International Vocabulary of Metrology

Fourth edition – Committee Draft (VIM4 CD)

11 January 2021

Please note that the contents of this document shall not be quoted in any publication

Please note that this CD still does not include the French text of the entries.

Introduction

The International Vocabulary of Metrology (VIM) is a guidance document that aims at disseminating scientific and technological knowledge about metrology by harmonizing worldwide the related fundamental terminology. While developed for being as understandable as possible to the wide readership of researchers and practitioners, its institutional task is to constitute a recommendation that JCGM member organizations are encouraged to implement, each according to its own purposes and in reference to its own scope.

The third edition of the VIM (denoted herein as the “VIM3”) was published by the JCGM in 2008, and republished with minor corrections in 2012. After publication, the JCGM Working Group responsible for VIM maintenance and revision (JCGM/WG 2) began considering feedback it had received. In the meantime, and most significantly, several JCGM member organizations pointed out the increasing importance of a metrologically-aware treatment of nominal properties, and therefore the need for more entries in the VIM about nominal properties and the process of their examination. This led WG 2 to the reconsideration of some key concepts of the VIM, starting from the ones related to the very distinction between quantitative and non-quantitative properties.
This fourth edition of the VIM (VIM4) has been designed to address these issues, with the awareness that metrology is an active body of knowledge, that is called to maintain its key role in an everchanging world. For measurement to remain a reliable source of public trust, its basic concept system, as provided by the VIM, must be open to consistently encompass innovation, while guaranteeing faithfulness to the long societal and scientific tradition of measurement.

Any new edition of the VIM has been an opportunity for providing an interpretation of how the body of knowledge about metrology is structured, and the VIM4 follows this path by providing a revised organization of its chapters.

* Chapter 1, “Quantities and units” introduces the key entities of metrology: quantities, units, values, and scales.
* Chapter 2, “Measurement” focuses on measurement as both an experimental and mathematical process, by also including the entries related to measurement models.
* Chapter 3, “Measurement quality”, is about what characterizes the quality of measurement processes and procedures, measurement instruments and systems, and of course measurement results, thus first of all measurement uncertainty but also measurement error, accuracy, and so on.
* Chapter 4, “Measuring devices and their properties” is about measuring instruments and systems, their components and their properties.
* Chapter 5, “Measurement standards (etalons) and metrological traceability” expands the context by dealing with metrological systems, including measurement standards and calibration: what is required for guaranteeing the metrological traceability of measurement results. A major change in the VIM4 with respect to the VIM3 is the new
* Chapter 6, “Nominal properties and examinations”, devoted to nominal properties and their examination. While the VIM3 included an entry for ‘nominal property’ (i.e., non-quantitative, only classificatory properties), a number of related additional entries have been introduced into the VIM4, mainly taken from the *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences* (IFCC-IUPAC Recommendations 2017; G.Nordin et al, Pure Appl. Chem. 90, 5, 2018), and adapted for making them consistent with the VIM. This required revising the entries that the VIM3 had introduced about ordinal properties, for which an order but not a unit is defined. The controversial issue is whether order is sufficient for making a property quantitative, and therefore whether the term “ordinal quantity” should be used for designating such properties. After a careful analysis, also taking into account that a scientific community of stakeholders interested in ordinal properties was not found, it was decided for the VIM4 to minimize the changes on this matter with respect to the VIM3, and to maintain the assumption that ordinal properties are (measurable) quantities.

A consequence of the more extensive treatment of nominal properties (and, to a lesser extent, ordinal quantities) in the VIM4 was that the definitions of ‘measurement’ and ‘metrology’ were considered more carefully. In particular, the question arose of whether the definitions of either or both should be expanded beyond quantities to include nominal property examination. An inquiry among JCGM member organizations was conducted, yielding sometimes strong opinions on both sides of the question. It was therefore decided that for now the time is not right to make such a change, but notes have been added to some relevant entries to indicate that the debate exists and could influence future versions of the VIM on this matter.

This systematic revision of the entries related to properties, thus including those about units, scales, and values, has led to focusing on the ambiguity of the term “quantity” (the same applies to “ordinal quantity” and “nominal property”), used to refer to both quantities in the general sense (such as length and mass) and individual properties (such as given lengths and given masses). In the context of a vocabulary of fundamental metrology the differences are significant: for example, comparisons in terms of equivalence and order apply to individual, not general, quantities, and values are attributed to individual, not general, quantities; vice versa, the distinction between base and derived quantities in a system of quantities refers to general, and not individual, quantities. While for linguistic simplicity just the term “quantity” is maintained in many occurrences in this vocabulary, two entries have been introduced, for ‘general quantity’, and ‘individual quantity’, and notes have been added to indicate whether ‘general quantity’ or ‘individual quantity’ is intended if there is any chance for ambiguity. This led us to provide an operational definition of ‘general quantity’ – “property whose instances can be compared by ratio or only by order” – that made it possible to avoid reference to magnitudes (in recognition of the sometimes incompatible ways in which this concept is understood, and also because the term “magnitude” is not cleanly translatable into some languages).

Another key change made in the VIM4 relates to the cluster of entities related to the characterization of the quality of measurement and its results: measurement uncertainty, measurement error, measurement accuracy, measurement trueness, true value of a quantity, and so on. The VIM3 explicitly acknowledged the existence of different interpretations about this fundamental subject – summarily presented as an opposition between an Error Approach (sometimes called Traditional Approach or True Value Approach) and an Uncertainty Approach – which led to difficulties to provide definitions that could be widely acceptable. An encompassing position has been chosen in the VIM4, by adopting operational definitions whenever possible, by phrasing the relevant definitions in terms of reference values, of which true values are specific cases when it applies, where the definitions are complemented with notes describing when and under which conditions the reference values are in fact true values, and when they are not. This approach is considered to provide for maximum flexibility for the differing perspectives on the necessity and usefulness of ‘true value’.

With the introduction of the revised International System of units (SI) in 2019, it is worth mentioning that in the VIM4 all relevant entries have been revised for guaranteeing their consistency with the new approach, in which units are individual quantities defined in reference to constants of nature.

Finally, the entire text of the VIM3 was revised with the aim of 1) improving readability of the definitions, the notes, and the examples, 2) adding some further clarifications through new notes and examples, and 3) reducing the explicit emphasis on terminology, perceived as a source of complexity. Furthermore, the VIM4 incorporates all annotations that were developed to the VIM3 to provide interim clarifications and simplified language. This means that the new definitions and notes have been drafted using simpler language, while maintaining strict compliance with basic terminological rules, in particular the condition that the definitions must be non-circular with each other.

NOTE: In the context of the current endeavor of providing increasingly sophisticated online access to measurement-related data and information, it is anticipated that the content of the VIM4 will be made accessible via internet in both human readable and machine readable formats.

1 Quantities and units

1.1 [VIM3: 1.1; VIM2: 1.1; VIM1: 1.01]

quantity <general>

general quantity

quantity in the general sense

kind of quantity

property whose instances can be compared by ratio or only by order

NOTE 1 The same term “quantity” is commonly used to refer to both quantities in the general sense, such as length and mass, and **individual quantities**, such as any given length and any given mass. Acknowledging the importance of this distinction, separate definitions are given in this Vocabulary for quantities in the general sense and individual quantities, but the short term “quantity” is used whenever the linguistic context is sufficient to identify the intended meaning.

The following table exemplifies the distinction between quantities in the general sense and individual quantities. In some cases a general quantity (such as length, in the table) can be classified into more specific general quantities (such as radius, wavelength, etc).

General quantity		Individual quantity
length, *l*	radius, *r*	radius of circle *a*, r_a or $r(a)$
	wavelength, *λ*	wavelength of the sodium D radiation, λ_D or λ(D; Na)
energy, *E*	kinetic energy, *T*	kinetic energy of particle *i* in a given system, T_i
	heat, *Q*	heat of vaporization of sample *i* of water, Q_i
electric charge, *Q*		electric charge of the proton, *e*
electric resistance, *R*		electric resistance of resistor *i* in a given circuit, R_i
amount-of-substance concentration of entity B, c_B		amount-of-substance concentration of ethanol in wine sample *i*, $c_i(C_2H_5OH)$
number concentration of entity B, C_B		number concentration of erythrocytes in blood sample *i*, C(Erys; B_i)
Rockwell C hardness, HRC		Rockwell C hardness of steel sample *i*, HRC_i

NOTE 2 Any individual quantity is an instance of a general quantity, so that for example the radius of circle *a* is an instance of length. Individual quantities that are instances of the same general quantity are comparable, and are said to be “quantities of the same kind”.

NOTE 3 The same term “quantity” is commonly used to refer to both quantities having a unit, such as length and mass, and **ordinal quantities**. A quantity having a unit is such that its instances can be compared:

– by ratio (for example one length may be found to be twice another length), and it is sometimes called a “ratio quantity”;

– by ratio of differences (for example the difference of two Celsius temperatures may be found to be twice the difference of two other Celsius temperatures), and it is sometimes called an “interval quantity”.

An ordinal quantity has no unit and its instances can be compared by order only.

NOTE 4 Symbols for quantities are given in the ISO 80000 and IEC 80000 series of standards Quantities and units. The symbols for quantities are written in italics. A given symbol can indicate different quantities.

NOTE 5 The preferred IUPAC and IFCC format for quantities in laboratory medicine is “System—Component; kind-of-quantity” (see U. Magdal Petersen, R. Dybkaer, H. Olesen (2012). Properties and units in the clinical laboratory sciences. Part XXIII. The NPU terminology, principles, and implementation: A user’s guide (IUPAC Technical Report). Pure Appl. Chem. 84(1): 137-165).

EXAMPLE The glucose concentration in blood plasma in a given person at a given time is described by “Plasma(Blood)—Glucose; amount-of-substance concentration equal to 5.1 mmol/l”.

NOTE 6 A quantity as defined here is a scalar. However, a vector or a tensor, the components of which are quantities, is also considered to be a multi-dimensional quantity, i.e., a quantity in a broader sense.

NOTE 7 Quantities can be classified as, for example, physical quantities, chemical quantities, and biological quantities, or as **base quantities** and **derived quantities**.

1.2 [VIM3: 1.1; VIM2: 1.1; VIM1: 1.01]
quantity <individual>

individual quantity

instance of a **general quantity**

NOTE 1 **Measurement units**, **measurands**, **values of quantities**, and **measured values** are all examples of individual quantities.

NOTE 2 In English sometimes “magnitude” is used to refer to individual quantities. Due to the fact that the term has different, incompatible meanings and that it is not always easy to translate it into other languages, the term “magnitude” is not used in this vocabulary.

EXAMPLE Examples of individual quantities, together with the general quantities of which they are instances, are presented in the table in the Note 1 to the entry 1.1.

1.3 [VIM3: 1.3; VIM2: 1.2]
system of quantities

set of **quantities** together with a set of non-contradictory equations relating those quantities

NOTE 1 The quantity mentioned in the definition is a general quantity having a unit.

NOTE 2 **Ordinal quantities**, such as Rockwell C hardness, are usually not considered to be part of a system of quantities because they are related to other quantities through empirical relations only.

1.4 [VIM3: 1.4; VIM2: 1.3; VIM1: 1.02]
base quantity

quantity in a conventionally chosen subset of a given **system of quantities**, where no quantity in the subset can be expressed in terms of the others

NOTE 1 The quantity mentioned in the definition is a general quantity having a unit.

NOTE 2 The subset mentioned in the definition is termed the “set of base quantities”.

EXAMPLE The set of base quantities in the **International System of Quantities** (ISQ) is given in 1.6.

NOTE 3 Base quantities are referred to as being mutually independent since a base quantity cannot be expressed as a product of powers of the other base quantities.

NOTE 4 The quantity *number of entities* can be regarded as a base quantity in any system of quantities.

1.5 [VIM3: 1.5; VIM2: 1.4; VIM1: 1.03]
derived quantity

quantity, in a **system of quantities**, defined in terms of the **base quantities** of that system

NOTE The quantity mentioned in the definition is a general quantity having a unit.

EXAMPLE In a system of quantities having length and mass as base quantities, mass density is a derived quantity defined as the quotient of mass and volume (length to the third power).

1.6 [VIM3: 1.6]
International System of Quantities

ISQ

system of quantities based on the seven **base quantities**: time, length, mass, electric current, thermodynamic temperature, amount of substance, and luminous intensity

NOTE 1 This system of quantities is published in the ISO 80000 and IEC 80000 series of International Standards Quantities and units.

NOTE 2 The **base units** of the **SI** are chosen in accordance with the base quantities of the ISQ.

NOTE 3 The term “time” is sometimes used for referring to an instant of time (for example 7:00 UTC) and sometimes to a duration, i.e., the range of a time interval.

1.7 [VIM3: 1.7; VIM2: 1.5; VIM1: 1.04]

quantity dimension

dimension of a quantity

dimension

relation of a **quantity** to the **base quantities** of a **system of quantities** as a product of powers of factors corresponding to the base quantities, omitting any numerical factor

NOTE 1 The quantity mentioned in the definition is a general quantity having a unit.

NOTE 2 A power of a factor is the factor raised to an exponent. Each factor is the dimension of a base quantity.

NOTE 3 The conventional symbolic representation of the dimension of a base quantity is a single upper-case letter in roman (upright) sans-serif type. The conventional symbolic representation of the dimension of a **derived quantity** is the product of powers of the dimensions of the base quantities according to the definition of the derived quantity. The dimension of a quantity *Q* is denoted by dim *Q*.

EXAMPLE 1 In the **ISQ**, the dimension of force is denoted by dim $F = \mathrm{T}^{-2}\,\mathrm{L}\,\mathrm{M}$.

EXAMPLE 2 In the same system of quantities, dim $\rho_\mathrm{B} = \mathrm{L}^{-3}\,\mathrm{M}$ is the dimension of mass concentration of component B, and $\mathrm{L}^{-3}\mathrm{M}$ is also the dimension of mass density, ρ (volumic mass).

EXAMPLE 3 The period *T* of a pendulum of length *l* at a place with the local acceleration of free fall *g* is

$$T = 2\pi\sqrt{\frac{l}{g}} \quad \text{or} \quad T = C(g)\sqrt{l}$$

where

$$C(g) = \frac{2\pi}{\sqrt{g}}$$

Hence dim $C(g) = \mathrm{T}\,\mathrm{L}^{-1/2}$.

NOTE 4 In deriving the dimension of a quantity, no account is taken of whether the quantity is scalar, vector, or tensor.

NOTE 5 In a given system of quantities,

- quantities of the same kind have the same dimension,
- quantities of different dimensions are always of different kinds, and
- quantities having the same dimension are not necessarily of the same kind.

NOTE 6 Symbols for the dimensions of the base quantities in the ISQ are:

Base quantity	Symbol for dimension
time	T
length	L
mass	M
electric current	I
thermodynamic temperature	Θ
amount of substance	N
luminous intensity	J

Thus, the dimension of a quantity *Q* is denoted by dim $Q = \mathrm{T}^{\alpha}\mathrm{L}^{\beta}\mathrm{M}^{\gamma}\mathrm{I}^{\delta}\Theta^{\varepsilon}\mathrm{N}^{\zeta}\mathrm{J}^{\eta}$ where the exponents, named “dimensional exponents”, are positive, negative, or zero.

1.8 [VIM3: 1.8; VIM2: 1.6; VIM1: 1.05]

quantity with unit one

dimensionless quantity

quantity for which all the exponents of the factors in its **dimension** are zero

NOTE 1 The quantity mentioned in the definition is a general quantity having a unit.

NOTE 2 The term “dimensionless quantity” is still commonly used and is kept here for historical reasons. However, all quantities, including *number of entities*, have a dimension. The term “quantity of dimension one” used in the previous edition of the VIM reflects the convention in which the symbolic representation of the dimension for such quantities was the symbol “1”.

