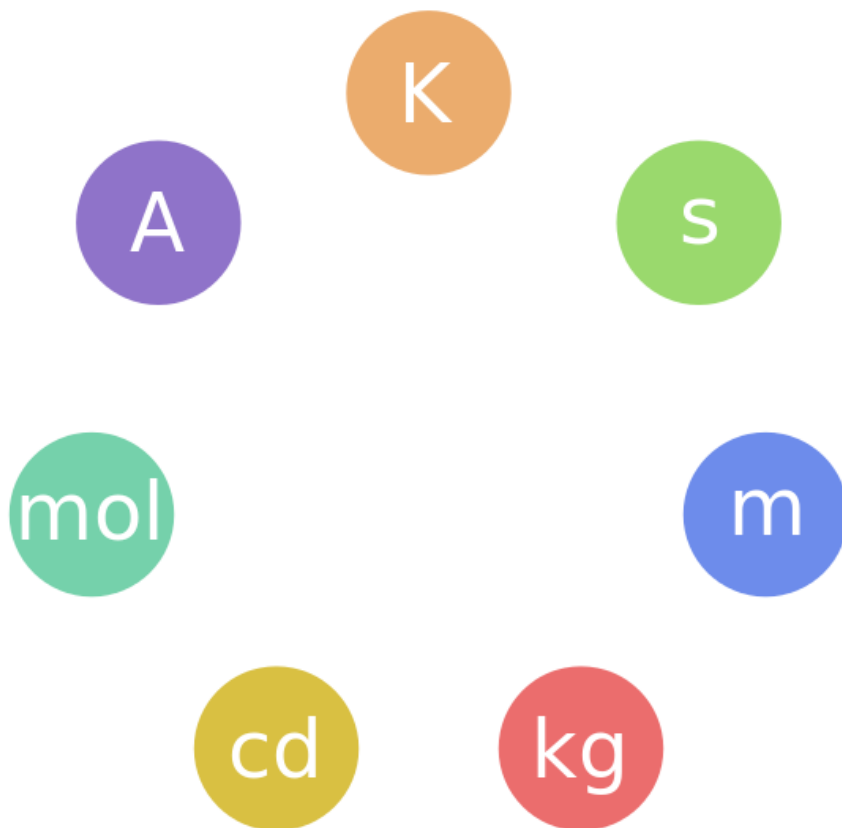


# Standard and standardization

- When adopting non-standard testing method
  - Methods verification
  - Agreed by the customers
  - When the customer does not specify the method, it shall select appropriate methods that have been published either in international/regional/national standards, or by reputable technical organizations, or in relevant scientific texts or journals, or as specified by the manufacturer of the equipments.
  - The laboratory shall inform the customer when the method proposed by the customer is considered to be inappropriate or out of date.

