

BS EN 45501:2015



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Metrological aspects of non-automatic weighing instruments

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee CPL/705, Weighing instruments.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Metrological aspects of non-automatic weighing instruments

Aspects métrologiques des instruments de pesage à
fonctionnement non automatique

Metrologische Aspekte der nichtselbsttätigen Waagen

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Foreword

This document (EN 45501:2015) has been prepared by a Joint CEN/CENELEC Working Group on Non-automatic Weighing Instruments.

The following dates are fixed:

- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2015-08-13
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2015-08-13

This document supersedes EN 45501:1992.

EN 45501:2015 includes the following significant technical changes with respect to EN 45501:1992:

In preparing this European Standard, EN 45501:1992 which formed the basis of this standard, was considered, but with additions and amendments to take into account the developments in technology which have occurred in the intervening years. Significant changes include, extensions to the EMC immunity requirements to reflect the greater use of wireless technology for many purposes, enhanced specifications for the integrity and security of software and testing regimes to confirm compliance, requirements for portable and mobile instruments, and recognition of the use of modular elements in families of instruments with enhanced testing requirements for both analog and digital modules and systems for confirming the compatibility of modules when combined into a single instrument or system.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For the relationship with EU Directive see informative Annex ZZ, which is an integral part of this document.

Introduction

This European Standard has been adapted from the OIML Recommendation R 76-1, Edition 2006, *Non-automatic weighing instruments - Part 1: Metrological and technical requirements - Tests* by a Joint Working Group from CEN and CENELEC. It was elaborated following a standardization request from the Commission of the European Communities to CEN and CENELEC to establish a European Standards related to Council Directive 2009/23/EC on Non-automatic weighing instruments.

Terminology

(terms, definitions and references)

The terminology used in this standard conforms to the “International Vocabulary of Basic and General Terms in Metrology” (VIM) [1], the “International Vocabulary of Terms in Legal Metrology” (VIML) [2]. In addition, for the purposes of this standard, the following definitions apply. An index of all the terms, definitions and references defined below can be found under T.8.

T.1 General definitions

T.1.1 Weighing instrument

Measuring instrument that serves to determine the mass of a body by using the action of gravity on this body.

NOTE In this standard “mass” (or “weight value”) is preferably used in the sense of “conventional mass” or “conventional value of the result of weighing in air”, according to OIML R111 or D28 whereas “weight” is preferably used for an embodiment (i.e. material measure) of mass that is regulated in regard to its physical and metrological characteristics.

The instrument may also be used to determine other quantities, magnitudes, parameters or characteristics related to the determined mass.

According to its method of operation, a weighing instrument is classified as an automatic weighing instrument or a non-automatic weighing instrument.

T.1.2 Non-automatic weighing instrument

Instrument that requires the intervention of an operator during the weighing process to decide that the weighing result is acceptable.

NOTE 1 Deciding that the weighing result is acceptable includes any intelligent action by the operator that affects the result, such as taking an action when an indication is stable or adjusting the mass of the weighed load, and to make a decision regarding the acceptance of each weighing result on observing the indication or releasing a print out. A non-automatic weighing process allows the operator to take an action (i.e. adjust the load, adjust the unit price, determine that the load is acceptable, etc.) which influences the weighing result in the case where the weighing result is not acceptable.

A non-automatic weighing instrument may be

- graduated or non-graduated, or
- self-indicating, semi-self-indicating or non-self-indicating.

NOTE 2 In this standard a non-automatic weighing instrument is called an “instrument”.

T.1.2.1 Graduated instrument

Instrument allowing the direct reading of the complete or partial weighing result.

T.1.2.2 Non-graduated instrument

Instrument not fitted with a scale numbered in units of mass.

T.1.2.3 Self-indicating instrument

Instrument in which the position of equilibrium is obtained without the intervention of an operator.

