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Sri Lanka Standard

GLOSSARY OF TERMS USED IN METROLOGY

SRI LANKA STANDARDS INSTITUTION

CONTENTS

Draft Sri Lanka Standard

GLOSSARY OF TERMS USED IN METROLOGY

FOREWORD

This standard was approved by the Sectoral Committee on Basic Mechanical Engineering Standards and authorized for adoption and publication as a Sri Lanka Standard by the Council of the Sri Lanka Standards Institution on .....

The majority of terms in this glossary have been taken unchanged from the ' International Vocabulary of Basic and General Terms in Metrology' published jointly by International Bureau of Weights and Measures(BIPM), International Electrotechnical Commission(IEC), International Organisation for Standardisation(ISO) and International Organization for Legal Metrology(OIML). Terms drawn from International Vocabulary carry numbers consisting of two groups, for example : 4.11 and the terms that are additional to the terms in the International vocabulary carry three group reference numbers, for example : 5.24.2.

The Sri Lanka Standards Institution gratefully acknowledges the use of the relevant publications of the BIPM, IEC, ISO, OIML and British Standards Institution in the preparation of this standard.

1 SCOPE

This glossary defines terms used in metrology.

2 REFERENCES

SLS 84 Basic quantities and units of the SI.

1 QUANTITIES AND UNITS

1.1	quantity (measurable)	An attribute of a phenomenon, body or substance, which may be distinguished qualitatively and determined quantitatively. NOTES 1. The term 'quantity' may refer to a quantity in a general sense [see examples (a) or to a specific quantity examples (b)]. 2. Quantities that are mutually comparable, also called quantities of the same kind, may be grouped together into categories of quantities, for example: a. Work, heat, energy; b. Thickness, circumference, wavelength. 3. Symbols for quantities are given in SLS 84. Examples: a. Quantities in a general sense: length, time, mass, temperature, electrical resistance; b. Specific quantities: length of a particular rod, electrical resistance of a particular wire.
1.2	base quantity	One of the quantities which, in a system of quantities, are conventionally accepted as independent of each other.
1.3	derived quantity	A quantity defined, in a system of quantities, as a function of base quantities of that system.
1.4	dimension of a quantity	An expression which represents a quantity of a system of quantities as the product of powers of the base quantities of the system. Example: LMT^{-2} is the dimension of force in the system of quantities length, mass and time (l, m, t).

1.5 dimensionless quantity

A quantity in the expression of which the exponents of the base quantities, in a given system, are zero.

Examples:
linear strain, coefficient of friction, refractive index are dimensionless quantities, in the system of quantities l,m,t.

1.6 unit (of measurement)

A specific quantity, adopted by convention, used to express quantitatively quantities which have the same dimension.

1.7 symbol of a unit (of measurement)

A conventional sign designating a unit of measurement.

Examples:
a. M is the symbol for metre;
b. A is the symbol for ampere.

1.8 system of units (of measurement)

A set of units established for a given system of quantities.

NOTE
A system of units comprises a set of chosen base units, together with derived units determined by their defining equations and proportionality factors.

Examples:
a. International System of Units, SI;
b. CGS system of units.

1.9 coherent system of units (of Measurement)

A system of units composed of a set of base units and coherent derived units.

Example:
the following units (expressed by their symbols) form part of the coherent system of units in mechanics within the International System of Units, SI:

m; kg; s;
m^2; m^3; Hz = s^{-1}; $m.s^{-2}$;

$kg.m^{-3}$; N = $m.kg.s^{-2}$;
PA = $kg.m^{-1}$ s^{-2};
J = $kg.m^2.s^{-2}$; W = $kg.m^2.s^{-3}$

1.10 **International System of Units, SI**

The coherent system of units adopted and recommended by the General Conference on Weights and Measures (CGPM).

NOTE
The SI is based at present on the following seven base units:
mitre, the unit of length;
kilogram, the unit of mass;
second, the unit of time;
ampere, the unit of electric current;
kelvin, the unit of thermodynamic temperature;
mole, the unit of amount of substance; and
candela, the unit of luminous intensity.

1.11 **base unit (of measurement)**

A unit of measurement of a base quantity in a given system of quantities.

1.12 **derived unit (of measurement)**

A unit of measurement of a derived quantity in a given system of quantities.

NOTE
1. In a given system of units, a derived unit can be expressed in terms of base units and proportionality factors.

2. Some derived units have special names and symbols: for example, in the SI :

newton (N), unit of force;
joule (J) , unit of energy;
volt (V), unit of electric potential

1.13 **coherent unit (of measurement)**

A derived unit of measurement which is expressed in terms of base units by a formula in which the proportionality factor is 1.