NOTE 3 The **units** and **values** of quantities with unit one are numbers.

NOTE 4 Some quantities with unit one are defined as the ratios of two quantities of the same kind.

EXAMPLES Plane angle, solid angle, refractive index, relative permeability, mass fraction, friction factor, Mach number.

NOTE 5 In reporting the values of quantities defined as the ratios of two quantities of the same kind, the relevant units should be specified when there is possibility of ambiguity.

EXAMPLES mg/kg (for mass fraction) or µmol/mol (for amount-of-substance fraction).

NOTE 6 *Number of entities* is a quantity with unit one.

EXAMPLES Number of turns in a coil, number of molecules in a given sample, degeneracy of the energy levels of a quantum system.

1.9 [VIM3: 1.9; VIM2: 1.7; VIM1: 1.06]
measurement unit

unit of measurement

unit

real scalar **individual quantity**, defined and adopted by convention, with which any other quantity of the same kind can be compared by ratio, resulting in a number

NOTE 1 Ordinal quantities have no units because they cannot be compared by ratio.

NOTE 2 Units are designated by conventionally assigned names and symbols.

NOTE 3 Units of quantities of the same **dimension** may be designated by the same name and symbol even when the quantities are not of the same kind. For example, “joule per kelvin” and J/K are respectively the name and symbol of both a unit of heat capacity and a unit of entropy, which are generally not considered to be quantities of the same kind. However, in some cases special unit names are restricted to be used with quantities of a specific kind only. For example, the unit second to the power minus one (1/s) is called “hertz” (Hz) when used for frequencies and “becquerel” (Bq) when used for activities of radionuclides.

NOTE 4 Units of **quantities with unit one** are numbers. In some cases these units are given special names, for example “radian” and “steradian”, or are expressed by quotients such as millimole per mole equal to 10^{-3} and microgram per kilogram equal to 10^{-9}.

NOTE 5 For a given quantity, the short term “unit” is often combined with the name of the quantity, such as “mass unit” or “unit of mass”.

1.10 [VIM3: 1.10; VIM2: 1.13; VIM1: 1.11]
base unit

measurement unit that is adopted by convention for a **base quantity**

NOTE 1 In each coherent **system of units**, there is only one base unit for each base quantity.

EXAMPLE In the **SI**, the metre is the base unit of length. In the CGS systems, the centimetre is the base unit of length.

NOTE 2 A base unit may also serve for a **derived quantity** of the same **dimension**.

EXAMPLE Rainfall, when defined as areic volume (volume per area), has the metre as a **coherent derived unit** in the SI.

NOTE 3 For *number of entities*, the number one, symbol “1”, can be regarded as a base unit in any **system of units**.

1.11 [VIM3: 1.11; VIM2: 1.14; VIM1: 1.12]
derived unit

measurement unit for a **derived quantity**

EXAMPLES The metre per second, symbol m/s, and the centimetre per second, symbol cm/s, are derived units of speed in the **SI**. The kilometre per hour, symbol km/h, is a unit of speed outside the SI but accepted for use with the SI. The knot, equal to one nautical mile per hour, is a unit of speed outside the SI.

1.12 [VIM3: 1.12; VIM2: 1.10; VIM1: 1.13]
coherent derived unit
coherent unit

derived unit that, for a given **system of quantities** and for a chosen set of **base units**, is a product of powers of base units with no other proportionality factor than one

NOTE 1 A power of a base unit is the base unit raised to an exponent.

NOTE 2 The coherence of a derived unit can be determined only with respect to a particular system of quantities and a given set of base units.

> EXAMPLES If the metre, the second, and the mole are base units, the metre per second is the coherent derived unit of velocity when velocity is defined by the **quantity equation** $v = \mathrm{d}r/\mathrm{d}t$, and the mole per cubic metre is the coherent derived unit of amount-of-substance concentration when amount-of-substance concentration is defined by the quantity equation $c = n/V$. The kilometre per hour and the knot, given as examples of derived units in 1.11, are not coherent derived units in such a system of quantities.

NOTE 3 A derived unit can be coherent with respect to one system of quantities but not to another.

> EXAMPLE The centimetre per second is the coherent derived unit of speed in a CGS **system of units** but is not a coherent derived unit in the **SI**.

NOTE 4 The coherent derived unit for every derived **quantity with unit one** in a given system of units is the number one, symbol “1”. The name and symbol of the **unit** one are generally not indicated.

1.13 [VIM3: 1.13; VIM2: 1.9; VIM1: 1.08]
system of units

set of **base units** and **derived units**, together with their multiples and submultiples, defined in accordance with given rules, for a given **system of quantities**

1.14 [VIM3: 1.14; VIM2: 1.11; VIM1: 1.09]
coherent system of units

system of units in which the **measurement unit** for each **derived quantity** is a **coherent derived unit**

NOTE 1 A system of units can be coherent only with respect to a system of quantities and the adopted **base units**.

NOTE 2 For a coherent system of units, **numerical value equations** have the same form, including numerical factors, as the corresponding **quantity equations**.

1.15 [VIM3: 1.15; VIM2: 1.15; VIM1: 1.14]
off-system measurement unit
off-system unit

measurement unit that does not belong to a given **system of units**

EXAMPLE 1 The electronvolt (about $1.602\,18 \cdot 10^{-19}$ J) is an off-system unit of energy with respect to the **SI**.

EXAMPLE 2 Day, hour, minute are off-system units of time with respect to the SI.

1.16 [VIM3: 1.16; VIM2: 1.12; VIM1: 1.10]
International System of Units
SI

system of units, based on a set of defining constants together with rules for their use, adopted by the 26$^{\text{th}}$ General Conference on Weights and Measures (CGPM)

NOTE 1 At the 26$^{\text{th}}$ CGPM (2018) the SI was revised. Effective from 20 May 2019, the SI is the system of units in which seven physical constants have stated fixed values. These seven defining constants are the hyperfine transition frequency of caesium 133, the speed of light in vacuum, the Planck constant, the elementary charge, the Boltzmann constant, the Avogadro constant, and the luminous efficacy, as defined in the current edition of the SI Brochure published by the Bureau International des Poids et Mesures (BIPM) and available on the BIPM website. From such constants and their values, and in accordance with the ISQ, the definitions of the base units of the SI are deduced, as documented in the SI Brochure. The names of the seven base quantities of the ISQ and the English names and the symbols of the corresponding base units of the SI are listed in the following table.

Base quantity	Base unit	
Name	Name	Symbol
time	second	s
length	metre	m
mass	kilogram	kg
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

NOTE 2 The **base units** and the **coherent derived units** of the SI form a coherent set, called the "set of coherent SI units".

NOTE 3 For a full description and explanation of the International System of Units, see the current edition of the *SI Brochure* published by the Bureau International des Poids et Mesures (BIPM) and available on the BIPM website.

NOTE 4 In **quantity calculus**, the quantity *number of entities* is often considered to be a **base quantity**, with the base unit one, symbol "1".

NOTE 5 The rules for the use of the SI units include the prefixes for **multiples of units** and **submultiples of units** listed in the following table, together with their English names and their symbols.

Factor	Prefix	
	Name	Symbol
10^{24}	yotta	Y
10^{21}	zetta	Z
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a
10^{-21}	zepto	z
10^{-24}	yocto	y

Source: the current edition of the *SI Brochure* published by the Bureau International des Poids et Mesures (BIPM) and available on the BIPM website.

1.17 **[VIM3: 1.17; VIM2: 1.16; VIM1: 1.15]**

multiple of a unit

measurement unit obtained by multiplying a given measurement unit by an integer greater than one

EXAMPLE 1 The kilometre is a decimal multiple of the metre.

EXAMPLE 2 The hour is a non-decimal multiple of the second.

NOTE 1 **SI** prefixes for decimal multiples of SI **base units** and SI **derived units** are given in Note 5 of entry 1.16.

NOTE 2 SI prefixes refer strictly to powers of 10, and should not be used for powers of 2. For example, 1 kilobit should not be used to represent 1 024 bits (2^{10} bits), which is 1 kibibit.

Prefixes for binary multiples are:

Factor	Prefix	
	Name	Symbol
$(2^{10})^8$	yobi	Yi
$(2^{10})^7$	zebi	Zi
$(2^{10})^6$	exbi	Ei
$(2^{10})^5$	pebi	Pi
$(2^{10})^4$	tebi	Ti
$(2^{10})^3$	gibi	Gi
$(2^{10})^2$	mebi	Mi
$(2^{10})^1$	kibi	Ki

Source: IEC 80000-13, *Quantities and units – Part 13: Information science and technology*.

1.18 [VIM3: 1.18; VIM2: 1.17; VIM1: 1.16]

submultiple of a unit

measurement unit obtained by dividing a given measurement unit by an integer greater than one

EXAMPLE 1 The millimetre is a decimal submultiple of the metre.

EXAMPLE 2 For a plane angle, the second is a non-decimal submultiple of the minute.

NOTE **SI** prefixes for decimal submultiples of SI **base units** and SI **derived units** are given in Note 5 of entry 1.16.

1.19 [VIM3: 1.27; VIM2: 1.22; VIM1: 1.21]

measurement scale

ordered set of **individual quantities** of the same **kind**, where each quantity is associated with an element of a set of ordered identifiers

NOTE 1 For a quantity having a **unit** a measurement scale is an ordered set including a unit and all or some of its products by a real number *k*, where *k* is the **numerical value** with which each quantity is identified.

> EXAMPLE Scale of length generated by taking the metre as the unit, where the length of *k* metres is associated with the identifier that is the number *k*.

NOTE 2 Measurement scales are usually defined in such a way that empirically distinguishable individual quantities are associated with distinct identifiers, and the association maintains the order, so that greater quantities are associated with greater identifiers.

NOTE 3 A measurement scale for **ordinal quantities** is an **ordinal scale**. A similar scale for **nominal properties** is a **reference set of nominal properties**.

1.20 [VIM3: 1.19; VIM2: 1.18; VIM1: 1.17]

value of a quantity

quantity value

value <quantity>

individual quantity identified as the product of a number and a **measurement unit** or on an **ordinal scale**

EXAMPLE 1 5.34 m or 534 cm as the same length identified in two different ways

EXAMPLE 2 0.152 kg or 152 g as the same mass identified in two different ways

EXAMPLE 3 112 m^{-1} as a curvature of arcs

EXAMPLE 4 −5 °C as a Celsius temperature

EXAMPLE 5 (7 + 3j) Ω as an electric impedance at a given frequency, where j is the imaginary unit

EXAMPLE 6 1.32 as a refractive index of samples

EXAMPLE 7 43.5 HRC as a Rockwell C hardness

EXAMPLE 8 3 μg/kg or 3 · 10^{-9} as the same mass fraction identified in two different ways

EXAMPLE 9 1.76 μmol/kg as a molality

EXAMPLE 10 5.0 IU/l as amount-of-substance concentration, where "IU" stands for "WHO International Unit"

NOTE 1 A value identified on an ordinal scale is a **value of an ordinal quantity**.

NOTE 2 Values of quantities appear in relations such as

l_a = 5.34 m

Such a relation is an actual equation, stating that the individual quantity identified as the length *l* of a given rod *a* and the individual quantity identified as 5.34 times the metre are the same.

NOTE 3 In some mathematical theories of measurement, values of quantities are more generically understood as symbols associated with quantities of objects for representation purposes. According to this understanding, in the equation in Note 1 the value 5.34 m is interpreted as a symbol representing the length *l* of rod *a*.

NOTE 4 According to the type of reference, a value of a quantity is either

- a product of a number and a **unit** (see Examples 1, 2, 3, 4, 5, 8 and 9); the measurement unit is generally not indicated for quantities with unit one (see Examples 6 and 8), or
- a number and a reference to a **measurement procedure** (see Example 7), or
- a number and a reference to a **reference material** (see Example 10).

NOTE 5 The number mentioned in the definition can be complex (see Example 5).

NOTE 6 A value can be presented in more than one way (see Examples 1, 2 and 8).

NOTE 7 In the case of vector or tensor quantities, each component has a value.

EXAMPLE Force acting on a given particle, for example in Cartesian components (F_x; F_y; F_z) = (−31.5; 43.2; 17.0) N.

NOTE 8 The second term, "quantity value", may be used in order to take advantage of the adjectival use of a noun in the English language. When there is no possible ambiguity or confusion, the term "value" may be used.

1.21 [VIM3: 1.20; VIM2: 1.21; VIM1: 1.20]

numerical value of a quantity

numerical quantity value

numerical value

ratio of a **quantity** and a **unit** of the same **kind**

NOTE 1 The numerical value {*Q*} of a quantity *Q* is frequently denoted {*Q*} = *Q*/denotes the unit. Hence, for any given **value of a quantity**, the numerical value depends on the unit.

EXAMPLE For a value of 5.700 kg, the numerical value is (5.700 kg)/kg = 5.700. The same information can be expressed as 5 700 g in which case the numerical value is (5 700 g)/g = 5 700.

NOTE 2 For **quantities with unit one**, there is no difference between the value and the numerical value of the quantity, when the **coherent unit** one is used. For quantities defined as the ratio of two quantities of the same kind, the ratio of two units is sometimes used to indicate the kind of the two quantities and to provide a multiplicative factor for the numerical value.

EXAMPLE 1 For an efficiency (ratio of output power to input power) equal to 0.7, the numerical value is 0.7, but it is 70 when the value is expressed as 70%.

EXAMPLE 2 In an amount-of-substance fraction equal to 3 mmol/mol, the numerical value is 3 and the unit is mmol/mol. The unit mmol/mol is numerically equal to 0.001.

NOTE 3 **Ordinal quantities** have no numerical values. The numeral in an expression of the **value of an ordinal quantity** is not a numerical value of a quantity, but an identifier for the ordinal position of the quantity on the **ordinal scale**.

1.22 [VIM3: 2.11; VIM2: 1.19; VIM1: 1.18]

true value of a quantity

true quantity value

true value

value consistent with a **quantity**, as it is defined

NOTE 1 True values are, in principle and in practice, unknowable. Some approaches consider that there is not a single true value but rather a set of true values, whereas some other approaches dispense altogether with true values and rely on **metrological compatibility** and **metrological traceability of measurement results** for assessing their validity.

NOTE 2 In the special case of a fundamental constant, the quantity is considered to have a unique true value.

NOTE 3 When the **definitional uncertainty** associated with the **measurand** is considered to be negligible compared to the other components of the **measurement uncertainty**, the measurand may be considered to have an “essentially unique” true value. This is the approach taken by the GUM and associated documents, where the word “true” is considered to be redundant.

1.23 [VIM3: 2.12]

conventional value of a quantity

conventional quantity value

conventional value

value attributed by agreement to a **quantity**, for a given purpose

EXAMPLE 1 Standard acceleration of free fall (formerly called “standard acceleration due to gravity”), g_n = 9.806 65 ms^{-2}.

EXAMPLE 2 Conventional value of the Josephson constant, K_{J-90} = 483 597.9 GHz V^{-1}.

EXAMPLE 3 Conventional value of a given mass standard, m = 100.003 47 g.

NOTE 1 The term “conventional true quantity value” is sometimes used for referring to conventional values, but its use is discouraged.

NOTE 2 Sometimes a conventional value is an estimate of a **true value**.

NOTE 3 A conventional value is sometimes considered to have an associated **measurement uncertainty**.

1.24 [VIM3: 5.18]

reference value of a quantity

reference quantity value

reference value

value used as a basis for comparison with values of **quantities** of the same kind

NOTE 1 Examples of reference values are **true values** of a **measurand**, in which case they are unknown, and **conventional values**, in which case they are known.

NOTE 2 A reference value with associated **measurement uncertainty** is usually provided with reference to

a) a material, for example a **certified reference material**,

b) a device, for example a stabilized laser,

c) a **reference procedure**,

d) a **measurement standard**.