T.1.2.4 Semi-self-indicating instrument

Instrument with a self-indicating weighing range, in which the operator intervenes to alter the limits of this range.

T.1.2.5 Non-self-indicating instrument

Instrument in which the position of equilibrium is obtained entirely by the operator.

T.1.2.6 Electronic instrument

Instrument equipped with electronic devices.

T.1.2.7 Instrument with price scales

Instrument that indicates the price to pay by means of price charts or scales related to a range of unit prices.

T.1.2.8 Price-computing instrument

Instrument that calculates the price to pay on the basis of the indicated weight value and the unit price.

T.1.2.9 Price-labeling instrument

Price-computing instrument that prints the weight value, unit price and price to pay for prepackages.

T.1.2.10 Self-service instrument

Instrument that is intended to be operated by the customer.

T.1.2.11 Mobile instrument

Non-automatic weighing instrument mounted on or incorporated into a vehicle.

NOTE 1 A vehicle-mounted instrument is a complete weighing instrument which is firmly mounted on a vehicle, and which is designed for that special purpose.

EXAMPLE 1: Postal scale mounted on a vehicle (mobile post office).

NOTE 2 A vehicle-incorporated instrument uses parts of the vehicle for the weighing instrument.

EXAMPLE 2: Garbage weighers, patient lifters, pallet lifters, fork lifters, wheel chair weighers.

T.1.2.12 Portable instrument for weighing road vehicles

Non-automatic weighing instrument having a load receptor, in one or several parts, which determines the total mass of road vehicles, and which is designed to be moved to other locations.

EXAMPLES: Portable weighbridge, group of associated non-automatic axle (or wheel) load weighers.

NOTE This standard covers only weighbridges and groups of associated non-automatic axle (or wheel) load weighers that determine simultaneously the total mass of a road vehicle with all axles (or wheels) being simultaneously supported by appropriate parts of a load receptor.

T.1.2.13 Grading instrument

Instrument which assigns a weighing result to a predetermined range of mass to determine a tariff or toll.

EXAMPLES: Postal scales, garbage weighers.

T.1.3 Indications of an instrument

Value of a quantity provided by a measuring instrument.

NOTE "Indication", "indicate" or "indicating" includes both displaying and/or printing.

T.1.3.1 Primary indications

Indications, signals and symbols that are subject to requirements of this European Standard.

T.1.3.2 Secondary indications

Indications, signals and symbols that are not primary indications.

T.2 Construction of an instrument

In this standard the term “device” is used for any means by which a specific function is performed, irrespective of the physical realization, e.g. by a mechanism or a key initiating an operation. The device may be a small part or a major portion of an instrument.

T.2.1 Main devices

T.2.1.1 Load receptor

Part of the instrument intended to receive the load.

T.2.1.2 Load-transmitting device

Part of the instrument for transmitting the force produced by the load acting on the load receptor to the load-measuring device.