NOTE
This term is an abbreviation of the more exact denomination 'derived unit of measurement in a coherent system of units' , for, with an isolated unit, the concept of coherence is meaningless.

Example:
the newton is the coherent unit of force in the SI:
$1\ N = 1\ kg.m.s^{-2}$

1.14 **off-system unit (of measurement)**

A unit of measurement which does not belong to a given system of units.
Examples:
a. The electronvolt ($1.602\ 19 \times 10^{-19}$ J) is an off-system unit of energy with respect to the SI;
b. Day, hour, minute are off-system units of time with respect to the SI.

1.15 **multiple of a unit (of measurement)**

A larger unit of measurement which is formed from a given unit according to scaling conventions.
Examples:
a. One of the decimal multiples of the metre is the kilometer;
b. One of the non-decimal multiples of the second is the hour.

1.16 **sub-multiple of a unit (of measurement)**

A smaller unit of measurement which is formed from a given unit according to scaling conventions.
Example:
one of the decimal sub-multiples of the metre is the millimeter.

1.17 **value (of a quantity)**

The expression of a quantity in terms of a number and an appropriate unit of measurement.
Examples:
5.3 m; 12 kg; -40 °C.

1.18 **true value (of a quantity)**

The value which characterizes a quantity perfectly defined, in the conditions which exist when that quantity is considered.

NOTE
The true value of a quantity is an ideal concept and, in general, cannot be known exactly. Indeed, quantum effects may preclude the existence of a unique true value.

1.19 **conventional true value (of a quantity)** A value of a quantity which, for a given purpose, may be substituted for the true value.

NOTE

A conventional true value is, in general, regarded as sufficiently close to the true value for the difference to be insignificant for the given purpose.

Example:

within an organization, the value assigned to a reference standard may be taken as the conventional true value of the quantity realized by the standard.

1.20 **numerical value (Of a quantity)** The number in the value of a quantity.

Example:

In the examples in 1.17, the numbers: 5.3; 12; -40

1.21 **reference value scale (of a quantity or property)** For a given quantity or property, a series of values determined in a defined manner and adopted by convention.

Examples :

a. The International Practical Temperature Scale based on the freezing and boiling points of a series of specified pure substances and on the use of specified measuring instruments and interpolation formulae;

b. t Mohs hardness scale based on the hardnesses of a series of specified minerals;

c. the Richter earthquake scale.

2 MEASUREMENTS

2.1 **measurement** The set of operations having the object of determining the value of a quantity:

2.2	metrology	The field of knowledge concerned with measurement. NOTE Metrology includes all aspects both theoretical and practical with reference to measurements, whatever their level of accuracy, and in whatever fields of science or technology they occur.
2.2.1	legal metrology	That part of metrology which treats of units of measurement, methods of measurement and of measuring instruments, in relation to the mandatory technical and legal requirements which have the object of ensuring a public guarantee from the point of view of the security and of the appropriate accuracy of measurements.
2.3	static measurement	The measurement of a quantity whose value can be considered constant for the duration of the measurement. NOTE The qualifier 'static' applies to the measurand and not to the method of measurement.
2.4	dynamic measurement	The determination of the instantaneous value of a quantity and, where appropriate, its variation with time. NOTE The qualifier 'dynamic' applies to the measurand and not to the method of measurement.
2.5	principle of measurement	The scientific basic of a method of of measurement. Examples: a. the thermoelectric effect applied to the measurement of temperature; b. the Josephson effect applied to the measurement of voltage; c. the Doppler effect applied to the measurement of velocity.
2.6	method of measurement	The set of theoretical and practical operations, in general terms, involved in the performance of measurements according to a given principle.

2.7 **measurement procedure**

The set of theoretical and practical operations, in detailed terms, involved in the performance of measurements according to a given method.

2.8 **measurement process**

All the information, equipment and operations relevant to a given measurement.

NOTE
This concept embraces all aspects relating to the performance and quality of the measurement; it includes for example the principle, method, procedure, values of the influence quantities and the measurement standards.

2.9 **measurand**

A quantity subjected to measurement.

NOTE
As appropriate, this may be the measured quantity or the quantity to be measured.

2.10 **influence quantity**

A quantity which is not the subject of the measurement but which influences the value of the measurand or the indication of the measuring instrument.

Examples :
ambient temperature, frequency of an alternating measured voltage.

2.11 **transformed value (of a measurand)**

A value of a quantity which represents the measurand and which is functionally related to it.

NOTE
The transformed value may be internal to a measuring system or may be provided as an output from the system.

Examples:
a. the value of the electrical output signal of a pressure transducer;
b. an indication of a measured force as 'per cent of full load';
c. the value represented by a binary train within a digital electronic system or computer.