1.25 [VIM3: 1.21]

quantity calculus

system of mathematical rules and operations applied to **quantities**

NOTE 1 The quantities mentioned in the definition are general quantities having a unit.

NOTE 2 In quantity calculus, **quantity equations** are preferred to **numerical value equations** because quantity equations are independent of the choice of **units**, whereas numerical value equations are not.

1.26 [VIM3: 1.22]
quantity equation

mathematical relation among **quantities** in a given **system of quantities**, independent of **measurement units**

NOTE 1 The quantities mentioned in the definition are either general or individual quantities having a unit.

NOTE 2 The quantities on the left-hand side and the right-hand side of a quantity equation must have the same dimension. Checking this is sometimes called the “dimensional analysis” of the equation.

EXAMPLE 1 $Q_1 = \zeta\, Q_2\, Q_3$ where Q_1, Q_2 and Q_3 denote different quantities, and where ζ is a numerical factor.

EXAMPLE 2 $T = (1/2)\, mv^2$ where T is the kinetic energy and v the speed of a specified particle of mass m.

EXAMPLE 3 $n = It/F$ where n is the amount of substance of a univalent component, I is the electric current and t the duration of the electrolysis, and where F is the Faraday constant.

1.27 [VIM3: 1.23]
unit equation

mathematical relation among **measurement units**

EXAMPLE 1 For the **quantities** in Example 1 of entry 1.26, denote the units of Q_1, Q_2, and Q_3, respectively, and ζ is a numerical factor, which equals 1 in a **coherent system of units**.

EXAMPLE 2 J := kg m^2/s^2, where J, kg, m, and s are the symbols for the joule, kilogram, metre, and second, respectively (the symbol := denotes “is by definition equal to” as given in the ISO 80000 and IEC 80000 series of International Standards *Quantities and units*).

EXAMPLE 3 km/h = (1/3.6) m/s.

1.28 [VIM3: 1.24]
conversion factor between units

ratio of two **measurement units** for **quantities** of the same kind

EXAMPLE km/m = 1 000 and thus 1 km = 1 000 m.

NOTE The units may belong to different **systems of units**.

EXAMPLE 1 h/s = 3 600 and thus 1 h = 3 600 s.
EXAMPLE 2 (km/h)/(m/s) = (1/3.6) and thus 1 km/h = (1/3.6) m/s.

1.29 [VIM3: 1.25]
numerical value equation

numerical quantity value equation

mathematical relation among **numerical values**, based on a given **quantity equation** and the related **measurement units**

EXAMPLE 1 For the **quantities** in Example 1 in entry 1.26, $\{Q_1\} = \zeta\, \{Q_2\}\, \{Q_3\}$ where $\{Q_1\}$, $\{Q_2\}$, and $\{Q_3\}$ denote the numerical values of Q_1, Q_2, and Q_3, respectively, provided that they are expressed in either **base units** or **coherent derived units** or both.

EXAMPLE 2 In the quantity equation for kinetic energy of a particle, $T = (1/2)\, mv^2$, if m = 2 kg and v = 3 m/s, then $\{T\} = (1/2) \cdot 2 \cdot 3^2$ is a numerical value equation giving the numerical value 9 of T in joules.

1.30 [VIM3: 1.26]
ordinal quantity <general>

general ordinal quantity

ordinal quantity in the general sense

quantity whose instances can be compared by order but not by ratio

EXAMPLE 1 Rockwell C hardness.

EXAMPLE 2 Octane number for petroleum fuel.

EXAMPLE 3 Earthquake strength on the Richter scale.

EXAMPLE 4 Subjective level of abdominal pain on a scale from zero to five.

NOTE Ordinal quantities are sometimes defined by the procedure according to which they are measured.

1.31 [VIM3: 1.26]
ordinal quantity <individual>

individual ordinal quantity

instance of a **general ordinal quantity**

NOTE 1 Ordinal quantities can enter into empirical relations only and have neither **units** nor **dimensions**. Differences and ratios of ordinal quantities have no physical meaning.

NOTE 2 Ordinal quantities are arranged according to **ordinal scales**.

1.32 [VIM3: 1.28; VIM2: 1.22; VIM1: 1.21]
ordinal scale

measurement scale, accepted by agreement, whose elements are related by order only

NOTE 1 A ordinal scale is an ordered set of explicitly chosen individual quantities, where each quantity is associated with an ordinal identifer.

> EXAMPLE 1 Mohs scale of mineral hardness, where the hardness of talc is associated with the ordinal identifier 1, the hardness of gypsium is associated with the ordinal identifier 2, and so on.
>
> EXAMPLE 2 Scale of octane numbers for petroleum fuel.

NOTE 2 An ordinal scale may be established by **measurements** according to a **measurement procedure**.

1.33 [new]
value of an ordinal quantity

value <ordinal quantity>

individual quantity identified on an **ordinal scale**

NOTE **Ordinal quantities** have no **numerical values**. The numeral in an expression of the value of an ordinal quantity is not a numerical value of a quantity, but an identifier for the ordinal position of the individual quantity on the scale.

2 Measurement

2.1 [VIM3: 2.1; VIM2: 2.1; VIM1: 2.01]
measurement

process of experimentally obtaining one or more **values** that can reasonably be attributed to a **quantity** together with any other available relevant information

NOTE 1 The quantity mentioned in the definition is an individual quantity.

NOTE 2 The relevant information mentioned in the definition may be about the values obtained by the measurement, such that some may be more representative of the **measurand** than others.

NOTE 3 Measurement is sometimes considered to apply to **nominal properties**, but not in this Vocabulary, where the process of obtaining values of nominal properties is called "**examination**".

NOTE 4 Measurement requires both experimental comparison of quantities or experimental counting of entities at some step of the process and the use of models and calculations that are based on conceptual considerations.

NOTE 5 The conditions of reasonable attribution mentioned in the definition take into account a description of the quantity commensurate with the intended use of a **measurement result**, a **measurement procedure**, and a calibrated **measuring system** operating according to the specified measurement procedure, including the measurement conditions. Moreover, a **maximum permissible error** and/or a **target uncertainty** may be specified, and the measurement procedure and the measuring system should then be chosen in order not to exceed these measuring system specifications.

2.2 [VIM3: 2.2; VIM2: 2.2; VIM1: 2.02]
metrology

science of **measurement** and its application

NOTE Metrology includes all theoretical and practical aspects of measurement, whatever the **measurement uncertainty** and field of application.

2.3 [VIM3: 2.3; VIM2: 2.6; VIM1: 2.09]
measurand

quantity intended to be measured

NOTE 1 The quantity mentioned in the definition is an individual quantity.

NOTE 2 The specification of a measurand requires knowledge of the **kind of quantity**, description of the state of the phenomenon, body, or substance carrying the quantity, including any quantity having a relevant effect on the quantity being measured, and, if required, the chemical entities involved.

NOTE 3 In some cases the measurand is specified additionally by a documented and accepted measurement procedure. ISO REMCO refers to this as an operationally defined measurand (see ISO 17034, *General requirements for the competence of reference material producers*, definition 3.7). In laboratory medicine the IUPAC-IFCC format for a procedure defined measurand is "System—Component; kind-of-quantity(procedure)".

> EXAMPLE The activity of the enzyme alanine transaminase (ALAT) in blood plasma, as specified by the IFCC Committee on Reference Systems for Enzymes, is:
> Plasma—Alanine transaminase; catalytic concentration(IFCC 2002) is equal to 1,2 µkat/L
> (IFCC Scientific Division. Committee on Reference Systems for Enzymes (2002). *Part 4. Reference procedure for the measurement of catalytic concentration of alanine aminotransferase*. Clin. Chem. Lab. Med. 40(7): 718-724).

In these cases only results obtained by the same procedure can be compared.

NOTE 4 In the past the term "measurand" was used to refer to both the quantity intended to be measured and the quantity being measured., i.e., the quantity with which the **measuring system** interacts. Given that, despite the best efforts of the measurer, the quantity intended to be measured might not be the same as the quantity being measured, this ambiguity was removed, by calling "measurand" only the former.

NOTE 5 The **measurement**, along with the measuring system and the conditions under which the measurement is carried out, might change the phenomenon, body, or substance such that the quantity being measured may differ from the measurand as defined. In this case, adequate **correction** to the **measured value** may be necessary depending on the target uncertainty.

> EXAMPLE 1 The potential difference between the terminals of a battery may decrease when using a voltmeter

with a significant internal conductance to perform the measurement. Given the knowledge of the internal resistances of the battery and the voltmeter, the open-circuit potential difference can be calculated from such resistances by applying suitable theoretical considerations.

EXAMPLE 2 If the measurand is the length of a steel rod in equilibrium with the ambient Celsius temperature of 20 °C, but the actual ambient temperature is 23 °C, then a correction is necessary.

NOTE 6 The term "analyte", or the name of a substance or compound, is sometimes (for example in chemistry) used for measurands. This usage is not consistent with the present Vocabulary because these terms do not refer to quantities.

2.4 [VIM3: 2.4; VIM2: 2.3; VIM1: 2.05]

measurement principle

principle of measurement

phenomenon or process serving as a basis of a **measurement**

EXAMPLE 1 Thermoelectric effect applied to the measurement of temperature.

EXAMPLE 2 Energy absorption applied to the measurement of amount-of-substance concentration.

EXAMPLE 3 Lowering of the concentration of glucose in blood in a fasting rabbit applied to the measurement of insulin concentration in a preparation.

2.5 [VIM3: 2.5; VIM2: 2.4; VIM1: 2.06]

measurement method

method of measurement

generic description of a logical organization of operations used in a **measurement**

NOTE 1 Measurement methods may be qualified in various ways such as:

- substitution measurement method,
- differential measurement method, and
- null measurement method;

or

- direct measurement method, and
- indirect measurement method.

See IEC 60050-300, *International Electrotechnical Vocabulary – Electrical and electronic measurements and measuring instruments*.

NOTE 2 The use of the terms "measurement method" and "measurement procedure" differs, for historical reasons, in different areas of **metrology**. In general, a measurement method specifies a broader category of operations than does a measurement procedure, which requires a detailed set of instructions.

2.6 [new]

primary method of measurement

primary measurement method

primary method

measurement method used to obtain a **measurement result** without reference to a **measurement standard** for a **quantity** of the same **kind**

NOTE 1 According to the current edition of the SI Brochure, primary methods are the highest-level experimental methods used for the realization of units using the equations of physics. The essential characteristic of a primary method is that it allows a quantity to be measured in a particular unit by using only measurements of quantities that do not involve that unit.

NOTE 2 The Joint Committee for Traceability in Laboratory Medicine (JCTLM) uses the term "primary reference measurement procedure" for primary methods of measurement.

2.7 [VIM3: 2.6; VIM2: 2.5; VIM1: 2.07]

measurement procedure

detailed description of a **measurement** according to one or more **measurement principles** and to a given **measurement method**, based on a **measurement model** and including any calculation to obtain a **measurement result**

NOTE 1 A measurement procedure is usually documented in sufficient detail to enable an operator to perform a measurement.

NOTE 2 A measurement procedure may include a statement concerning a **target uncertainty**.

NOTE 3 A measurement procedure is sometimes called a “standard operating procedure”, abbreviated as SOP.

NOTE 4 The use of the terms “measurement method” and “measurement procedure” differs, for historical reasons, in different areas of **metrology**. In general, a measurement method specifies a broader category of operations than does a measurement procedure, which requires a detailed set of instructions.

2.8 [VIM3: 2.7]
reference measurement procedure

reference procedure

measurement procedure used in the process of providing **measurement results** for assessing **trueness** of **values** obtained from other measurement procedures for **quantities** of the same **kind**

NOTE Reference measurement procedures are often used in **calibration** and in attributing values to properties of **reference materials**.

2.9 [VIM3: 2.8]
primary reference measurement procedure

primary reference procedure

reference measurement procedure used to obtain a **measurement result** without relation to a **measurement standard** for a **quantity** of the same **kind**

EXAMPLE The volume of water delivered by a 50 ml pipette at 20 °C is measured by weighing the water delivered by the pipette into a beaker, taking the mass of beaker plus water minus the mass of the initially empty beaker, and correcting the mass difference for the actual water temperature using the volumic mass (mass density).

NOTE 1 The Consultative Committee for Amount of Substance – Metrology in Chemistry and Biology (CCQM) uses the term “primary method of measurement” to refer to primary reference procedures.

NOTE 2 Specific kinds of primary reference procedures are direct primary reference procedures and ratio primary reference procedures, defined by the CCQM (5th Meeting, 1999).

NOTE 3 The Joint Committee for Traceability in Laboratory Medicine (JCTLM) uses the term “primary reference measurement procedure” for referring to **primary methods of measurement**.

2.10 [VIM3: 2.9; VIM2: 3.1; VIM1: 3.01]
measurement result

result of measurement

set of **values** being attributed to a **measurand** together with any other available relevant information

NOTE 1 A measurement result generally contains relevant information about the set of values, such that some may be more representative of the measurand than others. This may be reported as a probability distribution.

NOTE 2 A measurement result is sometimes reported as a single **measured value** and a **measurement uncertainty**. If the measurement uncertainty is negligible in comparison with **target uncertainty**, the measurement result is sometimes expressed as a single measured value. In this case only significant digits should be reported. In many fields, this is the common way of expressing a measurement result, however caution should be used.

NOTE 3 In the traditional literature, a measurement result was reported as a value attributed to a measurand and explained to mean an **indication**, or an uncorrected result, or a corrected result, according to the context.

NOTE 4 This definition differs from the definition in the second edition of the VIM (VIM2) (“value attributed to a measurand, obtained by measurement”) in recognition of the fact that “In general, the result of a measurement is only an approximation or estimate of the value of the measurand and thus is complete only when accompanied by a statement of the uncertainty of that estimate.” (GUM, entry 3.1.2).

2.11 [VIM3: 2.10]
measured value of a quantity
measured quantity value
measured value

value of a quantity representing a **measurement result**

NOTE 1 For a **measurement** involving replicate **indications**, each indication can be used to provide a corresponding measured value. This set of measured values can be used to calculate a resulting measured value, such as an average or median, usually with a decreased associated **measurement uncertainty**.

NOTE 2 When the range of the **true values** believed to represent the **measurand** is small compared with the measurement uncertainty, and therefore the definitional uncertainty is considered to be negligible, a measured value can be considered to be an estimate of an essentially unique true value and is often an average or median of individual measured values obtained through replicate indications.

NOTE 3 In cases where the range of the true values believed to represent the measurand is not small compared with the measurement uncertainty, a measured value is often an estimate of an average or median of the set of true values.

NOTE 4 In the GUM, the terms “result of measurement” and “estimate of the value of the measurand” or just “estimate of the measurand” are used for measured values.

NOTE 5 The term “measured value” can be used instead of the full term “measured quantity value” only if there is no possibility for ambiguity or misinterpretation in the particular context. In particular, “measured value” should not be used for indication and “indication” should not be used for measured value.

2.12 [VIM3: 2.48]
measurement model
model of measurement
model

mathematical relation among all **quantities** known to be involved in a **measurement**

NOTE 1 A general form of a measurement model is the equation $h(Y, X_1, \ldots, X_n) = 0$, where Y, the **output quantity**, is the **measurand**, the **value** of which is to be inferred from information about **input quantities** $X_1, \ldots, X_n$.

NOTE 2 In more complex cases where there are two or more output quantities, the measurement model consists of more than one equation.

2.13 [VIM3: 2.49]
measurement function

function of **quantities**, the **value** of which, when calculated using known values for the **input quantities in a measurement model**, is a **measured value** of the **output quantity in the measurement model**

NOTE 1 If a **measurement model** $h(Y, X_1, \ldots, X_n) = 0$ can explicitly be written as $Y = f(X_1, \ldots, X_n)$, where Y is the output quantity in the measurement model, the function f is the measurement function. More generally, f may symbolize an algorithm, yielding for input values $x_1, \ldots, x_n$ a corresponding unique output value $y = f(x_1, \ldots, x_n)$.