# Traceability

- International system of Unit - SI



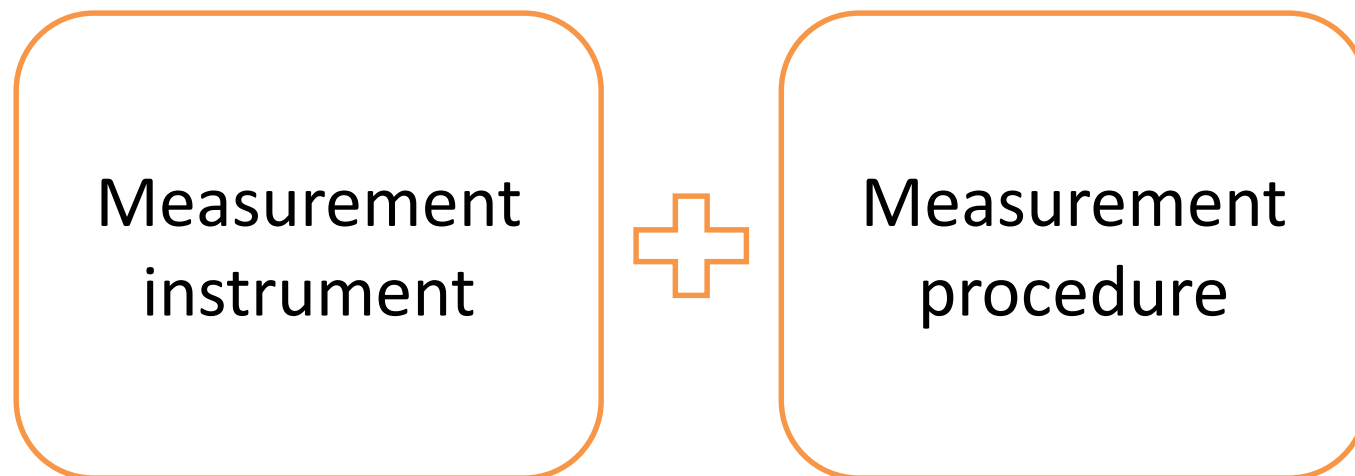
The SI base units

## Named units derived from SI base units

Name	Symbol	Quantity	Expressed in terms of other SI units	Expressed in terms of SI base units
<b>radian</b>	rad	angle		$\text{m}\cdot\text{m}^{-1}$
<b>steradian</b>	sr	solid angle		$\text{m}^2\cdot\text{m}^{-2}$
<b>hertz</b>	Hz	Frequency		$\text{s}^{-1}$
<b>newton</b>	N	force, weight		$\text{kg}\cdot\text{m}\cdot\text{s}^{-2}$
<b>pascal</b>	Pa	pressure, stress	$\text{N}/\text{m}^2$	$\text{kg}\cdot\text{m}^{-1}\cdot\text{s}^{-2}$
<b>joule</b>	J	energy, work, heat	$\text{N}\cdot\text{m}$	$\text{kg}\cdot\text{m}^2\cdot\text{s}^{-2}$
<b>watt</b>	W	power, radiant flux	$\text{J}/\text{s}$	$\text{kg}\cdot\text{m}^2\cdot\text{s}^{-3}$
<b>Coulomb</b>	C	electric charge or quantity of electricity		$\text{s}\cdot\text{A}$
<b>Volt</b>	V	voltage (electrical potential difference), electromotive force	$\text{W}/\text{A}$	$\text{kg}\cdot\text{m}^2\cdot\text{s}^{-3}\cdot\text{A}^{-1}$
<b>Farad</b>	F	capacitance	$\text{C}/\text{V}$	$\text{kg}^{-1}\cdot\text{m}^{-2}\cdot\text{s}^4\cdot\text{A}^2$
<b>Ohm</b>	$\Omega$	electric resistance, impedance, reactance	$\text{V}/\text{A}$	$\text{kg}\cdot\text{m}^2\cdot\text{s}^{-3}\cdot\text{A}^{-2}$
<b>Siemens</b>	S	electrical conductance	$\text{A}/\text{V}$	$\text{kg}^{-1}\cdot\text{m}^{-2}\cdot\text{s}^3\cdot\text{A}^2$
<b>Weber</b>	Wb	magnetic flux	$\text{V}\cdot\text{s}$	$\text{kg}\cdot\text{m}^2\cdot\text{s}^{-2}\cdot\text{A}^{-1}$
<b>Tesla</b>	T	magnetic flux density	$\text{Wb}/\text{m}^2$	$\text{kg}\cdot\text{s}^{-2}\cdot\text{A}^{-1}$
<b>Henry</b>	H	inductance	$\text{Wb}/\text{A}$	$\text{kg}\cdot\text{m}^2\cdot\text{s}^{-2}\cdot\text{A}^{-2}$
<b>degree Celsius</b>	$^{\circ}\text{C}$	temperature relative to 273.15 K		K
<b>lumen</b>	lm	luminous flux	$\text{cd}\cdot\text{sr}$	cd
<b>lux</b>	lx	illuminance	$\text{lm}/\text{m}^2$	$\text{m}^{-2}\cdot\text{cd}$
<b>becquerel</b>	Bq	radioactivity (decays per unit time)		$\text{s}^{-1}$
<b>gray</b>	Gy	absorbed dose (of ionizing radiation)	$\text{J}/\text{kg}$	$\text{m}^2\cdot\text{s}^{-2}$
<b>sievert</b>	Sv	equivalent dose (of ionizing radiation)	$\text{J}/\text{kg}$	$\text{m}^2\cdot\text{s}^{-2}$
<b>katal</b>	kat	catalytic activity		$\text{mol}\cdot\text{s}^{-1}$