2.12 measurement signal

A representation of a measurand within a measuring system.

NOTE
The input signal to a measuring system may be called the stimulus; the output signal may be called the response.

2.13 direct method

A method of measurement in which the value of a measurand is obtained directly, rather than by measurement of other quantities functionally related to the measurand.

NOTE
The method of measurement remains direct even if it is necessary to make supplementary measurements to determine the values of influence quantities in order to make corresponding corrections.

Examples:
a. measurement of a length using a graduated rule;
b. measurement of a mass using an equal-arm balance.

2.14 indirect method of measurement

A method of measurement in which the value of a measurand is obtained by measurement of other quantities functionally related to the measurand.

Examples:
a. measurement of a pressure by measurement of the height of a column of liquid;
b. measurement of a temperature using a resistance thermometer.

2.15 fundamental method of measurement

A method of measurement in which the value of a measurand is determined by measurement of the appropriate base quantities.

2.16 definitive method of measurement

A method of measurement of a quantity in accordance with a definition of the unit of that quantity.

2.17 **direct-comparison method of measurement**

A method of measurement in which the measurand is compared directly with a quantity of the same kind having a known value.

Example:

measurement of a length using a graduated rule.

2.18 **substitution method of measurement**

A method of measurement in which the measurand is replaced by a quantity of of the same kind, of known value, and chosen so that the effects on the indicating device are the same.

Example:

determination of a mass by means of a balance and known masses using the Borda substitution method.

2.18.1 **transposition method of measurement**

A method of measurement in which the value of the measurand is first balanced by an initial known value A of the same quantity: next the value of the measurand is put in the place of that known value and is balanced again by a second known value B. When the balance-indicating device produces the same indication in both cases, the value of the measurand is an appropriate mean of A and B.

2.19 **differential method of measurement**

A method of measurement in which the measurand is compared with a quantity of the same kind, of known value only slightly different from the value of the measurand, and in which the difference between the two values is measured.

Example:

measurement of the diameter of a piston by means of gauge blocks and a comparator.

2.20 **null method of measurement**

A method of measurement in which the value of the measurand is determined by balancing, adjusting one or more quantities, of known values, to which the measurand has a known relationship at balance.

NOTE
The measurand and the adjusted quantities may be of different kinds.

Example:
measurement of an electrical impedance by means of a bridge circuit and a null detector.

2.20.1 coincidence method of measurement

A method of measurement in which a very small difference between the value of the measurand and a known value of a quantity of the same kind with which it is compared, is determined by observation of the coincidence of gauge or scale marks or signals.

Examples:
a. measurement of the length of an object by means of an instrument employing a scale and a vernier.
b. measurement of the rate of a clock by the coincidence of time signals.

2.20.2 deflection method of measurement

A method of measurement in which the value of the measurand is determined by the deflection of an indicating device in relation to a scale.

Examples:
a. measurement of pressure by means of a pointer-type pressure gauge;
b. measurement of a mass by means of a self-indicating balance.

3 MEASUREMENT RESULTS

3.1 result of a measurement

The value of a measurand obtained by measurement.

NOTES
1. When the term 'result of a measurement' is used, it should be made clear whether it refers to:
a. the indication,
b. the uncorrected result,
c. the corrected result,
and whether averaging over several observations is involved.

2. A complete statement of the result of a measurement includes information about the uncertainty of measurement and about the values of appropriate influence quantities.

3.2 **indication (of a measuring instrument)** — Value of a quantity provided by a measuring instrument.

NOTES

1. The quantity may be the measurand, a measurement signal, or a quantity to be used in the calculation of the value of the measurand.

2. The indication of a material measure is the value assigned to it.

3.3 **uncorrected result** — The result of a measurement before correction for assumed systematic errors.

NOTES

1. If only a single indication is involved, the uncorrected result is identical to the indication.

2. In English, uncorrected result was formerly referred to as indicated value.

3.4 **corrected result** — The result of a measurement obtained after having made corrections to the uncorrected result in order to take account of assumed systematic errors.

3.5 **accuracy of measurement** — The closeness of the agreement between the result of a measurement and the (conventional)true value of the measurand.

NOTE

The use of the term precision for accuracy should be avoided.

3.6 repeatability of measurements

The closeness of the agreement between the results of successive measurements of the same measurand carried out subject to all of the following conditions:

a. the same method of measurement,
b. the same observer,
c. the same measuring instrument,
d. the same location,
e. the same conditions of use, and
f. repetition over a short period of time.

NOTE
Repeatability may be expressed quantitatively in terms of the dispersion of the results.