NOTE 2 A measurement function is also used to calculate the **measurement uncertainty** associated with the measured value of Y.

2.14 [VIM3: 2.50]
input quantity in a measurement model
input quantity

quantity, the **value** of which is required for calculating a **measured value** of a **measurand**

EXAMPLE When the length of a steel rod at a specified temperature is the measurand, the actual temperature, the length at that actual temperature, and the linear thermal expansion coefficient of the rod are input quantities.

NOTE 1 An input quantity is often an output quantity of a **measuring system**.

NOTE 2 **Indications**, **corrections**, and **influence quantities** can be input quantities.

2.15 [VIM3: 2.51]
output quantity in a measurement model

output quantity

quantity, the **measured value** of which is calculated using the **values** of **input quantities in a measurement model**

2.16 [VIM3: 2.52; VIM2: 2.7; VIM1: 2.10]
influence quantity

quantity that does not affect the quantity being measured but that affects the **measurement result**

NOTE 1 The quantities mentioned in the definition are individual quantities.

EXAMPLE 1 Frequency of the alternating current in the measurement with an ammeter of the amplitude of that current.

EXAMPLE 2 Amount-of-substance concentration of bilirubin in a direct measurement of haemoglobin amount-of-substance concentration in human blood plasma.

EXAMPLE 3 Temperature of a micrometer used for measuring the length of a rod, but not the temperature of the rod itself which can enter into the definition of the **measurand**.

EXAMPLE 4 Background pressure in the ion source of a mass spectrometer during a measurement of amount-of-substance fraction.

NOTE 2 An indirect measurement involves a combination of direct measurements, each of which may be affected by influence quantities.

NOTE 3 In the GUM and in the second edition of the VIM, the term “influence quantity” is used for referring not only to the quantities affecting the **measuring system**, as in the definition above, but also to those quantities that affect the quantities actually measured. Also, in the GUM influence quantities are not restricted to direct measurements.

2.17 [VIM3: 2.53; VIM2: 3.15, 3.16; VIM1: 3.14, 3.15]
correction

quantity, in a measurement model, compensating for an estimated **systematic error**

NOTE 1 The compensation can take different forms, such as an addend or a factor, or can be deduced from a table.

NOTE 2 Corrections can be used for both input quantities and output quantities in a measurement model. If any of the related estimated systematic errors are negligible with respect to the target uncertainty, the corresponding correction is usually avoided, especially if it is unpractical or uneconomical.

3 Measurement quality

3.1 [VIM3: 2.26; VIM2: 3.9; VIM1: 3.09]

measurement uncertainty

uncertainty of measurement

uncertainty

parameter characterizing the dispersion of the **values** being attributed to a **measurand**, based on the information used

NOTE 1 A way to interpret measurement uncertainty is as indecision or doubt, either about the essentially unique true value of the measurand that remains after making a measurement, or about the measured value to be chosen to represent a measurement result.

NOTE 2 The parameter characterizing dispersion is either positive or zero. It may be, for example, a **standard uncertainty** (or a specified multiple of it), or the half-width of an interval, having a stated **coverage probability**.

NOTE 3 Measurement uncertainty includes components arising from systematic effects, such as components associated with **corrections** and values attributed to quantities of **measurement standards**. Sometimes estimated systematic effects are not corrected for but, instead, associated measurement uncertainty components are incorporated.

NOTE 4 Measurement uncertainty comprises, in general, many components. Some of these may be evaluated by **Type A evaluation** from the probability distribution of the values from series of **measurements** and can be characterized by standard deviations. The other components, which may be evaluated by **Type B evaluation**, can also be characterized by standard deviations, evaluated from probability distributions based on experience or other information.

NOTE 5 In general, for given information, as mentioned in the definition, it is understood that the measurement uncertainty is associated with a stated value attributed to the measurand. A modification of this value results in a modification of the associated uncertainty.

NOTE 6 Measurement uncertainty is generally part of a **measurement result**. If instead a measurement result is reported as a single **measured value**, then only significant digits should be reported.

3.2 [VIM3: 2.27]

definitional uncertainty

measurement uncertainty resulting from the finite amount of detail in the definition of a **measurand**

EXAMPLE 1 The glucose concentration in blood plasma of a person at a given time varies depending on which part of the blood circulation the sample is drawn from. If not otherwise specified this variation contributes to definitional uncertainty.

EXAMPLE 2 The measured thickness of a sheet of material at a given temperature may vary at different points on the sheet because of manufacturing unevenness. If not otherwise specified this variation contributes to definitional uncertainty.

NOTE 1 Definitional uncertainty is the practical minimum measurement uncertainty achievable in any **measurement** of a given measurand. A measurand should be defined in such a way that the related **definitional uncertainty** is significantly less than the **target uncertainty**.

NOTE 2 Any change in the descriptive detail in the definition of a measurand usually leads to another definitional uncertainty.

NOTE 3 In the GUM, entry D.3.4, and in IEC 60359, *Electrical and electronic measurement equipment – Expression of performance*, definitional uncertainty is termed “intrinsic uncertainty”.

3.3 [VIM3: 4.24]

instrumental measurement uncertainty

instrumental uncertainty

component of **measurement uncertainty** arising from a **measuring instrument** or **measuring system** in use

NOTE 1 Instrumental uncertainty is evaluated through **calibration** of a measuring instrument or measuring system, except for a **primary measurement standard** for which other means are used.

NOTE 2 Instrumental uncertainty is used in a **Type B evaluation of measurement uncertainty**.

NOTE 3 Information relevant to instrumental uncertainty is usually given in the instrument specifications.

3.4 [VIM3: 2.28]
Type A evaluation of measurement uncertainty

Type A evaluation

evaluation of a component of **measurement uncertainty** by a statistical analysis of **measured values** obtained under defined **measurement** conditions

NOTE 1 For various types of measurement conditions, see **repeatability condition of measurement**, **intermediate precision condition of measurement**, and **reproducibility condition of measurement**.

NOTE 2 For information about statistical analysis, see for example the GUM.

NOTE 3 See also the GUM, entry 2.3.2, and the ISO 5725 series of International Standards, *Accuracy (trueness and precision) of measurement methods and results*, ISO 13528, *Statistical methods for use in proficiency testing by interlaboratory comparison*, ISO/TS 21748, *Guidance for the use of repeatability, reproducibility and trueness estimates in measurement uncertainty estimation*, ISO 21749, *Measurement uncertainty for metrological applications – Repeated measurements and nested experiments*.

3.5 [VIM3: 2.29]
Type B evaluation of measurement uncertainty

Type B evaluation

evaluation of a component of **measurement uncertainty** determined by means other than a **Type A evaluation**

EXAMPLES Evaluation based on information

- associated with authoritative published **values**,
- associated with the value of a property of a **certified reference material**,
- obtained from a **calibration** certificate,
- about drift,
- obtained from the **accuracy class** of a verified **measuring instrument**,
- obtained from limits inferred through personal experience.

NOTE See also the GUM, entry 2.3.3.

3.6 [VIM3: 2.30]
standard measurement uncertainty

standard uncertainty of measurement
standard uncertainty

measurement uncertainty specified as a standard deviation

3.7 [VIM3: 2.31]
combined standard measurement uncertainty

combined standard uncertainty

standard uncertainty that is obtained using the standard uncertainties associated with the **input quantities in a measurement model**

NOTE In case of correlations of the random variables modelling input quantities in a measurement model, covariances must also be taken into account when calculating the combined standard uncertainty; see also the GUM, entry 2.3.4.

3.8 [VIM3: 2.32]
relative standard measurement uncertainty

standard uncertainty divided by the absolute value of a **measured value**

3.9 [VIM3: 2.33]
uncertainty budget

statement of a **measurement uncertainty**, of the components of that measurement uncertainty, and of their calculation and combination

NOTE An uncertainty budget should specify the **measurement model**, estimates and measurement uncertainties associated with the **quantities** in the measurement model, covariances, type of applied probability distributions, degrees of freedom, type of evaluation of measurement uncertainty, and any **coverage factor** if **expanded uncertainty** is considered.

3.10 [VIM3: 2.34]
target measurement uncertainty

target uncertainty

measurement uncertainty specified as an upper limit and decided on the basis of the intended use of **measurement results**

NOTE The target uncertainty of a given **measurement** should be significantly greater than the **definitional uncertainty** of the **measurand**.

3.11 [VIM3: 2.35]
expanded measurement uncertainty

expanded uncertainty

product of a **combined standard uncertainty** and a factor greater than one

NOTE 1 The factor mentioned in the definition is a **coverage factor** and depends upon the type of probability distribution of the **output quantity in a measurement model** and the selected **coverage probability**. Expanded uncertainties are meaningful only for symmetric distributions.

NOTE 2 Expanded measurement uncertainty is termed “overall uncertainty” in paragraph 5 of Recommendation INC-1 (1980) (see the GUM) and simply “uncertainty” in IEC documents.

3.12 [VIM3: 2.36]
coverage interval

interval containing the **value of a quantity** with a stated probability, based on the information available

NOTE 1 A coverage interval does not need to be centred on the chosen **measured value** (see JCGM 101, *Evaluation of measurement data – Supplement 1 to the “Guide to the expression of uncertainty in measurement” – Propagation of distributions using a Monte Carlo method*).

NOTE 2 A coverage interval should not be termed “confidence interval” to avoid confusion with the statistical concept (see the GUM, entry 6.2.2).

NOTE 3 A coverage interval can be derived from an **expanded uncertainty** (see the GUM, entry 2.3.5).

NOTE 4 In this definition “the value of a quantity” is sometimes interpreted as referring to the **true value of the quantity**, where the adjective “true” is considered to be redundant as in the GUM.

NOTE 5 The definition has been taken from JCGM 101, *Evaluation of measurement data – Supplement 1 to the “Guide to the expression of uncertainty in measurement” – Propagation of distributions using a Monte Carlo method*, entry 3.12.

3.13 [VIM3: 2.37]
coverage probability

probability that the **value of a quantity** is contained within a specified **coverage interval**

NOTE 1 Coverage probability is also termed “level of confidence” in the GUM.

NOTE 2 In this definition “the value of a quantity” is sometimes interpreted as referring to the **true value of the quantity**, where the adjective “true” is considered to be redundant as in the GUM.

NOTE 3 The definition has been taken from JCGM 101, *Evaluation of measurement data – Supplement 1 to the “Guide* *to the expression of uncertainty in measurement" – Propagation of distributions using a Monte Carlo method*, entry 3.13.

3.14 [VIM3: 2.38]
coverage factor

number greater than one by which a **combined standard uncertainty** is multiplied to obtain an **expanded uncertainty**

NOTE 1 Coverage factors are meaningful for computing expanded uncertainties only for symmetric distributions.

NOTE 2 A coverage factor is usually symbolized k (see also the GUM, entry 2.3.6).

3.15 [VIM3: 2.13; VIM2: 3.5; VIM1: 3.05]
measurement accuracy

accuracy

closeness of agreement between a **measured value** and a **reference value** of a **measurand**

NOTE 1 The term "closeness of agreement" is maintained in this Vocabulary in keeping with its traditional usage. However, depending on the context, accuracy is sometimes considered to be a **quantity** that can be evaluated.

NOTE 2 Accuracy is customarily thought of as pertaining to either

1) a **measurement procedure**. In this case accuracy is generally known and reported quantitatively, sometimes in terms of **bias** and standard deviation. Algorithms for evaluation are given in the ISO 5725 series of International Standards, Accuracy (trueness and precision) of measurement methods and results);

2) a **measuring instrument** or a **measuring system**. In this case accuracy is generally known and reported quantitatively, sometimes in terms of an **accuracy class**;

3) a single measured value or a set of measured values. In either of these cases accuracy cannot be known because the reference value in this case is a **true value** of the **measurand**. While accuracy and **measurement uncertainty** are not the same, sometimes accuracy is reported in terms of measurement uncertainty and sometimes measurement uncertainty is reported in terms of accuracy.

NOTE 3 Accuracy can be interpreted as the combination of **measurement trueness** and **measurement precision**. However, the term "measurement accuracy" should not be used for measurement trueness and the term "measurement precision" should not be used for measurement accuracy.

NOTE 4 A measurement is said to be more accurate when it offers a smaller measurement error.

3.16 [VIM3: 2.14]
measurement trueness

trueness

closeness of agreement between the average of **measured values** obtained by replicate **measurements** and a **reference value**

NOTE 1 The term "closeness of agreement" is maintained in this Vocabulary in keeping with its traditional usage. However, depending on the context, trueness is sometimes considered to be a **quantity** that can be evaluated.

NOTE 2 Measurement trueness is customarily thought of as pertaining to either 1) a **measurement procedure**, 2) a **measuring instrument** or a **measuring system**, or 3) a single measured value or a set of measured values.

NOTE 3 In practice, the number of averaged measured values must be large enough to make random variability of the result negligible. Measurement trueness may be reported in terms of parameters listed in the ISO 5725 series of International Standards, *Accuracy (trueness and precision) of measurement methods and results*.

NOTE 4 A measurement is said to have better trueness when it offers a smaller **systematic error**, which is estimated by means of **bias**, while trueness is not related to **random error**.

NOTE 5 The term "measurement accuracy" should not be used for measurement trueness.

3.17 [VIM3: 2.15]
measurement precision

precision

closeness of agreement among **indications** or **measured values** obtained by replicate

measurements on the same or similar objects under specified conditions

NOTE 1 The term “closeness of agreement” is maintained in this Vocabulary in keeping with its traditional usage. However, depending on the context, precision is sometimes considered to be a **quantity** that can be evaluated.

NOTE 2 Measurement precision is customarily thought of as pertaining to either 1) a **measurement procedure**, 2) a **measuring instrument** or a **measuring system**, or 3) a set of measured values.

NOTE 3 Measurement precision may be reported in terms of standard deviation, variance, or coefficient of variation under the specified conditions of measurement.

NOTE 4 The specified conditions mentioned in the definition can be, for example, **repeatability conditions of measurement**, **intermediate precision conditions of measurement**, or **reproducibility conditions of measurement** (see ISO 5725-1, *Accuracy (trueness and precision) of measurement methods and results – Part 1: General principles and definitions*).

NOTE 5 A measurement is said to have better precision when it offers a smaller **random error**, while it is not related to **systematic error**.

NOTE 6 Sometimes the term “measurement precision” is erroneously used to mean **measurement accuracy**.

NOTE 7 Precision may be evaluated by replicate measurements on similar items, provided variability among items is accounted for, or is negligible.

3.18 [VIM3: 2.16; VIM2: 3.10; VIM1: 3.10]

measurement error

error of measurement

error

measured value minus a **reference value**

NOTE 1 Measurement error is customarily thought of as pertaining to either 1) a measurement procedure, 2) a measuring instrument/system, or 3) a single measured value or a set of measured values.

NOTE 2 The term “measurement error” can be used either a) when there is a single reference value to refer to, which occurs if a **calibration** is made by means of a **measurement standard** with a **measured value** having a negligible **measurement uncertainty** or if a **conventional value** is given, in which case the measurement error is known, or b) if a **measurand** is supposed to be represented by a set of **true values** of negligible range (an essentially unique true value), in which case the measurement error is not known.

NOTE 3 Measurement error is traditionally interpreted as having systematic components and random components, though the distinction between **systematic error** and **random error** may depend on the context. Sometimes systematic error and random error are combined additively.

NOTE 4 A known measurement error should be reported together with an associated uncertainty.

NOTE 5 Measurement error should not be confused with production error or mistake.