# Traceability

**Measurements** are defined as a set of operations for the purpose of determining the magnitude.



# Traceability

- **Traceability:** The ability to correlate a measurement result or a metrological standard with a specified reference standard (usually a national measurement basis or an international measurement basis) through an uninterrupted comparison chain with defined uncertainty
- In the laboratory accreditation, traceability reflects a character of the measurement results and the values of metrological standard, that is, any measurement results and the values of metrological standard, ultimately must be linked to national or international measurement criteria, to ensure that the unit of measurement is unified, and the value of measurement standards are accurate and reliable, so that the measurement results are comparable, repeatable and reproducible , and the way is to follow this comparison chain, trace back to the metrological standard

# Traceability

- **Object:** All measuring instruments and equipments (including support equipments), and standard materials that affect the accuracy or effectiveness of the test results.
- **Purpose:** To ensure the accuracy and consistency of the measurement results. This is the basis of the credibility of the measurement results, but also the premise of the international mutual recognition of measurement results.
- **Approach:** Send the objects to the qualified, capable body, which can also provide traceability for verifying and calibration. The qualification refers to the statutory metrological authority, the authorized metrological authority, the accredited calibration laboratory. The measurement capability refers to their measurement uncertainty meets the requirements.

# Traceability

- **Evidence of traceability:** Calibration Certificate, etc.
- How the laboratory selects the appropriate metrological or calibration laboratory?
  - a) **Reference standard** - a statutory metrological authority or an accredited calibration laboratory
  - b) **Measuring instruments** - a statutory metrological authority or accredited calibration laboratory, or authorized industry metrological institution
  - c) **Reference materials** - traceable to SI unit or certified reference materials
  - d) **In exceptional circumstances** – traceable to recognized standards or participating the inter-laboratory comparison test or proficiency test
  - e) **International laboratory**
    - ✓ Traceable to the highest metrology basis of a country or economy who signed the MRA and can show evidence to trace to SI units
    - ✓ The calibration laboratory that recognized by the members of APLAC, ILAC Multilateral Accreditation Agreement

# Traceability

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- What are the differences between Metrological Verification and Calibration?

# Traceability

Metrological Verification	Calibration
Metrological verification procedures	Calibration procedures or calibration methods
Fully assess the metrological characteristics of measuring instruments and compliance with technical requirements	Determine the indication error or assignment of the measuring instruments
Give the conclusion of pass or failed	Only provide the calibration data (when necessary, determine whether to meet the expected requirements)
If pass, issue the Metrological Verification Certificate If failed, issue a notice of failure	Issue Calibration Certificate
Specify the Metrological verification period	Not specified
With legal, administrative and law enforcement	Voluntary actions

# Measurement uncertainty

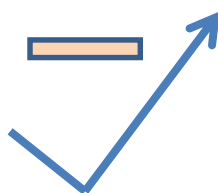
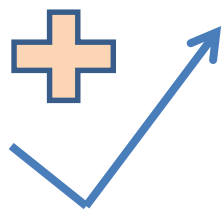
- Measurement uncertainty is a degree of doubt about the measurement results

For example:

$37.2\text{ }^{\circ}\text{C} \pm 0.1\text{ }^{\circ}\text{C}$  (95%)

# Measurement uncertainty

- **Error:** The difference between the measured result and true value



# Measurement uncertainty

- **Random error:** The difference between measurement results and the mean (average) of the results obtained by infinitely measurements on the same object and under repeated conditions
- **System error:** The difference between the mean (average) of the results obtained by infinitely measurements on the same object under repeated conditions, and the true value.