3.7 reproducibility of measurements

The closeness of the agreement between the results of measurements of the same measurand, where the individual measurements are carried out changing conditions such as :

a) method of measurement,
b) observer,
c) measuring instrument,
d) location,
e) conditions of use; and
f) time.

NOTES
1. A valid statement of reproducibility requires specification of the conditions changed.

2. Reproducibility may be expressed quantitatively in terms of the dispersion of the results.

3.8 experimental standard deviation

For a series of n measurements of the same measurand, the parameter s characterizing the dispersion of the results and given by the formula :

$$S = \sqrt{\sum_{i=1}^{n} x_i - \bar{x}}$$

xi being the result of the i th measurement and $\bar{x}$ being the arithmetic mean of the n results considered.

NOTES

1. The experimental standard deviation should not be confused with the population standard deviation of a population of size N and of mean m, given by the formula:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N} (x_i - m)^2}{N}}$$

2. Considering the series of n measurements as a sample of a population, s is an estimate of the population standard deviation.

3. The expression $s/\sqrt{n}$ provides an estimate of the standard deviation of the arithmetic mean x with respect to the mean m of the overall population. The expression $s/\sqrt{n}$ is called the experimental standard deviation of the mean.

3.9 uncertainty of measurement — An estimate characterizing the range of values within which the true value of a measurand lies.

NOTE
Uncertainty of measurement comprises, in general, many components. Some of these components may be estimated on the basis of the statistical distribution of the results of series of measurements and can be characterized by experimental standard deviations. Estimates of other components can only be based on experience or other information.

3.10 (absolute) error of measurement — The result of a measurement minus the (conventional) true value of the measurand.

NOTES

1. The term relates equally to :
   the indication,
   the uncorrected result,
   the corrected result.

2. The known parts of the error of measurement may be compensated by applying appropriate corrections. The error of the corrected result can only be charaterized by an uncertainty.

3. 'Absolute error' , which has a sign, should not be confused with absolute value of an error which is the modulus of an error.

3.10.1 deviation — The divergence of the value of a measurand from a standard or reference value.

NOTE
Particularly in statistics, the reference value is frequently the arithmetic mean of the results in a series of measurements.

3.11 relative error — The absolute error of measurement divided by the (conventional) true value of the measurand.

3.12 random error — A component of the error of measurement which, in the course of a number of measurements of the same measurand, varies in an unpredictable way.

NOTE
It is not possible to correct for random error.

3.13 systematic error — A component of the error of measurement which, in the course of a number of measurements of the same measurand, remains constant or varies in a predictable way.

NOTES
1. Systematic errors and their causes may be known or unknown.

2. For a measuring instrument, see 'bias error'.

3.14 correction — The value which, added algebraically to the uncorrected result of a measurement, compensates for an assumed systematic error.

NOTES
1. The correction is equal to the assumed systematic error, but of opposite sign.

2. Since the systematic error cannot be known exactly, the correction is subject to uncertainty.

3.15 **correction factor** The numerical factor by which the uncorrected result of a measurement is multiplied to compensate for an assumed systematic error.

NOTE
Since the systematic error cannot be known exactly, the correction factor is subject to uncertainty.

4 MEASURING INSTRUMENTS

Many different terms are employed to describe the artefacts which are used in measurement. This vocabulary defines only a selection of preferred terms; the following list is more complete and is arranged in an approximate hierarchy.

element
component
part
measuring transducer
measuring device
reference material
material measure
masuring instrument
apparatus
equipment
measuring chain
measuring system
measuring installation

4.1 **measuring instrument** A device intended to make a measurement, alone or in conjunction with other equipment.

4.2 **material measure** A device intended to reproduce or supply, in a permanent manner during its use, one or more known values of a given quantity.

2. The known parts of the error of measurement may be compensated by applying appropriate corrections. The error of the corrected result can only be charaterized by an uncertainty.

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It is not possible to correct for random error.

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A component of the error of measurement which, in the course of a number of measurements of the same measurand, remains constant or varies in a predictable way.

NOTES
1. Systematic errors and their causes may be known or unknown.

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The value which, added algebraically to the uncorrected result of a measurement, compensates for an assumed systematic error.

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masuring instrument
apparatus
equipment
measuring chain
measuring system
measuring installation

4.1 **measuring instrument** A device intended to make a measurement, alone or in conjunction with other equipment.

4.2 **material measure** A device intended to reproduce or supply, in a permanent manner during its use, one or more known values of a given quantity.

NOTE
The quantity concerned may be called the supplied quantity.
Examples :
a weight; a measure of volume (of one or several values, with or without a scale); an electrical resistor; a gauge block; a standard signal generator.