3.19 [VIM3: 2.17; VIM2: 3.14; VIM1: 3.13]

systematic measurement error

systematic error of measurement

systematic error

component of **measurement error** that in replicate **measurements** remains constant or varies in a predictable manner

NOTE 1 A **reference value** for a systematic error is a **true value**, or a **measured value** of a **measurement standard** of negligible **measurement uncertainty**, or a **conventional value**.

NOTE 2 Systematic error, and its causes, can be known or unknown. A **correction** can be applied to compensate for a known systematic error.

NOTE 3 Systematic error usually equals measurement error minus **random error**.

3.20 [VIM3: 2.18]

measurement bias

bias

estimate of a **systematic error**

NOTE 1 This definition applies to **measurements** where the systematic error is not known (i.e., where the **reference**

value is a **true value**) and therefore it needs to be estimated. In these cases, the estimated value should be accompanied with an **uncertainty**.

NOTE 2 Sometimes measurement bias is incorporated in a **measurement model** as a **correction**.

3.21 [VIM3: 2.19; VIM2: 3.13; VIM1: 3.12]
random measurement error

random error of measurement

random error

component of **measurement error** that in replicate **measurements** varies in an unpredictable manner

NOTE 1 A **reference value** for a random error is the average that would ensue from replicate measurements of the same **measurand**. In practice, the number of averaged values must be large enough to make random variability of the average negligible.

NOTE 2 Random errors of a set of replicate measurements form a distribution that can be summarized by its average, which is generally assumed to be zero, and its standard deviation.

NOTE 3 Random error usually equals measurement error minus **systematic error**.

3.22 [VIM3: 2.20; VIM2: 3.6 Notes 1 and 2]
repeatability condition of measurement

repeatability condition

condition of **measurement** that is held fixed while performing two or more measurements over a short period of time

NOTE 1 A set of repeatability conditions typically includes **measurement procedure**, **measuring system**, measuring system operator, operating conditions, and measurement location.

NOTE 2 In chemistry, the term “intra-serial precision condition of measurement” is sometimes used for referring to repeatability conditions.

NOTE 3 The short period of time mentioned in the definition is intended to be as short as necessary in order to avoid the occurrence of changes in the set of conditions (see ISO 5725-1, *Accuracy (trueness and precision) of measurement methods and results – Part 1: General principles and definitions*, entry 4.4).

NOTE 4 Repeatability may be evaluated by replicate measurements on similar objects, provided variability among the objects is accounted for, or is negligible.

3.23 [VIM3: 2.21; VIM2: 3.6; VIM1: 3.06]
measurement repeatability

repeatability

measurement precision under a set of **repeatability conditions**

3.24 [VIM3: 2.22]
intermediate precision condition of measurement

intermediate precision condition

condition of **measurement**, out of a set of conditions that includes the same **measurement procedure**, same location, and replicate measurements on the same or similar objects over an extended period of time, but may include other conditions involving changes

NOTE 1 The changes mentioned in the definition may include new **calibrations**, **calibrators**, operators, and **measuring systems**.

NOTE 2 The specification of an intermediate precision condition should include the conditions changed and unchanged, to the extent practical.

NOTE 3 In chemistry, the term “inter-serial precision condition of measurement” is sometimes used for referring to intermediate precision conditions.

NOTE 4 The extended period of time mentioned in the definition is intended to be long enough to allow for conditions involving changes to actually occur.

NOTE 5 Intermediate precision may be evaluated by replicate measurements on similar objects, provided variability among the objects is accounted for, or is negligible.

3.25 [VIM3: 2.23]
intermediate measurement precision

intermediate precision

measurement precision under a set of **intermediate precision conditions**

NOTE Relevant statistical terms are given in ISO 5725-3, *Accuracy (trueness and precision) of measurement methods and results – Part 3: Intermediate measures of the precision of a standard measurement method*.

3.26 [VIM3: 2.24; VIM2: 3.7 Note 2]
reproducibility condition of measurement

reproducibility condition

condition of **measurement**, out of a set of conditions that includes different locations, operators, **measuring systems**, and replicate measurements on the same or similar objects

NOTE 1 The specification of a reproducibility condition should include the conditions changed and unchanged, to the extent practical.

NOTE 2 In some cases the different measuring systems mentioned in the definition may use different **measurement procedures**.

3.27 [VIM3: 2.25; VIM2: 3.7; VIM1: 3.07]
measurement reproducibility

reproducibility

measurement precision under **reproducibility conditions**

NOTE Relevant statistical terms are given in ISO 5725-1, *Accuracy (trueness and precision) of measurement methods and results – Part 1: General principles and definitions* and ISO 5725-2, *Accuracy (trueness and precision) of measurement methods and results – Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*.

3.28 [VIM3: 2.26; VIM2: 5.21; VIM1: 5.23]
maximum permissible measurement error

maximum permissible error

limit of error

MPE

extreme **measurement error**, with respect to a known **reference value**, permitted by specifications or regulations for a given **measurement**, **measuring instrument**, or **measuring system**

NOTE 1 Usually, the terms “maximum permissible errors” or “limits of error” are used where there are two different extreme values.

NOTE 2 The term “tolerance” should not be used for referring to maximum permissible errors.

3.29 [VIM3: 4.27; VIM2: 5.22; VIM1: 5.25]
datum measurement error

datum error

measurement error of a **measuring instrument** or **measuring system** at a specified **measured value**

3.30 [VIM3: 4.28; VIM2: 5.23; VIM1: 5.26]

zero error

error at zero

datum error where the specified **measured value** is zero

NOTE Zero error should not be confused with absence of **measurement error**.

3.31 [VIM3: 2.29]

null measurement uncertainty

measurement uncertainty where the **measured value** is zero

NOTE 1 Null measurement uncertainty is associated with a null or near zero **indication** and covers an interval where one does not know whether the **measurand** is too small to be detected or the indication of the **measuring instrument** is due only to noise.

NOTE 2 Null measurement uncertainty also applies when a difference is obtained between **measurement** of a sample and a blank.

4 Measuring devices and their properties

4.1 [VIM3: 3.1; VIM2: 4.1; VIM1: 4.01]
measuring instrument

device used for making **measurements**, alone or in conjunction with one or more supplementary devices

NOTE 1 A measuring instrument that can be used alone for making measurements is a **measuring system**.

NOTE 2 A measuring instrument is either an **indicating measuring instrument** or a **material measure**.

4.2 [VIM3: 3.2; VIM2: 4.5; VIM1: 4.05]
measuring system

set of one or more **measuring instruments** and often other components, assembled and adapted to give information used to generate **measured values** within specified intervals for **quantities** of specified **kinds**

NOTE 1 The components mentioned in the definition may be devices, reagents, and supplies.

NOTE 2 A measuring system is sometimes referred to as “measuring equipment” or “device”, for example in ISO 10012, *Measurement management systems – Requirements for measurement processes and measuring equipment* and ISO 17025, *General requirements for the competence of testing and calibration laboratories*.

NOTE 3 Although the terms “measuring system” and “measurement system” are frequently used synonymously, the latter is instead sometimes used to refer to a measuring system plus all other entities involved in a measurement, including the object under measurement and the person(s) performing the measurement.

NOTE 4 A measuring system can be used as a **measurement standard**.

4.3 [VIM3: 3.3; VIM2: 4.6; VIM1: 4.06]
indicating measuring instrument

measuring instrument providing an output signal carrying information about the **value** of the **quantity** being measured

EXAMPLES Voltmeter, micrometer, thermometer, electronic balance.

NOTE 1 The quantity being measured that is mentioned in the definition might not be the same as the **measurand**, for example when the measuring instrument does not properly interact with the object under measurement.

NOTE 2 An indicating measuring instrument may provide a record of its **indication**.

NOTE 3 An output signal may be presented in visual or acoustic form. It may also be transmitted to one or more other devices.

4.4 [VIM3: 3.4; VIM2: 4.6; VIM1: 4.06]
displaying measuring instrument

indicating measuring instrument where the output signal is presented in visual form

4.5 [VIM3: 3.5; VIM2: 4.17; VIM1: 4.19]
scale of a displaying measuring instrument

component of a **displaying measuring instrument**, consisting of an ordered set of marks together with any associated **values**

4.6 [VIM3: 3.6; VIM2: 4.2; VIM1: 4.02]
material measure

measuring instrument reproducing or supplying, in a permanent manner during its use, **quantities** of one or more given kinds, each with an assigned **value**

EXAMPLES Standard weight, volume measure (supplying one or several values, with or without a **measurement**

scale), standard electric resistor, line scale (ruler), gauge block, standard signal generator, **certified reference material**.

NOTE 1 The **indication** of a material measure is its assigned value.

NOTE 2 A material measure can be used as a **measurement standard**.

4.7 [VIM3: 3.7; VIM2: 4.3; VIM1: 4.03]

measuring transducer

component of a **measuring system** that provides an output **quantity** having a specified relation to the input quantity

EXAMPLES Thermocouple, electric current transformer, strain gauge, pH electrode, Bourdon tube, bimetallic strip.

4.8 [VIM3: 3.8; VIM2: 4.14; VIM1: 4.15]

sensor

component of a **measuring system** that is directly affected by a phenomenon, body, or substance carrying a **quantity** being measured

EXAMPLES Sensing coil of a platinum resistance thermometer, rotor of a turbine flow meter, Bourdon tube of a pressure gauge, float of a level-measuring instrument, photocell of a spectrometer, thermotropic liquid crystal which changes colour as a function of temperature.

NOTE In some fields, the term “detector” is used for referring to sensors.

4.9 [VIM3: 3.9; VIM2: 4.15; VIM1: 4.16]

detector

device or substance that indicates the presence of a phenomenon, body, or substance when a threshold **value** of an associated **quantity** is exceeded

EXAMPLES Halogen leak detector, litmus paper.

NOTE 1 In some fields, the term “detector” is used for referring to sensors.

NOTE 2 In chemistry, the term “indicator” is frequently used for referring to detectors.

4.10 [VIM3: 3.10; VIM2: 4.4; VIM1: 4.04]

measuring chain

series of elements of a **measuring system** constituting a single path of the signal from a **sensor** to an output element

EXAMPLE 1 Electro-acoustic measuring chain comprising a microphone, attenuator, filter, amplifier, and voltmeter.

EXAMPLE 2 Mechanical measuring chain comprising a Bourdon tube, system of levers, two gears, and a mechanical dial.

4.11 [VIM3: 3.11; VIM2: 4.30; VIM1: 4.33]

adjustment

adjustment of a measuring system

set of operations carried out on a **measuring system** so that it provides prescribed **indications** corresponding to given **values** of a **quantity** being measured

NOTE 1 If there is any doubt that the context in which the term is being used is that of metrology, the long form “adjustment of a measuring system” might be used.

NOTE 2 Types of adjustment of a measuring system include **zero adjustment**, offset adjustment, and span adjustment (sometimes called “gain adjustment”).

NOTE 3 Adjustment of a measuring system should not be confused with **calibration**, which is sometimes a prerequisite for adjustment.

NOTE 4 After an adjustment of a measuring system, the measuring system must usually be recalibrated.

4.12 [VIM3: 3.12]
zero adjustment

zero adjustment of a measuring system

adjustment of a measuring system so that it provides a null **indication** corresponding to a zero **value** of a **quantity** being measured

NOTE 1 If there is any doubt that the context in which the term is being used is that of metrology, the long form "zero adjustment of a measuring system" might be used.

4.13 [VIM3: 4.1; VIM2: 3.2; VIM1: 3.02]
indication

instrumental indication

reading

value of a quantity provided by an **indicating measuring instrument**

NOTE 1 Step 2 of the **calibration** of a **measuring instrument** or a **measuring system** involves establishing the relation between indications and **measured values**. Indications are thus independent of whether the instrument has been calibrated.

NOTE 2 An indication and a corresponding **value** of the **quantity** being measured are not necessarily values of quantities of the same **kind**. For example, an indication might be the value of the angle of deflection of a pointer on the measuring instrument, whereas the quantity being measured might be a pressure. The two entities are not to be confused, even though a symbol of a value of the quantity being measured might be written on the instrument display.

NOTE 3 Indications are sometimes understood as quantities, rather than as values.

4.14 [VIM3: 4.2]
blank indication

background indication

indication obtained from a phenomenon, body, or substance similar to the one under investigation, but for which a **quantity** of interest is supposed not to be present, or is not contributing to the indication

4.15 [VIM3: 4.3; VIM2: 4.19; VIM1: 4.21]
indication interval

interval of **values** bounded by extreme possible **indications**

NOTE 1 An indication interval is usually stated in terms of its smallest and greatest values, for example "99 V to 201 V".

NOTE 2 In some fields, the term referring to an indication interval is "range of indications", not to be confused with a range of a nominal indication interval.

4.16 [VIM3: 4.4; VIM2: 5.1; VIM1: 5.01]
nominal indication interval

nominal interval

indication interval, bounded by rounded or approximate extreme **indications**, obtainable with a particular setting of the controls of a **measuring instrument** or **measuring system** and used to designate that setting

NOTE 1 A nominal indication interval is usually stated as its smallest and greatest values, for example "100 V to 200 V".

NOTE 2 In some fields, the term "nominal range" is used for referring to nominal intervals.

4.17 [VIM3: 4.6; VIM2: 5.3; VIM1: 5.03]
nominal value

nominal value of a quantity
nominal value of a quantity of a measuring system

rounded or approximate **value** of a characterizing **quantity** of a **measuring system** that provides guidance for its appropriate use

EXAMPLE 1 100 Ω as the nominal value of electric resistence as a characterizing quantity of a standard resistor.

EXAMPLE 2 1 000 ml as the nominal value of volume as a characterizing quantity of a single-mark volumetric flask.

EXAMPLE 3 0.1 mol/l as the nominal value of amount-of-substance concentration as a characterizing quantity of a solution of hydrogen chloride, HCl, as used in a measuring instrument.

NOTE 1 If there is any doubt that the context in which the term is being used is that of metrology, the long form “nominal value of a quantity of a measuring system” might be used.

NOTE 2 The terms “nominal value” and “nominal value of a quantity” should not be used for referring to nominal property values.

4.18 [VIM3: 4.7; VIM2: 5.4; VIM1: 5.04]
measuring interval

working interval

interval of **values** of **quantities** of the same kind that can be measured by a given **measuring instrument** or **measuring system** with specified **instrumental uncertainty**, under defined conditions

NOTE 1 In some fields, the terms “measuring range” or “measurement range” are used for referring to measuring intervals.

NOTE 2 The lower limit of a measuring interval should not be confused with **detection limit**.

4.19 [new]
operating condition

state of a **measuring instrument** or **measuring system** when it is in operation

NOTE The state of a measuring instrument or measuring system can include whether and how it is powered / energized, the state of internal components / circuitry / interconnections when energized (for example, what is constant and what varies with time), and what are the **values** of the environmental **quantities** that are known to influence the **indication** in a significant, predictable but otherwise undesirable way.

EXAMPLE A set of operating conditions for a battery-powered voltmeter could include the required type and voltage of the battery, the temperature range over which the electronic circuitry is designed to operate properly when the voltmeter is in operation, what part of the circuitry is designed to remain constant (for example, electric current) and what part of the circuitry varies with time during normal operation, the values of environmental quantities known to significantly influence the indication of the voltmeter in a predictable but undesirable way (for example, ambient temperature and humidity, ambient electromagnetic fields) and the actual **measurement** range employed.

4.20 [VIM3: 4.9; VIM2: 5.5; VIM1: 5.05]
rated operating condition

operating condition that must be achieved in order that a **measuring instrument** or **measuring system** perform as designed

NOTE Rated operating conditions generally specify intervals of **values** for a **quantity** being measured and for any **influence quantity**.

4.21 [VIM3: 4.10; VIM2: 5.6; VIM1: 5.06]
limiting operating condition

extreme **operating condition** that a **measuring instrument** or **measuring system** is required to withstand without damage, and without degradation of specified metrological properties, when it is subsequently operated under its **rated operating conditions**

NOTE 1 Limiting conditions for storage, transport or operation can differ.