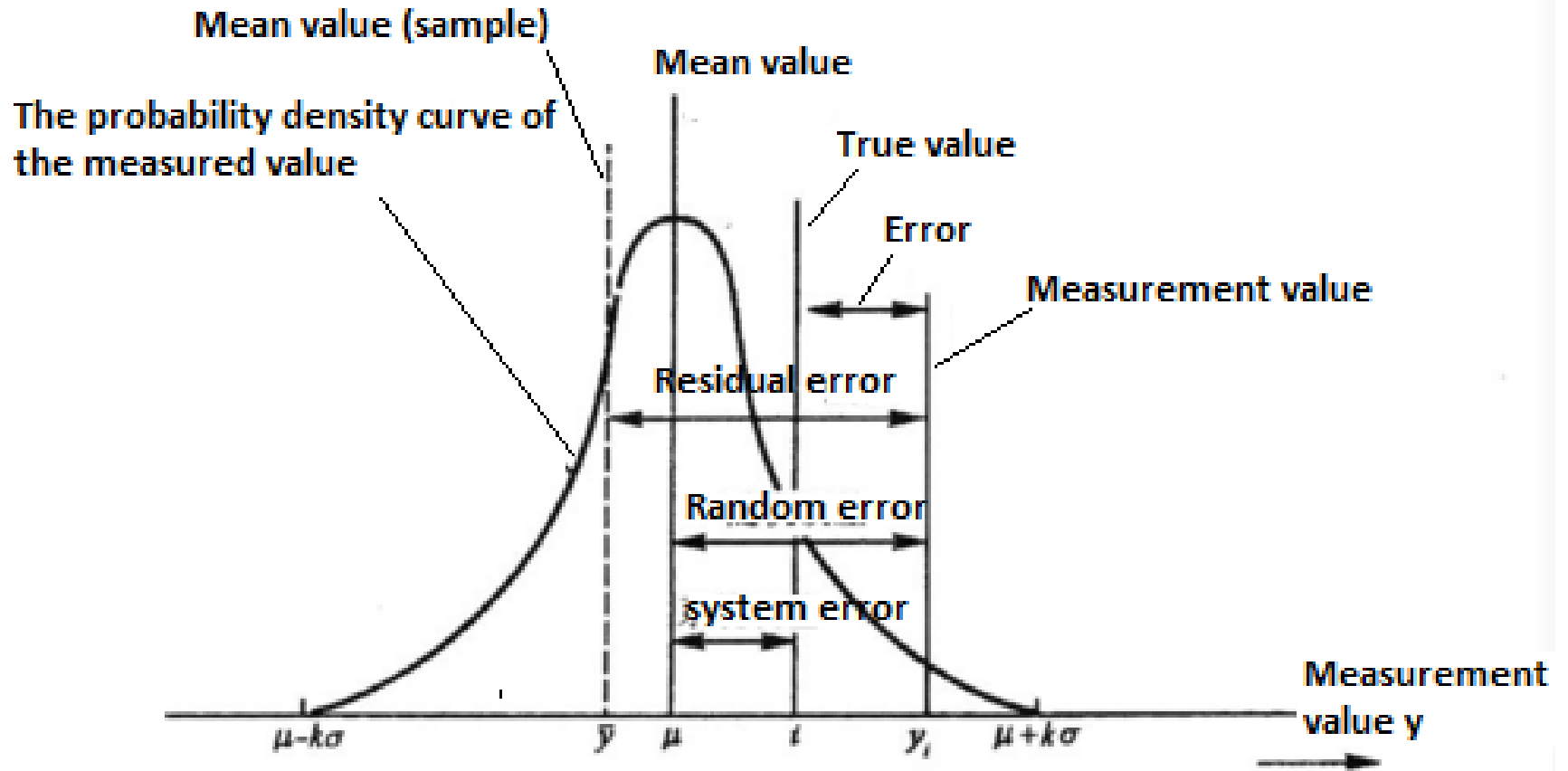
# Measurement uncertainty

$$\begin{aligned}\text{Error} &= \text{Measurement results} - \text{true value} \\ &= \text{Measurement results} - \text{mean value} + \text{mean} \\ &\quad \text{value} - \text{true value} \\ &= \text{Random error} + \text{system error}\end{aligned}$$