4.3 measuring transducer

A measuring device which provides an output quantity having a given relationship to the input quantity.

Examples:
a. thermocouple;
b. current transformer;
c. electropneumatic converter.

4.4 measuring chain

A series of elements of a measuring instrument or system which constitutes the path of the measurement signal from the input to the output.

Example:
an electro-acoustic measuring chain comprising a microphone, attenuator, filter, amplifier and voltmeter.

4.5 measuring system

A complete set of measuring instruments and other equipment assembled to carry out a specified measurement task.

NOTE
The term measuring installation is reserved for measuring apparatus, usually of the larger kind, which is permanently installed, for example:
boiler-house instrumentation,
prover-loop for flow measurement.

Examples :
a. apparatus for measuring the resistivity of electrotechnical materials;
b. apparatus for the calibration of clinical thermometers.

4.6 **displaying (measuring) instrument**
indicating (measuring) instrument

Measuring instrument that displays an indication.

NOTES
1. The display may be analogue or digital.
2. The values of more than one quantity may be displayed simultaneously.
3. A displaying measuring instrument may also record an indication.

Examples :
a. analogue indicating voltmeter;
b. digital frequency meter;
c. micrometer

4.7 **recording (measuring) instrument**

measuring instrument that provides a record (permanent or semi-permanent) of an indication.

NOTES
1. The record may be analogue (continuous or discontinuous line) or digital.
2. Values of more than one quantity may be recorded simultaneously.
3. A recording measuring instrument may also display an indication.

Examples:
a. barograph;
b. thermoluminescent dosimeter;
c. recording spectrometer.

4.8 **totalizing (measuring) instrument**

A measuring instrument which determines the value of a measurand by summation of partial values of the measurand obtained simultaneously or consecutively from one or more sources.

Example :
electrical power summation-meter.

4.9 **integrating (measuring) instrument**

A measuring instrument which determines the value of a measurand by integrating a quantity with respect to another quantity.

Example;
electrical energy meter.

4.10 **analogue measuring instrument**

A measuring instrument in which the output and/or display is a continuous function of the value of the measurand.

NOTE
This term relates to the form of presentation of the output or display, not to the principle of operation of the instrument.

Examples :
a. moving coil voltmeter;
b. mercury-in-glass thermometer;
c. Bourdon pressure gauge.

4.11 **digital measuring instrument** — A measuring instrument which provides a digitized output and/or display.

NOTE
This term relates to the form of presentation of the output or display, not to the principle of operation of the instrument.

Example :
digital voltmeter.

4.12 **indicating device** — For a measuring instrument, the set of components which displays the value of a measurand or a related value.

NOTES
1. The term may include the indicating means or setting device of a material measure, for example, of a signal generator.

2. An analogue indicating device provides an analogue indication; a digital indicating device provides a digital indication.

3. A form of presentation of the indications either by means of a digital indication in which the least significant digit moves continuously thus permitting interpolation, or by means of a digital indication supplemented by a scale and index, is called a semi-digital indication.

4. The English term readout device is used as a general descriptor of the means whereby the response of a measuring instrument is made available.

4.13 **recording device** For a recording instrument, the set of components which records the value of a measurand or a related value.

4.14 **recording medium** A strip, disc, sheet or other structure on which is recorded the value of a measurand or a related value.

NOTES
1. A recording medium bearing pre-printed coordinate lines is generally called a **recording chart**.

2. An electronic or magnetic recording medium may be called a **memory**.

4.15 **sensor** The element of a measuring instrument or measuring chain to which a measurand is directly applied.

Examples:
a. thermocouple of a thermoelectric thermometer;
b. rotor of a turbine flow meter;
c. Bourdon tube of a pressure gauge;
d. float of a level measuring instrumnet.

4.16 **detector** A device or substance which indicates the presence of a particular quantity without necessarily providing its value.

NOTE
In some cases, an indication may be produced only when the value of the quantity reaches a given threshold.

Examples:
a. halogen leak detector;
b. temperature-sensitive paint.

4.17 **scale mark** A line or other mark on an indicating device corresponding to one or more defined values of a measurand.

NOTES
1. For digital and semi-digital indications, the numbers themselves are equivalent to scale marks.

2. The term **gauge mark** is often used in cases where only one or a few marks are involved.

4.18 index

The fixed or movable part of an indicating device whose position with reference to the scale marks enables an indicated value to be determined.

Examples:
a. pointer;
b. luminous spot;
c. liquid surface;
d. recording pen.

4.19 scale

An ordered set of scale marks, together with any associated numbering, forming a part of an indicating device.

4.20 scale length

For a given scale, the length of the line between the first and the last scale marks and passing through the centres of all the shortest scale marks.