NOTE 2 Limiting conditions can include limiting **values** of a **quantity** being measured and of any **influence quantity**.

4.22 [VIM3: 4.11; VIM2: 5.7; VIM1: 5.07]

reference operating condition

reference condition

operating condition prescribed for evaluating the performance of a **measuring instrument** or **measuring system** or for comparison of **measurement results**

NOTE 1 Reference operating conditions specify intervals of **values** of the **measurand** and of the **influence quantities**.

NOTE 2 In IEC 60050-300, *International Electrotechnical Vocabulary – Electrical and electronic measurements and measuring instruments*, definition 311-06-02, the term "reference condition" refers to an operating condition under which the specified **instrumental uncertainty** is the smallest possible.

4.23 [VIM3: 4.12; VIM2: 5.10; VIM1: 5.10]

sensitivity

sensitivity of a measuring instrument

quotient of the change in an **indication** of a **measuring instrument** and the corresponding change in a given **value** of the **quantity** being measured

NOTE 1 If there is any doubt that the context in which the term is being used is that of **metrology**, the long form "sensitivity of a measuring instrument" might be used.

NOTE 2 Sensitivity of a measuring instrument can depend on (i) the quantity being measured, (ii) the **influence quantities**, and (iii) aging of the instrument. Sensitivity is evaluated under the condition that the influence quantities do not change.

NOTE 3 The change considered in the value of the quantity being measured must be large compared with the **resolution** of the measuring instrument.

4.24 [VIM3: 4.13]

selectivity

selectivity of a measuring instrument

property of a **measuring instrument**, whereby it provides **indications** that are independent of **quantities** other than the quantity being measured but that are of the same kind as the measurand

EXAMPLE 1 Capability of a quadrupole mass spectrometer to provide indications of the presence of background gases in an ultrahigh vacuum chamber by the ion current generated, without disturbance by other specified sources of electric current.

EXAMPLE 2 Capability of a measuring instrument to provide indications about the power of a signal component at a given frequency without being disturbed by signal components or other signals at other frequencies.

EXAMPLE 3 Capability of a receiver to discriminate between indications about a wanted signal and unwanted signals, often having frequencies slightly different from the frequency of the wanted signal.

EXAMPLE 4 Capability of a measuring instrument for ionizing radiation to provide indications about a given radiation to be measured in the presence of concomitant radiation.

EXAMPLE 5 Capability of a measuring instrument to provide indications about the amount-of-substance concentration of creatininium in blood plasma without being influenced by the glucose, urate, ketone, and protein concentrations.

EXAMPLE 6 Capability of a mass spectrometer to provide indications about the amount-of-substance abundance of the ^{28}Si isotope and of the ^{30}Si isotope in silicon from a geological deposit without influence between the two, or from the ^{29}Si isotope.

NOTE 1 If there is any doubt that the context in which the term is being used is that of **metrology**, the long form "selectivity of a measuring instrument" might be used.

NOTE 2 In chemistry the property of a measuring instrument being selective to only one **measurand** in a sample is often termed “specificity”.

NOTE 3 In chemistry, selectivity of a measuring instrument is usually obtained for quantities with selected components in concentrations within stated intervals.

4.25 [VIM3: 4.14]
resolution

resolution of a measuring instrument

smallest change in the **quantity** being measured that causes a detectable change in the corresponding **indication**

NOTE 1 If there is any doubt that the context in which the term is being used is that of **metrology**, the long form “resolution of a measuring instrument” might be used.

NOTE 2 Resolution can depend on the **value** of the quantity being measured. It may also depend on noise (internal or external) or friction.

NOTE 3 The resolution of a **measuring instrument** is not the same thing as the resolution of a **displaying device**. The difference is that the resolution of a displaying device is determined from detectable changes in indications of the displaying device, whereas the resolution of a measuring instrument is determined from detectable changes in **measured values** when using the measuring instrument, which are in turn based on knowing the relation of the measured value to the indication as obtained through **calibration** of the measuring instrument.

NOTE 4: Resolution is not necessarily the same as **discrimination threshold**.

4.26 [VIM3: 4.16; VIM2: 5.11; VIM1: 5.12]
discrimination threshold

largest change in the **quantity** being measured that causes no detectable change in the corresponding **indication**

NOTE 1 Discrimination threshold may depend, for example, on noise (internal or external) or friction. It can also depend on the **value** of the quantity being measured and how the change is applied.

NOTE 2: Discrimination threshold is not necessarily the same as **resolution**.

4.27 [VIM3: 4.17; VIM2: 5.13; VIM1: 5.14]
dead band

maximum interval through which the **quantity** being measured can be changed in both directions without producing a detectable change in the corresponding **indication**

NOTE 1 Dead band can depend on the rate of change of the quantity being measured.

NOTE 2 A dead band may be exploited, or purposely introduced, to prevent the occurrence of changes in the indication unrelated to the **value** of the quantity being measured, such as those caused by noise.

4.28 [VIM3: 4.18; VIM2: 4.15 Note 1]
detection limit

limit of detection

value of the **measurand** for which the probability of falsely claiming the absence of a component in a material is β, given a probability α of falsely claiming its presence

NOTE 1 The abbreviation LOD is sometimes used for referring to detection limit.

NOTE 2 Detection limit is usually considered to be a feature of a particular **measurement procedure** in a given laboratory.

NOTE 3 The term “sensitivity” is discouraged for referring to detection limits.

NOTE 4 IUPAC recommends default values for α and β equal to 0.05.

4.29 **[VIM3: 4.19; VIM2: 5.14; VIM1: 5.16]**
stability
stability of a measuring instrument

property of a **measuring instrument**, whereby its metrological properties remain constant in time

NOTE 1 If there is any doubt that the term refers to a measuring instrument, the long form “stability of a measuring instrument” might be used.

NOTE 2 Stability may be quantified in several ways.

EXAMPLE 1 In terms of the duration of a time interval over which a metrological property changes by a stated amount.

EXAMPLE 2 In terms of the change of a property over a stated time interval.

4.30 **[VIM3: 4.20; VIM2: 5.25; VIM1: 5.28]**
instrumental bias

average of replicate **indications** minus a **reference value**

4.31 **[VIM3: 4.21; VIM2: 5.16; VIM1: 5.18]**
instrumental drift

gradual undesirable change over time in **indication** of a **measuring instrument** due to its limited **stability** for the same **quantity** being measured

NOTE Instrumental drift is related neither to a change in a quantity being measured nor to a change of any recognized **influence quantity**.

4.32 **[VIM3: 4.23; VIM2: 5.17; VIM1: 5.19]**
step response time

duration between the instant when an input **quantity** to a **measuring instrument** or **measuring system** is subjected to an abrupt change between two specified constant values and the instant when a corresponding **indication** settles within specified limits around its final steady value

4.33 **[VIM3: 4.25; VIM2: 5.19; VIM1: 5.22]**
accuracy class

class of **measuring instruments** or **measuring systems** that meet stated metrological requirements that are intended to keep **measurement errors** and **instrumental uncertainties** within specified limits under specified **operating conditions**

NOTE 1 An accuracy class is usually denoted by a number or symbol adopted by convention.

NOTE 2 Accuracy class may apply to **material measures**.

5 Measurement standards (etalons) and metrological traceability

5.1 [VIM3: 5.1; VIM2: 6.1; VIM1: 6.01]
measurement standard

etalon

realization of the definition of a **quantity** with stated **value** and associated **measurement uncertainty**, used as a reference

NOTE 1 A measurement standard can be a **measuring system**, a **material measure**, or a **certified reference material**.

EXAMPLE 1 Laser interferometer (measuring system) used to realize the definition of the metre (utilizing the defining constant of the speed of light) with standard uncertainty of 0.1 µm.

EXAMPLE 2 Pressure balance (measuring system) used to generate and measure absolute-mode atmospheric pressure with a standard uncertainty of 0.2 Pa.

EXAMPLE 3 1 kg mass standard (material measure) with **standard uncertainty** of 3 µg.

EXAMPLE 4 100 Ω standard resistor (material measure) with standard uncertainty of 1 µΩ.

EXAMPLE 5 Caesium frequency standard (measuring system) with a relative standard uncertainty of $2 \cdot 10^{-15}$.

EXAMPLE 6 Standard buffer solution (reference material) with a pH of 7.072 with standard uncertainty of 0.006.

EXAMPLE 7 Set of reference materials containing cortisol in human serum having a certified value with measurement uncertainty for each solution.

EXAMPLE 8 Reference material providing values with measurement uncertainties for the mass concentration of each of ten different proteins.

NOTE 2 In science and technology, the noun “standard” is used with at least two different meanings: as a specification, technical recommendation, or similar normative document (in French “norme”) and as a measurement standard (in French “étalon”). This Vocabulary is concerned solely with the second meaning.

NOTE 3 Measurement standards are used to conserve, reproduce, or disseminate the specified individual quantity, and to calibrate measuring systems.

NOTE 4 A measurement standard is frequently used as a reference in establishing **measured values** and associated measurement uncertainties for other quantities of the same kind, thereby establishing **metrological traceability** through **calibration** of other measurement standards, **measuring instruments**, or **measuring systems**.

NOTE 5 The definition of an individual quantity can be realized in three different ways. The first one is the direct realization of the definition (e.g., realizing the definition of the metre through a device which implements the definition of the speed of light in vacuum and the second). The second way, termed “reproduction”, is the setting up of a measurement standard based on a physical phenomenon (for example, a Josephson array in the case of a voltage standard). The third way is to adopt a material measure as a measurement standard.

NOTE 6 The standard uncertainty associated with a measurement standard is always a component of the **combined standard uncertainty** (see the GUM, entry 2.3.4) in a **measurement result** obtained using the measurement standard. Frequently, this component is small compared with other components of the combined standard uncertainty.

NOTE 7 Since the relevant quantity of the measurement standard might change over time, the stated value must be attributed and measurement uncertainty must be evaluated at the time that the measurement standard is used.

NOTE 8 A measurement standard may realize the definition of more than one quantity of the same kind or of different kinds. For example, a working standard for electric power measuring instruments may provide both alternating current (AC) voltage and AC current sinusoidal waveforms with preset phase angles.

NOTE 9 The realization is sometimes called “embodiment”.

NOTE 10 The term “measurement standard” is sometimes used for referring to other metrological tools, for example software measurement standards (see ISO 5436-2, *Geometrical product specifications (GPS) – Surface texture: Profile method; Measurement standards – Part 2: Software measurement standards*).

5.2 [VIM3: 5.2; VIM2: 6.2; VIM1: 6.06]
international measurement standard

measurement standard recognized by signatories to an international agreement and intended to serve worldwide and used as the basis for assigning **values** to other measurement standards for the **kind of quantity** concerned

EXAMPLE 1 Prior to the introduction of the revision of the **SI** in 2019, the International Prototype of the Kilogram, as is maintained by the International Bureau of Weights and Measures (BIPM).

EXAMPLE 2 Chorionic gonadotrophin, World Health Organization (WHO) 5th international standard 2013, 07/364, 179 International Units per ampoule.

EXAMPLE 3 VSMOW2 (Vienna Standard Mean Ocean Water) distributed by the International Atomic Energy Agency (IAEA) for **measurements** of differential stable isotope amount-of-substance ratio.

5.3 [VIM3: 5.3; VIM2: 6.3; VIM1: 6.07]
national measurement standard

national standard

measurement standard recognized by national authority to serve in a state or economy as the basis for assigning **values** to other measurement standards for the **kind of quantity** concerned

5.4 [VIM3: 5.4; VIM2: 6.4; VIM1: 6.04]
primary measurement standard

primary standard

measurement standard established using a **primary method**, or a **primary reference procedure**, or created as an artefact, chosen by convention

EXAMPLE 1 Primary standard of amount-of-substance concentration prepared by dissolving a known amount of substance of a chemical component to a known volume of solution.

EXAMPLE 2 Primary standard for pressure based on separate **measurements** of force and area.

EXAMPLE 3 Primary standard for isotope amount-of-substance ratio measurements, prepared by mixing known amount of substances of specified isotopes.

EXAMPLE 4 Prior to the introduction of the revision of the SI in 2019, the International Prototype of the Kilogram, as an artifact, chosen by convention and maintained by the International Bureau of Weights and Measures (BIPM).

5.5 [VIM3: 5.5; VIM2: 6.5; VIM1: 6.05]
secondary measurement standard

secondary standard

measurement standard established through **calibration** with respect to a **primary standard** for a **quantity** of the same kind

NOTE Calibration may be obtained directly by comparison between a primary standard and a secondary standard, or involve an intermediate **measuring system** calibrated by the primary standard and assigning a **measurement result** to the secondary standard.

5.6 [VIM3: 5.6; VIM2: 6.6; VIM1: 6.08]
reference measurement standard

reference standard

measurement standard designated for the **calibration** of other measurement standards for **quantities** of a given kind in a given organization or at a given location

5.7 [VIM3: 5.7; VIM2: 6.7; VIM1: 6.09]
working measurement standard

working standard

calibrator

measurement standard that is used routinely to calibrate or verify **measuring instruments** or **measuring systems**

NOTE 1 A working standard is usually calibrated with respect to a **reference standard**.

NOTE 2 When a working standard is used for **verification**, it is sometimes called “check standard” or “control standard”.

NOTE 3 The term “calibrator” is often used in the context of **calibration** in manufacturing, chemistry, and laboratory medicine.

5.8 [VIM3: 5.8; VIM2: 6.9; VIM1: 6.11]
travelling measurement standard

travelling standard

measurement standard, sometimes of special construction, suitably robust for transport between different locations

EXAMPLE Portable battery-operated caesium-133 frequency measurement standard.

5.9 [VIM3: 5.9; VIM2: 6.8; VIM1: 6.10]
transfer measurement device

transfer device

device used as an intermediary to compare **measurement standards**

EXAMPLE Adjustable callipers used to compare end standards.

NOTE Measurement standards are sometimes used as transfer devices.

5.10 [VIM3: 5.10]
intrinsic measurement standard

intrinsic standard

measurement standard based on an inherent and reproducible property of a phenomenon or substance

EXAMPLE 1 Triple-point-of-water cell as an intrinsic standard of thermodynamic temperature.

EXAMPLE 2 Intrinsic standard of electric potential difference based on the Josephson effect.

EXAMPLE 3 Intrinsic standard of electric resistance based on the quantum Hall effect.

EXAMPLE 4 Sample of pure copper as an intrinsic standard of electric conductivity.

NOTE 1 The **value** of the relevant property of an intrinsic standard is assigned by consensus and does not need to be established by relating it to another standard of the same type. Its **measurement uncertainty** is determined by considering two components: the first associated with its value assigned by consensus and the second associated with its construction, implementation, and maintenance.

NOTE 2 An intrinsic standard usually consists of a system produced according to the requirements of a consensus procedure and subject to periodic **verification**. The consensus procedure may contain provisions for the application of **corrections** necessitated by the implementation.

NOTE 3 Intrinsic standards that are based on quantum phenomena usually have outstanding **stability**.

NOTE 4 The adjective “intrinsic” does not mean that such a measurement standard may be implemented and used without special care or that such a standard is immune to internal and external influences.

NOTE 5 The adjective “inherent” in the definition corresponds to the requirement that the property of the involved phenomenon or substance is constant in space and time.

5.11 [VIM3: 5.11; VIM2: 6.12; VIM1: 6.14]
conservation of a measurement standard

maintenance of a measurement standard

set of operations necessary to preserve the metrological properties of a **measurement standard** within stated limits

NOTE Conservation commonly includes periodic **verification** of predefined metrological properties or **calibration**, storage under suitable conditions, and specified care in use.