Measurement results

$$\begin{aligned}&= \text{True value} + \text{error} \\ &= \text{True value} + \text{random error} + \text{system error}\end{aligned}$$

# Measurement uncertainty



Measurement error diagram

# Measurement uncertainty

- Uncertainty of the measurement results:  
Characterize the dispersion of the measured value reasonably, the parameters associated with the measurement results.
- The measurement uncertainty can be expressed by the standard deviation, or its multiple, or the half width of the confidence level interval

$$U = k\sigma = ku \quad (k: \text{coverage factor})$$

# Measurement uncertainty

- A type of Uncertainty: refers to evaluating the uncertainty by statistical analysis; the standard uncertainty is expressed by standard deviation.
- B type of Uncertainty: refers to evaluating the uncertainty by other methods;

# Measurement uncertainty

## The main differences between Error and Uncertainty

No	Content	Error	Uncertainty
1	Definition	Indicating that the measurement result deviates from the true value and is a definite value	Indicating the dispersion of the measured value and is an interval. Expressed by a standard deviation, a multiple of the standard deviation, or a half width of the confidence level interval
2	Classification	According to the laws appear in the measurement results, divided into random errors and system errors, they are the ideal concept of the infinite measurements	According to whether obtained by the statistical method, divided into A class and B class, they are expressed by standard uncertainty.
3	Operability	Since the true value is unknown, the value of the measurement error can not always be obtained.	Measurement uncertainty can be evaluated by information such as experiment, data, experience, etc., so that the measurement uncertainty can be quantitatively determined
4	Numerical symbol	Either positive or negative (or zero) , can not be indicated by a sign $\pm$	Is an unsigned parameter, always expressed as a positive value; When obtained by variance, use the positive square root

# Measurement uncertainty

## The main differences between Error and Uncertainty

No	Content	Error	Uncertainty
5	Correction	When the estimated system error is known, the measurement result can be corrected	The measurement results can not be corrected with measurement uncertainty. When calculate the uncertainty, it should consider the imperfect correction introduced to the uncertainty component
6	Results	Error is exist. The error belongs to a given measurement result and has no relationship with the instrument or method	Uncertainty is related to people's knowledge and understanding on the object under measurement, the influences, and the measurement process. It is reasonably given to any of the measured values, all have the same measurement uncertainty

# Measurement uncertainty

- Measure the length

Steel rulers      10.0mm

Caliper            10.00mm

Which error is smaller?

What about the uncertainty?

# Measurement uncertainty

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Both error and uncertainty can be used to describe the measurement results, but there is no definite relationship in between.

# Measurement uncertainty

- The performance of the measuring instrument can be expressed by the indication error and the maximum allowable error.
- The different instruments, even with the same model number, their indication error is generally different. The indication error must be obtained by verification or calibration. Each instrument needs to be verified or calibrated.
- If knowing the indication error, you can correct the measurement results, the inverse sign of indication error is the correction. The uncertainty of the corrected value is related to the uncertainty of the measured value.
- The maximum allowable error is the permissible error limit for a given measuring instrument, specification, procedure, etc. The maximum allowable error is abbreviated as MPE or mpe, which is specified by the manufacturer of the instrument. Obviously, it is not the actual error of an instrument, and therefore can not be used for correction.
- The MPE can be obtained from the instrument manual, and its value is usually signed as  $\pm$  and can be expressed in absolute error, relative error, reference error, or their combination
- MPE itself is not a measurement uncertainty, it gives the qualified interval of indication error, which can be used for calculating the uncertainty. When the indication value is used directly as the measurement result, the standard uncertainty component introduced by the instrument can be obtained use MPE and according to the B type method.

# Measurement uncertainty

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For example:

$\pm 0.1 \mu\text{V}$ ,

$\pm 0.1 \mu\text{m}$ ,

$\pm 0.1\%$ ,

# Measurement uncertainty

- Uncertainty is a parameter associated with the measurement result, that is to say that only the measurement results have uncertainty.
- "measurement instrument uncertainty"?
- If the measuring instrument has been calibrated, then we sometimes call the uncertainty introduced by the instrument's indication error from the calibration as the instrument's uncertainty

*Thank you!*





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