White paper

Why metrology matters

Simply put, metrology is the science of measurement and its application. It includes all theoretical and practical aspects of measurement, at any level of uncertainty in any field of application. We all use metrology dozens of times a week. If you have measured cream in your coffee or used an alarm clock or pumped gas into your car, you applied metrology principles. Metrology deals with making accurate, repeatable measurements with a known level of uncertainty.

History

The measurements we take for granted today started as far back as 3000 BC in ancient Egypt with the use of the Royal Cubit which was the length of the pharaoh's arm from bent elbow to the tip of his middle finger. A master cubit was crafted in granite and subsequent tools created from the master cubit. As you can imagine, this wasn't a sustainable measurement system. Which pharaoh created the tool? Did succeeding pharaoh's change the measurement unit to match their forearms? Did measurement confusion reign with each new pharaoh?

Fast forward a couple of thousand years when seventeen nations met in Paris in 1875 for the Metre Convention (Convention du Mètre), to establish a permanent organizational structure to act in common accord on all matters relating to units of measurement. The Treaty of 1875 has some 58 government signatories today. The treaty established three essential organizations:

CGPM—General Conference on Weights and Measures: The main decision-making body composed of member states

CIPM—International Committee for Weights and Measures: Advises the CGPM on technical matters of metrology

BIPM—International Bureau of Weights and Measures: Operates under the CGPM and CIPM and maintains the SI—International System of Units

International System of Units—SI

In the United States of America, there are two measurement systems in use: the U. S. Customary System and the International System of Units, known as the SI. The U.S. Customary System is used in mainly commercial and personal activities (inch, ounce, cup, etc.), while the SI is used in science, medicine, industry sectors and some areas of government. The SI is used by most countries exclusively; indeed it is the foundation of our worldwide measurement system. The SI has seven base units as defined in the chart below.

Base quantity	SI base unit	SI symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Thermodynamic temperature	Kelvin	K
Amount of substance	Mole	mol
Luminous intensity	Candela	cd

As an evolving system, the SI is updated and improved as technology permits. For example, up until 1960, the base unit meter was based on a platinum-iridium prototype rod cast in 1889. Now, it is defined as a constant of nature—the distance light travels in a vacuum during one period of radiation, corresponding to the transition between two hyperfine levels of the ground state of the cesium-133 atom. This defines the meter as the distance light travels in 1/299 792 458th of a second.

Effective May 20, 2019, the CGPM passed a resolution redefining the kilogram based on a constant of nature, the Planck constant, which would remove the risk of referencing a single, delicate artifact.

Redefining the kilogram will have repercussions-especially for derived units. Derived units are quantities we are all familiar with, use daily and, are made up of products and powers of SI units.

Looking at the last column in the chart below, one can appreciate how redefining the kilogram, or any base unit for that matter, can have a ripple effect throughout the SI.

Derived quantity	Name	Symbol	SI base unit
Area	Square meter	m^2	m^2
Volume	Cubic meter	m^3	m^3
Velocity	Meter per second	m/s	$m \cdot s^{-1}$
Force	Newton	N	$m \cdot kg \cdot s^{-2}$
Pressure	Pascal	Pa	$m^{-1} \cdot kg \cdot s^{-2}$
Electric resistance	Ohm	Ω	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}$
Capacitance	Farad	F	$m^2 \cdot kg^{-1} \cdot s^4 \cdot A^2$
EMF	Volt	V	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-1}$
Temperature	Degree celsuis	°C	K

Why does metrology matter?

Metrology is born out of physics and is ubiquitous; it underpins most other technologies to some degree. It has three primary and critical subfields:

Scientific or Fundamental Metrology establishes quantity systems and the development of new measurement methods and standards. Handled by the BIPM internationally, Fluke Biomedical, RaySafe and its distributors also participate through committees established by the national measurement institutes (NMI)

The BIPM has several vital committees that provide guidance documents for the metrology community and have a mission to harmonize worldwide metrological practices and disseminate scientific and technological knowledge

- Joint Committee for Guides in Metrology (JCGM)
  - JCGM 100:2008 (GUM—Evaluation of Measurement Data)
  - JCGM 200:2012 (VIM—International Vocabulary of Metrology)
- Joint Committee for Traceability in Laboratory Medicine (JCTLM)

Applied, Technical or, Industrial metrology is the application of measurement science to manufacturing and other industrial processes. It ensures the suitability, calibration and, quality control of measurement instruments.

Applied, Technical or, Industrial metrology includes traceability to the SI to ensure confidence in measurement. Measurement can be defined as the process of experimentally obtaining one or more quantity values that can reasonably be attributed to another quantity.

Legal Metrology involves the technical and administrative procedures established by law, by public authorities to guarantee the quality of measurements. Statutory requirements come from: the need to protect health, public safety, environmental concerns, enabling taxation, consumer protection, fair trade and more.

Legal Metrology ensures that we maintain our measurement systems. Manufacturers, hospitals and, medical facilities have a legal responsibility to keep records to show that medical devices and the test instruments used to calibrate them are accurate and traceable. There are number of organizations that provide international support for legal metrology, including:

- International Organization of Legal Metrology (OIML)
- European Cooperation in Legal Metrology (WELMEC)
- Asia-Pacific Legal Metrology Forum (APLMF)

Why measurements matter

Imagine the chaos if every country and state had a different measurement system. Our economy and our everyday lives rely on consistency and trust in the goods we buy and sell. We also expect that the products we use must be capable of operating within their stated minimum performance standards.

Interoperability is also crucial. In a global economy, we need measurements on components manufactured overseas to be as accurate as the measurements we perform in the US. The reliable quality of parts means we can trust that the individual pieces will fit together, physically and electrically without effort.

Adhering to standards and producing products that match measurement guidelines is a requirement for any manufacturer today. Metrology accuracy and traceability permeate every aspect of the industrial products built.

The pharaohs' pyramids remind us that metrology has been understood for centuries and it

continues to evolve as devices, calibration and measurements become more and more sophisticated.

As a participating member in many national and international measurement organizations, Fluke Biomedical and RaySafe continues to hold ourselves to the highest product standards. Customers trust the instruments we build to provide consistent, dependable and, accurate measurements.

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