5.12 [VIM3: 5.13; VIM2: 6.13; VIM1: 6.15]
reference material

RM

material, sufficiently homogeneous and stable with reference to one or more specified properties, which has been established to be fit for its intended use in **measurement** or in **examination**

NOTE 1 Reference materials can be certified reference materials or reference materials without a certified property value.

NOTE 2 For a reference material to be used as a measurement standard for calibration purposes it needs to be a certified reference material.

NOTE 3 Reference materials can be used for **measurement precision** evaluation and quality control.

EXAMPLE Human serum without an assigned quantity value for the amount-of-substance concentration of the inherent cholesterol, used for quality control.

NOTE 4 Properties of reference materials can be **quantities** or **nominal properties**.

NOTE 5 A reference material is sometimes incorporated into a specially fabricated device.

EXAMPLE Spheres of uniform size mounted on a microscope slide.

NOTE 6 Some reference materials have assigned values in a **unit** outside the **SI**. Such materials include vaccines to which International Units (IU) have been assigned by the World Health Organization.

NOTE 7 A given reference material can only be used for one purpose in a **measurement**, either calibration or quality control, but not both.

NOTE 8 ISO/REMCO has an analogous definition but uses the term “measurement process” (ISO Guide 30, *Reference materials – Selected terms and definitions*, definition 2.1.1) for both measurement and examination.

5.13 [VIM3: 5.14; VIM2: 6.14; VIM1: 6.16]
certified reference material

CRM

reference material, characterized by a metrologically valid approach for one or more specified properties, accompanied by an RM certificate that provides the values of the specified properties, associated uncertainties, and statements of **metrological traceability**

NOTE 1 Metrologically valid approaches for the characterization of RMs are given in ISO 17034, *General requirements for the competence of reference material producers*.

NOTE 2 Only certified reference materials, thus having certified property values, can be used for **calibration** or for assessing **measurement trueness**.

EXAMPLE Human serum with assigned value for the substance concentration of total cholesterol with associated **uncertainty** and a statement of metrological traceability in an accompanying certificate, used for calibration of in-vitro diagnostic assays.

NOTE 3 This definition is taken from ISO Guide 30, *Reference materials – Selected terms and definitions*, developed by ISO/REMCO, where the modifiers “metrological” and “metrologically” are used for both **quantities** and **nominal properties**.

5.14 [new]
certified value of a CRM

value, assigned to a property of a **certified reference material** (CRM) that is accompanied by an **uncertainty** and a statement of **metrological traceability**, identified as such in the CRM certificate

NOTE The value mentioned in the definition of either a value of a quantity or a value of a nominal property.

5.15 [VIM3: 5.15]
commutability of a reference material

property of a **reference material**, demonstrated by the closeness of agreement between the relation among the **measurement results** for a stated **quantity** in this material, obtained according to **measurement procedures** for which the material is intended for use, and the relation obtained among the measurement results for other specified materials

NOTE 1 The reference material in question is usually a **calibrator** and the other specified materials are usually routine samples.

NOTE 2 If an internationally recognized **reference measurement procedure** for the **measurand** exists, it should be included to investigate commutability (see ISO 15193, *In vitro diagnostic medical devices – Measurement of quantities in samples of biological origin – Requirements for content and presentation of reference measurement procedures*).

NOTE 3 Manufacturers' working calibrator(s) and end-user calibrator(s) are not typically required to be commutable, but their capacity for transferring **trueness** from a commutable reference material used as a higher order calibrator to the **values** assigned to clinical samples using an end-user measurement procedure must be assured.

5.16 [VIM3: 5.16]
reference data

data related to a property of a phenomenon, body, or substance, or to a system of components of known composition or structure, obtained from an identified source, critically evaluated, and verified for accuracy

EXAMPLE Reference data for solubility of chemical compounds as published by IUPAC.

NOTE "Data" is a plural form, "datum" is the singular. "Data" is commonly used in the singular sense, instead of "datum".

5.17 [VIM3: 5.17]
standard reference data

reference data issued by a recognized authority

EXAMPLE 1 **Values** of the fundamental physical constants, as regularly evaluated and recommended by CODATA of ICSU.

EXAMPLE 2 Relative atomic mass values, also called atomic weight values, of the elements, as evaluated every two years by IUPAC-CIAAW, approved by the IUPAC General Assembly, and published in Pure Appl. Chem.

5.18 [VIM3: 2.39; VIM2: 6.11; VIM1: 6.13]
calibration

operation performed on a **measuring instrument** or a **measuring system** that, under specified conditions

1. establishes a relation between the **values** with **measurement uncertainties** provided by **measurement standards** and corresponding **indications** with associated measurement uncertainties and
2. uses this information to establish a relation for obtaining a **measurement result** from an indication

NOTE 1 The objective of calibration is to provide **traceability** of measurement results obtained when using a calibrated measuring instrument or measuring system.

NOTE 2 The outcome of a calibration may be expressed by a statement, calibration function, **calibration diagram**, **calibration curve**, or calibration table. In some cases, it may consist of an additive or multiplicative **correction** of the indication with associated measurement uncertainty.

NOTE 3 Calibration should not be confused with **adjustment of a measuring system**, often mistakenly called "self-calibration", nor with **verification** of calibration. Calibration is sometimes a prerequisite for verification, which provides confirmation that specified requirements (often **maximum permissible errors**) are met. Calibration is sometimes also a prerequisite for **adjustment**, which is the set of operations carried out on a measuring system such that the system provides prescribed indications corresponding to given values of **quantities** being measured, typically obtained from measurement standards.

NOTE 4 Sometimes the first step alone of the operation mentioned in the definition is intended as being calibration, as it was in previous editions of this Vocabulary. The second step is in fact required to establish **instrumental uncertainty** for the measurement results obtained when using the calibrated measuring system. The two steps together aim to demonstrate the metrological traceability of measurement results obtained by a calibrated measuring system. In the past the second step was usually considered to occur after the calibration.

NOTE 5 A comparison between two measurement standards may be viewed as a calibration if the comparison is used to check and, if necessary, correct the value and measurement uncertainty attributed to one of the measurement standards.

5.19 [VIM3: 4.31]
calibration function

calibration curve

functional relation between **indications** and corresponding **measured values**

NOTE 1 A calibration function expresses a functional relation that does not supply a **measurement result** as it bears no information about the **measurement uncertainty**.

NOTE 2 The functional relation mentioned in the definition is defined, in an inverse fashion, from the first step of calibration, where indications are related to values of quantities of **measurement standards**. Sometimes the function is defined by curve-fitting discrete pairs of indications and values of quantities of measurement standards.

5.20 [VIM3: 4.30]
calibration diagram

graphical expression of the relation between **indication** and corresponding **measurement result**

NOTE 1 A calibration diagram is the strip of the plane defined by the axis of the indications and the axis of **measured values**, that represents the relation between an indication and a set of measured values. A one-to-many relation is given, and the width of the strip for a given indication provides the **instrumental uncertainty** within specified **operating conditions**.

NOTE 2 Alternative expressions of the relation mentioned in the definition include a **calibration function** and associated **measurement uncertainty**, a calibration table, or a set of calibration functions.

5.21 [VIM3: 2.40]
calibration hierarchy

sequence of **calibrations** from a reference to the final **measuring system**, where the outcome of each calibration depends on the outcome of the previous calibration

NOTE 1 **Measurement uncertainty** necessarily increases along the sequence of calibrations.

NOTE 2 The elements of a calibration hierarchy are one or more **measurement standards** and measuring systems operated according to **measurement procedures**.

NOTE 3 The reference mentioned in this definition is sometimes thought of in different ways. Probably most commonly, the reference is considered to be the definition of a **unit**, through its practical realization (for example, a realization of the definition of a unit of the **SI**; “traceable to the SI”). However, sometimes the reference is thought of as the realization itself, that is, a **quantity**. The reference could also be any measurement standard for a quantity of the same kind (for example, a length standard used in a machine shop for measuring lengths). In the case of **ordinal quantities**, the reference is typically a **measurement procedure** (for example, a procedure for using a hardness measurement machine to obtain values of Rockwell C hardness). The quantity that is the reference or is carried by the reference must have a **reference value** and a measurement uncertainty.

5.22 [VIM3: 2.41; VIM2: 6.10; VIM1: 6.12]
metrological traceability

property of a **measurement result** whereby the result can be related to a reference through a documented unbroken chain of **calibrations**, each contributing to the **measurement uncertainty**

NOTE 1 The reference mentioned in this definition is sometimes thought of in different ways. Probably most commonly, the reference is considered to be the definition of a **unit**, through its practical realization (for example, a realization of the definition of a unit of the **SI**; “traceable to the SI”). However, sometimes the reference is thought of as the realization itself, that is, a **quantity**. The reference could also be any **measurement standard** for a quantity of the same kind (for example, a length standard used in a machine shop for measuring lengths). In the case of **ordinal quantities**, the reference is typically a **measurement procedure** (for example, a procedure for using a hardness measurement machine to obtain values of Rockwell C hardness). The quantity that is the reference or is carried by the reference must have a reference value and a measurement uncertainty.

NOTE 2 Metrological traceability requires an established **calibration hierarchy**.

NOTE 3 The documentation of the chain of calibrations must specify the time at which the reference was used in establishing the calibration hierarchy, i.e., when the first calibration in the calibration hierarchy was performed, along with any other relevant metrological information about the reference.

NOTE 4 For **measurements** with more than one **input quantity in the measurement model**, each of the input **values** and their uncertainties should itself be metrologically traceable and the calibration hierarchy involved may form a branched structure or a network. The effort involved in establishing metrological traceability for each input value, and in particular in evaluating its uncertainty, should be commensurate with its relative contribution to the measurement result.

NOTE 5 Metrological traceability of a measurement result does not ensure that the measurement uncertainty is adequate for a given purpose or that no mistakes have been made.

NOTE 6 ILAC considers the elements for confirming metrological traceability to be an unbroken **metrological traceability chain** to an **international measurement standard** or a **national measurement standard**, a documented measurement uncertainty, a documented measurement procedure, accredited technical competence, metrological traceability to the **SI**, and recalibration intervals (see ILAC P-10, *ILAC policy on traceability of measurement results*).

NOTE 7 The abbreviated term “traceability” is sometimes used for metrological traceability as well as other entities, such as sample traceability, document traceability, instrument traceability, or material traceability, where the history (“trace”) of an item is meant. Therefore, the full term “metrological traceability” is preferred if there is any risk of confusion.

5.23 [VIM3: 2.42; VIM2: 6.10 Note 2]
metrological traceability chain

traceability chain

sequence of **measurement standards** and **calibrations** that is used to relate a **measurement result** to a reference

NOTE 1 A metrological traceability chain is defined through a **calibration hierarchy**.

NOTE 2 A metrological traceability chain is used to establish **metrological traceability** of a measurement result.

5.24 [VIM3: 2.43]
metrological traceability to a measurement unit

metrological traceability to a unit

metrological traceability where the reference is the definition of a **measurement unit** through its practical realization

NOTE The term “traceability to the SI” is used for referring to metrological traceability to a unit of the **International System of Units**.

5.25 [VIM3: 2.44]
verification

provision of objective evidence that a given item fulfils specified requirements

EXAMPLE 1 Confirmation that a given **reference material** as claimed is homogeneous for the **value** and **measurement procedure** concerned, down to a measurement portion having a stated mass, where “measurement portion” is intended to refer to amount of material, of proper size, for measurement of any quantity of interest, removed from the reference material.

EXAMPLE 2 Confirmation that performance properties or legal requirements of a **measuring system** are achieved.

EXAMPLE 3 Confirmation that a **target measurement uncertainty** can be met.

NOTE 1 When applicable, **measurement uncertainty** should be taken into consideration in a verification.

NOTE 2 The item mentioned in the definition may be, for example, a process, measurement procedure, material, compound, or measuring system.

NOTE 3 The specified requirements mentioned in the definition may be, for example, that a manufacturer's specifications are met.

NOTE 4 Verification in legal metrology, as defined in *International Vocabulary of Legal Metrology* (VIML), and in conformity assessment in general, pertains to the examination and marking and/or issuing of a verification certificate for a measuring system.

NOTE 5 Verification should not be confused with **calibration**. Not every verification is a **validation**.

NOTE 6 In chemistry, verification of the identity of the entity involved, or of activity, requires a description of the structure or properties of that entity or activity.

5.26 [VIM3: 2.45]
validation

verification, where the specified requirements are adequate for an intended use

EXAMPLE A **measurement procedure**, ordinarily used for the **measurement** of mass concentration of nitrogen in water, may be validated also for measurement of mass concentration of nitrogen in human serum.

5.27 [VIM3: 2.46]
metrological comparability of measurement results

metrological comparability

property of **measurement results**, for **quantities** of a given **kind**, where the results are metrologically traceable to the same reference

EXAMPLE Measurement results, for the distances between the Earth and the Moon, and between Paris and London, are metrologically comparable when they are both metrologically traceable to the same **unit**, for example the metre.

NOTE 1 The reference mentioned in this definition is sometimes thought of in different ways. Probably most commonly, the reference is considered to be the definition of a **unit**, through its practical realization (for example, a realization of the definition of a unit of the **SI**; "traceable to the SI"). However, sometimes the reference is thought of as the realization itself, that is, a **quantity**. The reference could also be any **measurement standard** for a quantity of the same kind (for example, a length standard used in a machine shop for measuring lengths). In the case of **ordinal quantities**, the reference is typically a **measurement procedure** (for example, a procedure for using a hardness measurement machine to obtain values of Rockwell C hardness). The quantity that is the reference or is carried by the reference must have a reference value and a measurement uncertainty.

NOTE 2 Metrological comparability of measurement results does not necessitate that the **measured values** compared be of the same order of magnitude. The same applies to the associated **measurement uncertainties**.

5.28 [VIM3: 2.47]
metrological compatibility of measurement results

metrological compatibility

property of a set of **measurement results** for a specified **measurand**, such that the absolute value of the difference of any pair of **measured values** from two different measurement results is smaller than some chosen multiple of the **standard uncertainty** of that difference

NOTE 1 Metrological compatibility of measurement results replaces what was traditionally termed "staying within the error", as it represents the criterion for deciding whether two measurement results refer to the same measurand or not. If in a set of **measurements** of a measurand, thought to be constant, a measurement result is not compatible with the others, either the measurement was not correct (for example, its **measurement uncertainty** was assessed as being too small) or the measured **quantity** changed between measurements.

NOTE 2 The measurement uncertainty associated with the difference between any pair of measured values should account for the possible correlation between random variables modeling the measurand. If such random variables are completely uncorrelated, the standard uncertainty of their difference is equal to the root mean square sum of their standard uncertainties, while it is lower for positive covariance or higher for negative covariance.

6 Nominal properties and examinations

6.1 [VIM3: 1.30]
nominal property <general>

general nominal property
nominal property in the general sense
kind of nominal property

property whose instances can be compared only by equivalence

NOTE 1 Nominal properties can be general nominal properties or **individual nominal properties**, as exemplified in the following table.

General nominal property	Individual nominal property
shape	shape of a given piece of metal
chemical species	chemical species in a given sample
taxon	taxon of fish in a given sample
sequence variation	variation of DNA sequence in the gene of a given person in relation to a reference sequence
blood group	erythrocyte antigen in the ABO system for a given person
tumour type	type of tumour in the bladder of a given person according to the WHO classification 2016

NOTE 2 Any individual nominal property is an instance of a general nominal property, so that for example sodium ion in a given sample is an instance of chemical species. Individual nominal properties that are instances of the same general nominal property are comparable, and are said to be “nominal properties of the same kind”.

NOTE 3 Nominal properties are distinguished from **quantities**, which are properties that can be compared in terms of greater or lesser.

NOTE 4 In some contexts, but not in this Vocabulary, nominal properties are also called “qualitative properties”.

NOTE 5 Light of a given wavelength is perceived as a colour, so that such a colour can be considered as a quantity, at least an **ordinal quantity** because the ratio of two colours has no physical meaning. Other colours are nominal properties, because they cannot be obtained by the perception of a monochromatic light and cannot be totally ordered.