NOTES
1. The line may be real or imaginary, curved or straight.

2. Scale length is expressed in units of length regardless of the units of the measurand or the units marked on the scale.

4.21 scale range

For a given scale, the range of scale values between the extreme scale marks.

NOTE
The scale range is expressed in the units marked on the scale, regardless of the units of the measurand, and is normally stated in terms of its lower and upper limits, for example : 100 °C to 200 °C.

4.22 scale division

The part of a scale between any two successive scale marks.

4.23 scale spacing

The distance between any two successive scale marks measured along the same line as the scale length.

NOTE
Scale spacing is expressed in units of length, regardless of the units of the measurand or the units marked on the scale.

4.24 **scale interval** — The difference between the scale values corresponding to two successive scale marks.

NOTE
Scale interval is expressed in the units marked on the scale, regardless of the units of the measurand.

4.25 **linear scale** — A scale in which each scale spacing is related to the corresponding scale interval by a coefficient of proportionality which is constant throughout the scale.

NOTE
A linear scale having constant scale intervals is called a regular scale.

4.26 **non-linear scale** — A scale in which each scale spacing is related to the corresponding scale interval by a coefficient of proportionality which is not constant throughout the scale.

NOTE
Some non-linear scales are given special names such as logarithmic scale, square-law scale.

4.27 **suppressed-zero scale** — A scale whose scale range does not include the scale value corresponding to zero value of the measurand.

Example:
scale of a clinical thermometer.

4.28 **expanded scale** — A scale in which part of the scale range occupies a disproportionately large part of the scale length.

4.29 **dial** — That part of an indicating device, fixed or moving, which carries the scale or scales.

NOTE
In some indicating devices, the dial takes the form of drums or discs bearing numbers and moving relative to a fixed index or window.

4.30	scale numbering	The set of numbers, marked on a scale, which either correspond to the values of the measurand defined by the scale marks or merely indicate the numerical order of the scale marks.
4.31	zero of a measuring instrument	The direct indication of a measuring instrument when the instrument is in use with zero value of the measurand, any auxiliary power supply required to operate the instrument being switched on. NOTE 1. This term is commonly called **electrical zero** in the case of a measuring instrument having an electrical auxiliary power supply. 2. The term **mechanical zero** is often used when the instrument is not in use and any auxiliary power supply is switched off. 3. The mechanical zero may possibly not coincide with the electrical zero; in some types of instrument the mechanical zero may be indeterminate.
4.32	gauging (of a measuring instrument)	The operation of fixing the positions of the gauge marks or scale marks of a measuring instrument (in some cases of certain principal marks only), in relation to the corresponding values of the measurand.
4.33	adjustment	The operation intended to bring a measuring instrument into a state of performance and freedom from bias suitable for its use.
4.34	user adjustment	The operation intended to bring a measuring instrument into a state of performance and freedom from bias suitable for its use, employing only the means at the disposal of the user.

5 CHARACTERISTICS OF MEASURING INSTRUMENT

Most of the terms used to describe the characteristics of a measuring instrument are equally applicable to a measuring device, a measuring transducer or a measuring system and may also be applied to a material measure by analogy. For this reason, in this section, the term 'measuring instrument' appears in bold type.

Similarly, the terms 'indication' and 'direct indication' may be taken to imply what is recorded by a recording instrument or the measurement signal within a measuring system. For this reason, in this section these terms appear in bold type.

5.1 nominal range For each scale range, the set of values of the measurand for which a **measuring instrument** gives values within that scale range at a particular setting of its controls.

NOTE
The nominal range is expressed in units of the measurand, regardless of the units marked on the scale, and is normally stated in terms of its lower and upper limits, for example 100 °C to 200 °C.
Where the lower limit is zero, the nominal range is commonly stated solely in terms of its upper limit, for example a nominal range of 0 V to 100 V is expressed as '100 V'.

5.2 span The modulus of the difference between the two limits of a nominal range of a measuring instrument.
Example:
nominal range - 10 V to + 10 V span 20 V

5.3 nominal value A value used to designate a characteristic of a device or to give a guide to its intended use.

NOTE
The nominal value may be a rounded value of the characteristic concerned and is often an approximate value of the quantity realized by a standard.

Examples :
a. the value marked on a standard resistor;
b. the value of 1 mol/l designating an acid solution of H+ ion amount-of-substance concentration of 0.998 mol/l.

5.4 **specified measuring range**
specified working range

The set of values of a measurand for which the error of a measuring instrument is intended to lie within specified limits.

NOTE
The upper and lower limits of the specified measuring range are sometime called the maximum capacity and minimum capacity respectively.

5.5 **rated operating conditions**

Conditions of use giving the ranges of the measurand and of the influence quantities, and other important requirements, for which the metrological characteristics of a measuring instrument are intended to lie within specified limits.

NOTE
The rated operating conditions generally specify rated values of the measurand and of the influence quantities.

5.6 **limiting conditions**

The extreme conditions which a measuring instrument can withstand without damage and without degradation of its metrological characteristics when it is subsequently operated under its rated operating conditions.

NOTE
1. The limiting conditions for storage, transport and operation may be different.
2. The limiting conditions generally specify limiting values of the measurand and of the influence quantities.

5.7 **reference conditions**

Conditions of use for a measuring instrument prescribed for performance testing, or to ensure valid intercomparison of results of measurements.

NOTE
The reference conditions generally specify reference values or reference ranges for the influence quantities affecting the measuring instrument.

5.8 **instrument constant**

The coefficient by which a direct indication must be multiplied to obtain indication of a measuring instrument.

NOTES
1. A measuring instrument in which the direct indication is equal to the value of the measurand has an instrument constant of 1.
2. Multi-range measuring instruments with a single scale have several instrument constants which correspond, for example, to different positions of a selector mechanism.
3. For some measuring instruments, the transformation from direct indication to indication may be more complex than a simple multiplication by an instrument constant.

5.09 **response characteristic**

For defined conditions, the relationship between a stimulus and the corresponding response.

NOTES
1. The relationship may be based on theoretical or experimental considerations, it may be expressed in the form of an algebraic equation, a numerical table or a graph.
2. When the stimulus aries as a function of time, one form of the response characteristic is the transfer function (the Laplace transform of the response divided by that of the stimulus).

5.10 **sensitivity**

The change in the response of a measuring instrument divided by the corresponding change in the stimulus.

NOTE
Sensitivity may depend on the value of the stimulus.

5.11 discrimination

The ability of a measuring instrument to respond to small changes in the value of the stimulus.

5.12 discrimination threshold

The smallest change in a stimulus which produces a perceptible change in the response of a measuring instrument.

NOTE
The discrimination threshold may depend on, for example, noise (internal or external), friction, damping, inertia, quantization.
Example:
If the smallest change in load which produces a perceptible displacement of the pointer of a balance is 90 mg, then the discrimination threshold of the balance is 90 mg.

5.13 resolution (of an indicating device)

A quantitive expression of the ability of an indicating device to distinguish meaningfully between closely adjacent values of the quantity indicated.

5.14 dead band

The range through which a stimulus can be varied without producing a change in the response of a measuring instrument.

NOTE
The inherent dead band is sometimes deliberately increased to reduce unwanted change in the response for small changes in the stimulus.

5.15 hysteresis

The property of a measuring instrument whereby its response to a given stimulus depends on the sequence of preceding stimuli.

NOTE
Although hysteresis is normally considered in relation to the measurand, it may also be considered in relation to influence quantities.

5.16 stability

The ability of a measuring instrument to maintain constant its metrological characteristics.

		NOTE It is usual to consider stability with respect to time. Where stability with respect to another quantity is considered, this should be stated explicitly.
5.17	transparency	The ability of a measuring instrument not to affect the value of the measurand.
5.18	drift	The slow variation with time of a metrological characteristic of a measuring instrument.
5.19	response time	The time interval between the instant when a stimulus is subjected to a specified abrupt change and the instant when the response reaches and remains within specified limits of its final steady value.
5.20	tracking error (of a measuring instrument)	The error arising from a lag in the response of a measuring instrument to a changing stimulus.
5.21	accuracy of a measuring instrument	The ability of a measuring instrment to give indications approaching the true value of a measurand.
5.22	accuracy class	A class of measuring instruments which meet certain metrological requirements that are intended to keep errors within specified limits. NOTE An accuracy class is usually denoted by a number or symbol adopted by convention and called the class index.
5.23	limits of permissible error (of a measuring instrument); maximum permissible errors (of a measuring instrument)	The extreme values of an error permitted by specifications, regulations etc. for a given measuring instrument.