6.2 [VIM3: 1.30]
nominal property <individual>

individual nominal property

instance of a **nominal general property**

EXAMPLE Examples of individual nominal properties, together with the general nominal properties of which they are instance, are presented in the table in the Note 1 to the entry 6.1.

6.3 [new]
reference set of nominal properties

nominal scale

set of **individual nominal properties** of the same **kind**, accepted by agreement, where each nominal property is associated with an element of a set of identifiers

6.4 [new]
value of a nominal property

value <nominal property>

individual nominal property identified in a **reference set of nominal properties**

EXAMPLE 1 For shape, sphere is a value in the set {sphere, prism, pyramid, other shape}.

EXAMPLE 2 For taxon of bone fishes, the species *Pollachius virens* is a value in the set of the fish species according to an established taxonomy system.

EXAMPLE 3 For the sequence variation corresponding to a substitution of G for A in a position 20210 of the DNA in the human prothrombin gene, G20210A is the value.

EXAMPLE 4 For colour, as found in anthropological surveys to be in wide use across cultures, white is a value in the set {white, black, red, green, yellow, blue, brown, grey, orange, purple, and pink} (IEC 60050-845, *International Electrotechnical Vocabulary – Lighting*).

EXAMPLE 5 For blood group in the ABO system, A_1 is a value in the set {A_1, A_2, B, AB, O}.

EXAMPLE 6 For tumour type according to the WHO 2016 classification of tumours of the urinary system, urothelial type is a value.

NOTE 1 Values of nominal properties are not names/terms. In Example 1, where X = {sphere, prism, pyramid, other shape} is the set of possible values, a value of shape (in X) is sphere, which is a geometrical entity, not the term "sphere". Indeed the same value may be designated by the term "sphere" in English, "sphère" in French, and other terms in other languages.

NOTE 2 The term "value" in the phrase "value of a nominal property" is intended in analogy with its use in "value of a quantity". In this sense, the fact that the shape of a given object is spherical, and that the considered set of possible values of shape is X = {sphere, prism, pyramid, other shape}, can be written "shape(object) = sphere in X" in analogy with the fact that the length of that rod is 1.23 m can be written "length(rod) = 1.23 m". Hence values are not necessarily quantitative.

NOTE 3 The set of possible values of a nominal property may be revised, for example with the introduction of new elements, as a result of an **examination**.

NOTE 4 The term "value of a nominal property" has been taken from G. Nordin, R. Dybkaer, U. Forsum, X. Fuentes-Arderiu, F. Pontet, *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC Recommendations 2017)*, Pure Appl. Chem., 1-23, 2018, entry 3.1.

6.5 [new]

examination of a nominal property

examination

classification

process of experimentally obtaining one or more **values** that can reasonably be attributed to a **nominal property** together with any other available relevant information

EXAMPLE 1 Examination of the taxon of a fish as determined by a sample of its mitochondrial DNA.

EXAMPLE 2 Examination of the DNA sequence of the human prothrombin gene to determine the presence of the G to A transition at nucleotide position 20210.

EXAMPLE 3 Examination of erythrocyte antigens A and B by observation and interpretation of agglutination reactions of erythrocytes towards antibodies to A and B antigen respectively.

EXAMPLE 4 Examination of morphologic appearance of thin slices of tissue collected in a biopsy of the tumour.

EXAMPLE 5 Examination of the iris colour of the eyes of a person.

NOTE 1 The relevant information mentioned in the definition may be about the **reliability** of the values obtained by the examination, such that some may be more representative of the examinand than others.

NOTE 2 In some cases an examination is performed through intermediate stages, which are **measurements** and whose results are used to obtain the examination result.

NOTE 3 Some other common terms for referring to examinations are "evaluation", "characterization", "inspection", "determination", "qualitative analysis", "qualitative measurement", "identification".

NOTE 4 In ISO 15189, *Medical laboratories – Requirements for quality and competence* the term "examination" is also used for referring to measurement.

NOTE 5 The term "examination" has been taken, and the definition has been adapted, from G. Nordin, R. Dybkaer, U. Forsum, X. Fuentes-Arderiu, F. Pontet, *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC Recommendations 2017)*, Pure Appl. Chem., 1-23, 2018, entry 2.6.

6.6 [new]

examination principle

phenomenon or process serving as a basis of an **examination**

EXAMPLE 1 DNA sequencing to determine the nucleic acid sequence.

EXAMPLE 2 Agglutination reaction of red blood cells for the detection of antigens on cell surfaces by the use of antibodies of known specificity.

EXAMPLE 3 Recognition of the morphological pattern of tissue observed using light microscopy.

EXAMPLE 4 Mass spectrometry or chromatography used to identify chemical species.

NOTE 1 The phenomenon mentioned in the definition can be of a physical, chemical, or biological nature.

NOTE 2 The term “examination principle” has been taken, and the definition has been adapted, from G. Nordin, R. Dybkaer, U. Forsum, X. Fuentes-Arderiu, F. Pontet, *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC Recommendations 2017)*, Pure Appl. Chem., 1-23, 2018, entry 2.10.

6.7 [new]
examination method

generic description of a logical organization of operations used in an **examination**

EXAMPLE 1 DNA is extracted from a fish sample and parts of the mitochondrial cytochrome b (cyt b) gene amplified by PCR. The amplified DNA is sequenced, compared to a DNA sequence, and the fish taxon is assigned.

EXAMPLE 2 DNA is extracted from the plasma obtained from a blood sample of a patient. DNA in the region of the prothrombin gene is amplified by PCR and its sequence examined. The examination method shows if a mutation is present at location 20210 and if this mutation is present in two alleles (homozygous mutation) or one allele (heterozygous).

EXAMPLE 3 A suspension of erythrocytes is mixed with solutions containing antibodies to A-antigen and B-antigen respectively. The agglutination, or absence of agglutination, of cells is recorded and interpreted.

EXAMPLE 4 Observation of morphology by light microscopy of thin slices of tissue mounted on glass plates, stained by a combination of hematoxylin and eosin stain and comparison for equivalence with reference images and reference descriptions with specified criteria.

NOTE 1 Referring to an examination method is insufficient to allow an examination with prescribed **examination reliability**, but aids in formulating one or more **examination procedures**.

NOTE 2 The term “examination method” and the definition have been taken from G. Nordin, R. Dybkaer, U. Forsum, X. Fuentes-Arderiu, F. Pontet, *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC Recommendations 2017)*, Pure Appl. Chem., 1-23, 2018, entry 2.11.

6.8 [new]
examination procedure

detailed description of an **examination** according to one or more **examination principles** and to a given **examination method** and any decision algorithm necessary to obtain an **examination result**

NOTE 1 An examination procedure specifies the **nominal property** involved, any sampling procedure, equipment, **reference materials** needed, and the set of possible **values of a nominal property** used. The examination procedure also specifies how many **examined values** are necessary to obtain an examination result and how to evaluate the **examination reliability**.

NOTE 2 An examination procedure is intended to provide operational details and should be sufficient for a trained operator to perform an examination satisfactorily.

NOTE 3 An examination procedure can include measurement procedures or prescribe using measurement results.

NOTE 4 The term “examination procedure” and the definition have been taken from G. Nordin, R. Dybkaer, U. Forsum, X. Fuentes-Arderiu, F. Pontet, *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC Recommendations 2017)*, Pure Appl. Chem., 1-23, 2018, entry 2.12.

6.9 [new]
examinand

nominal property intended to be examined

NOTE 1 The nominal property mentioned in the definition is an individual nominal property.

EXAMPLE 1 The taxon of a given bone fish.
EXAMPLE 2 The erythrocyte surface antigen within the ABO system for blood from a given person.
EXAMPLE 3 The tumour type in the bladder of a given person.

NOTE 2 The examinand may be different from the nominal property actually being examined due to changes of the object bearing the property during the **examination**.

EXAMPLE A drug is detected in a processed sample of blood. Under the condition of physiological pH in blood the substance appears in its salt form. Due to a deviating pH in the sample material the drug actually being detected is in its acid form.

NOTE 3 The term "examinand" and the definition have been taken from G. Nordin, R. Dybkaer, U. Forsum, X. Fuentes-Arderiu, F. Pontet, *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC Recommendations 2017)*, Pure Appl. Chem., 1-23, 2018, entry 2.7.

6.10 [new]
examination result

set of **values** being attributed to an **examinand** together with any other available relevant information

EXAMPLE 1 The fish in the sample is identified to be of the species Pollachius virens, with a given risk of misclassification.

EXAMPLE 2 The prothrombin gene carries the factor II mutation in one allele (G/A) with a given risk of misclassification.

EXAMPLE 3 The erythrocyte antigen within the ABO system is A, with a given risk of misclassification.

NOTE 1 An examination result sometimes contains relevant information about the set of values of the nominal property, such that some may be more representative of the examinand than others. This may be quantified by a probability distribution over the set of values, from which **examination reliability**, and therefore the risk of misclassification, can be computed.

NOTE 2 In many cases an examination result is a single examined value, with no explicit information about examination reliability, then implying that the risk of misclassification is negligible for the intended use.

NOTE 3 The term "examination result" and the definition have been taken from G. Nordin, R. Dybkaer, U. Forsum, X. Fuentes-Arderiu, F. Pontet, *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC Recommendations 2017)*, Pure Appl. Chem., 1-23, 2018, entry 3.4.

6.11 [new]
examined value

value of a nominal property representing an **examination result**

NOTE 1 The examined value may be obtained indirectly through a process, which may involve examination results of other **nominal properties** or **measurement results**.

NOTE 2 The term "examined value" and the definition have been taken from G. Nordin, R. Dybkaer, U. Forsum, X. Fuentes-Arderiu, F. Pontet, *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC Recommendations 2017)*, Pure Appl. Chem., 1-23, 2018, entry 3.5.

6.12 [new]
examination reliability

examination confidence

probability that an **examined value** is the same as a reference **value of a nominal property**

NOTE 1 Examination reliability provides an indication of the quality of the result of an **examination**. It may be expressed in the form of a probability mass function. The metrological understanding of examination reliability is not well established, compared, for example, with **standard measurement uncertainty** and has to be agreed upon. Without such agreement the degree of belief in an examination result is often expressed on an ordinal scale, for example "weak", "fair", "strong", or "very strong" evidence in favour of a hypothesis. Requirements for examination reliability, for example in conformity assessment of nominal properties have to be stated for each case (see JCGM 106, *Evaluation of measurement data – The role of measurement uncertainty in conformity assessment*).

EXAMPLE 1 A tumour in urine bladder is categorized as urothelial type cancer with a stated examination reliability.

EXAMPLE 2 For the **nominal property** shape, the set of possible values is {sphere, prism, pyramid, other shape}, and the reference value is sphere. Having repeated the examination of the shape of a given object five times, one of the examined values is prism, and the others are spheres. The examination reliability is therefore 4/5 = 0.8.

NOTE 2 The definition has been adapted from G. Nordin, R. Dybkaer, U. Forsum, X. Fuentes-Arderiu, F. Pontet, *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC*

Recommendations 2017), Pure Appl. Chem., 1-23, 2018, entry 3.8, where the term “examination trueness” is used.

6.13 [new]
examining system

set of one or more devices and often other components, assembled and adapted to give information used to generate **examined values** from a **reference set of nominal properties**

NOTE 1 The components mentioned in the definition may include reagents and supplies.

NOTE 2 A human eye may be an essential element of an examining system.

NOTE 3 The term “examining system” and the definition have been taken from G. Nordin, R. Dybkaer, U. Forsum, X. Fuentes-Arderiu, F. Pontet, *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC Recommendations 2017)*, Pure Appl. Chem., 1-23, 2018, entry 2.8.

6.14 [new]
examination standard

realization of the definition of a given **nominal property**, with stated **value** and associated **examination reliability**, used as a reference

EXAMPLE 1 Based on the DNA sequence obtained for a material used as an examination standard, the fish is identified to be of the taxon *Pollachius virens*.

EXAMPLE 2 Based on the DNA sequence examination for a material used as an examination standard, the prothrombin gene carries the factor II mutation in one allele.

EXAMPLE 3 Reagents used for the identification of A and B antigen are CE marked according to the Regulation (EU) 2017/746 of the European Parliament and of the Council of 5 April 2017 on in vitro diagnostic medical devices and have the minimal potency as defined by WHO (WHO Expert Committee on Biological Standardization, *International standards for minimum potency of anti-A and anti-B blood grouping reagents*, WHO/BS/06.2053, 2006)

EXAMPLE 4 Published descriptions of the morphological characteristics of different tumour types in the bladder (H. Moch, P.A. Humphrey, T.M. Ulbright, V. Reuter, WHO *Classification of tumours of the urinary system and male genital organs*, International Agency for Research on Cancer; Lyon, France, 2016).

NOTE 1 The realization can be, for example, a **reference material**, a record in a reference database, a classification algorithm, or a class in a classification system.

NOTE 2 The term “examination standard” has been taken, and the definition has been adapted, from G. Nordin, R. Dybkaer, U. Forsum, X. Fuentes-Arderiu, F. Pontet, *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC Recommendations 2017)*, Pure Appl. Chem., 1-23, 2018, entry 4.1.

6.15 [new]
examination calibration

examination training

process that confers to one or more persons or to an **examining system** the capacity to provide **values of a nominal property**, and the **examination reliability** of each value, from specified **examinations** after having examined one or more **examination standards** under specified conditions

EXAMPLE Training of examiners to perform an examination, for example by examining sets of cases with known tumour types, to achieve high degree of reproducibility between training and qualified examiners.

NOTE 1 An examining system to be calibrated can be a software system.

NOTE 2 The objective of examination calibration is to provide traceability of examination results obtained when using a calibrated examining system.

NOTE 2 The term “examination calibration” and the definition have been taken from G. Nordin, R. Dybkaer, U. Forsum, X. Fuentes-Arderiu, F. Pontet, *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC Recommendations 2017)*, Pure Appl. Chem., 1-23, 2018, entry 4.3.

6.16 [new]
examination traceability

property of an **examination result** whereby the result can be related to a reference through a documented unbroken chain of **examination calibrations**, each affecting the **examination reliability**

EXAMPLE 1 The examination result, which is the species Pollachius virens, is traceable to a database of fish species, as concluded from a comparison of the obtained DNA sequence from a sample of the fish with the DNA sequences in that database.

EXAMPLE 2 The **value** A1 for an erythrocyte antigen within the ABO system is traceable to the current classification of blood group systems as described by International Society of Blood Transfusion (ISBT) (http://www.isbtweb.org/working-parties/red-cell-immunogenetics-and-blood-group-terminology).

NOTE 1 The reference mentioned in this definition might be thought of in different ways. One type of reference is an agreed **reference set of nominal properties**. The reference could also be a specified **examination procedure**.

NOTE 2 The term "examination traceability" has been taken, and the definition has been adapted, from G. Nordin, R. Dybkaer, U. Forsum, X. Fuentes-Arderiu, F. Pontet, *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC Recommendations 2017)*, Pure Appl. Chem., 1-23, 2018, entry 3.21.

6.17 [new]
comparability of examination results

property of **examination results**, for **nominal properties** of a given kind, where the results are traceable to the same reference

EXAMPLE 1 Examination results for the colours of two different biological fluids are comparable when they are both traceable to the same reference system for colours, for example RAL colour standard or any other reference colour system.

EXAMPLE 2 Examination results belonging to the same blood group system are comparable.

NOTE The term "comparability of examination results" and the definition have been adapted from G. Nordin, R. Dybkaer, U. Forsum, X. Fuentes-Arderiu, F. Pontet, *Vocabulary on nominal property, examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC Recommendations 2017)*, Pure Appl. Chem., 1-23, 2018, entry 3.22.

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