5.24	error (of indication) of a measuring instrument	The indication of measuring instrument minus the (conventional) true value of the measurand. NOTE - For a material measure, the indication is its nominal or marked value.
5.24.1	response-law error (of a measuring instrument)	That part of the error of a measuring instrument which results from the indication or response departing from the intended relationship to the value of the measurand, over a defined range. NOTE This term may be qualified in accordance with the intended response law, e.g. 'square-law response error', 'logarithmic-law response error' etc.
5.24.2	quantization error (of a measuring instrument)	The error of a measuring instrument which may result from the conversion of the value of a measurand into a digital form. NOTE If the least significant bit of the digitized response is n, the limits of the quantization error are + 1/2n.
5.25	datum error (of a measuring instrument)	The error of a measuring instrument at a specified scale value or a specified value of the measurand, chosen for checking the instrument.
5.26	zero error (of a measuring instrument)	The datum error for zero value of the measurand.
5.27	intrinsic error (of a measuring instrument)	The error of a measuring instrument used under reference conditions.
5.27.1	influence error	The error which results from the departure of one of the influence quantities from its reference conditions.
5.28	bias error (of a measuring instrument)	The systematic component of the error of a measuring instrument.
5.29	freedom from bias (error) (of a measuring instrument)	The ability of a measuring instrument to give indications free from bias error.

5.30 **repeatability error (of a measuring instrument)**

The random component of the error of a measuring instrument.

5.31 **repeatability (of a measuring instrument)**

The ability of a measuring instrument to give, under defined condition of use, closely similar response for repeated applications of the same stimulus.

NOTE
The defined conditions of use are usually as follows:

a. repetition over a short period of time,
b. use at the same location under constant ambient conditions,
c. reduction to a minimum of the variations due to the observer.

5.32 **fiducial error (of a measuring instrument**

The error of a measuring instrument divided by a value specified for the instrument.

NOTE
The specified value is generally called the fiducial value, and may be, for example, the span or the upper limit of the nominal range of the measuring instrument.

6 MEASUREMENT STANDARDS

6.1 **measurement standard**

A material measure, measuring instrument or system intended to define, realize, conserve or reproduce a unit or one or more known values of a quantity in order to transmit them to other measuring instruments by comparison.

Examples:

a. 1-kg mass standard;
b. standard gauge block;
c. 100- standard resistor;
d. saturated Weston standard cell;
e. standard ammeter;
f. caesium atomic frequency standard.

6. 2 **collective standard**

A set of similar material measures or measuring instruments fulfilling, by their combined use, the role of a standard.

NOTES

1. A collective standard is usually intended to provide a single value of a quantity.
2. The value provided by a collective standard is an appropriate mean of the values provided by the individual instruments.

Examples:

a. collective voltage standard consisting of a group of Weston cells;

b. collective standard of luminous intensity consisting of a group of similar incandescent lamps.

6.3 group standard, series of standards

A set of standards of specially chosen values which individually or in suitable combination reproduce a series of values of a quantity over a given range.

Examples:

a. set of weights;

b. set of hydrometers covering contiguous ranges of density.

6.4 primary standard

A standard which has the highest metrological qualities in a specified field.

NOTE

The concept of primary standard is equally valid for base units and for derived units.

6.5 secondary standard

A standard whose value is fixed by comparison with a primary standard.

6.6 international standard

A standard recognized by an international agreement to serve internationally as the basis for fixing the value of all other standards of the quantity concerned.

6.7 national standard

A standard recognized by an official national decision as the basis for fixing the value, in a country, of all other standards of the quantity concerned.

NOTE

The national standard in a country is often a primary standard.

6.8	reference standard	A standard, generally of the highest metrological quality available at a given location, from which measurements made at that location are derived.
6.9	working standard	A standard, which, usually calibrated against a reference standard, is used routinely to calibrate or check material measures or measuring instruments.
6.10	transfer standard	A standard used as an intermediary to compare standards, material measures or measuring instruments. NOTE When the comparison device is not strictly a standard, the term transfer device should be used. Example: adjustable callipers used to intercompare end standards.
6.11	travelling standard	A standard, sometimes of special construction, intended for transport between different locations. Example : a portable battery-operated caesium atomic frequency standard.
6.12	traceability	The property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons.
6.13	calibration	The set of operations which establish, under specified conditions, the relationship between values indicated by a measuring instrument or measuring system, or values represented by a material measure, and the corresponding known values of a measurand. NOTES 1. The result of a calibration permits the estimation of errors of indication of the measuring instrument, measuring system or material measure, or the assignment of values to marks on arbitrary scales.

2. A calibration may also determine other metrological properties.
3. The result of a calibration may be recorded in a document, sometimes called a calibration certificate or a calibration report.
4. The result of a calibration is sometimes expressed as a calibration factor, or as a series of calibration factors in the form of a calibration curve.

6.14 conservation of a measurement standard

All the operations necessary to preserve the metrological characteristics of a measurement standard within appropriate limits.

NOTE
The operations commonly include regular calibration, storage under good conditions and care in use.

6.15 reference material

A material or substance one or more properties of which are sufficiently well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials.

6.16 certified reference material

A reference material one or more of whose property values are certified by a technically valid procedure, accompanied by or traceable to a certificate or other documentation which is issued by a certifying body.

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