T.2.1.3 Load-measuring device

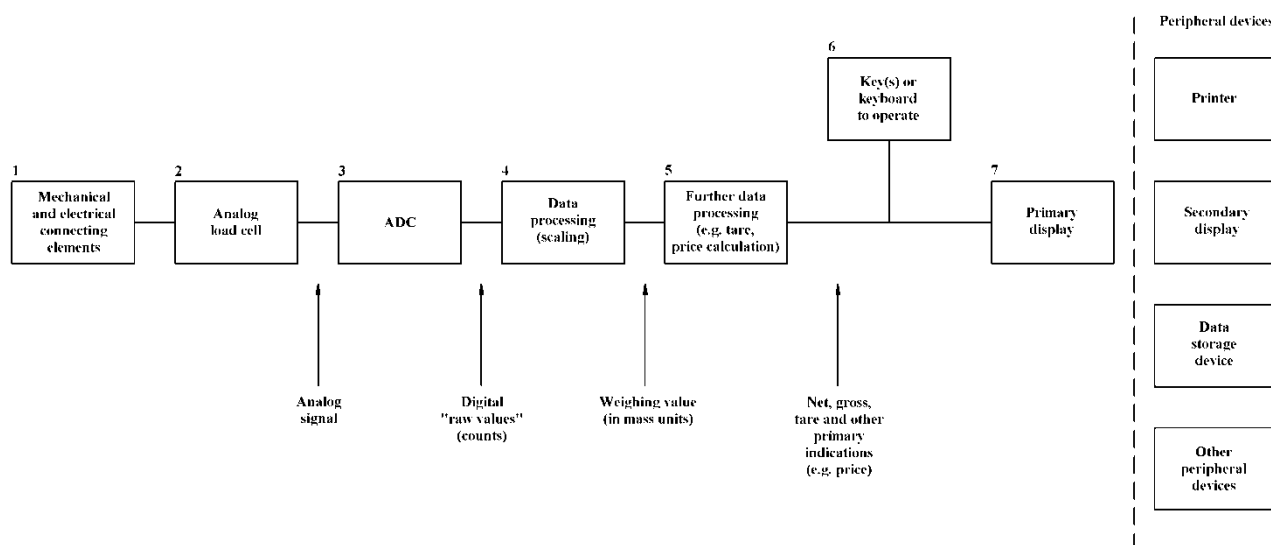
Part of the instrument for measuring the mass of the load by means of an equilibrium device for balancing the force coming from the load transmitting device, and an indicating or printing device.

T.2.2 Module

Identifiable part of an instrument that performs a specific function or functions, and that can be separately evaluated in accordance with specific metrological and technical performance requirements in the relevant standard. The modules of a weighing instrument are subject to specified partial error limits.

NOTE Typical modules of a weighing instrument are: load cell, indicator, analog or digital data processing device, weighing module, terminal, primary display.

Evaluation Certificates and Parts Certificates in accordance with this standard can be issued for the modules mentioned in T.2.2.2 to T.2.2.7.



Analog load cell	(T.2.2.1)	2
Digital load cell	(T.2.2.1)	2 + 3 + (4)*
Indicator	(T.2.2.2)	(3) + 4 + (5) + (6) + 7
Analog data processing device	(T.2.2.3)	3 + 4 + (5) + (6)
Digital data processing device	(T.2.2.4)	(4) + 5 + (6)
Terminal	(T.2.2.5)	(5) + 6 + 7
Primary display	(T.2.2.6)	7
Weighing module	(T.2.2.7)	1 + 2 + 3 + 4 + (5) + (6)
NOTE Numbers in brackets indicate options.		

**Figure 1 - Definition of typical modules according to T.2.2 and 3.10.2
(other combinations are possible)**

T.2.2.1 Load cell

Force transducer which, after taking into account the effects of the acceleration of gravity and air buoyancy at the location of its use, measures mass by converting the measured quantity (mass) into another measured quantity (output).

NOTE Load cells equipped with electronics including amplifier, analog-to-digital converter (ADC), and data processing device (optionally) are called digital load cells (see Figure 1).

T.2.2.2 Indicator

Electronic device of an instrument that may perform the analog-to-digital conversion of the output signal of the load cell, and which further processes the data, and displays the weighing result in units of mass.

T.2.2.3 Analog data processing device

Electronic device of an instrument that performs the analog-to-digital conversion of the output signal of the load cell, further processes the data, and supplies the weighing result in a digital format via a digital interface without displaying it. It may optionally have one or more keys (or mouse, touch-screen, etc.) to operate the instrument.

T.2.2.4 Digital data processing device

Electronic device of an instrument that further processes the data, and supplies the weighing result in a digital format via a digital interface without displaying it. It may optionally have one or more keys (or mouse, touch-screen, etc.) to operate the instrument.

T.2.2.5 Terminal

Digital device that has one or more keys (or mouse, touch-screen, etc.) to operate the instrument, and a display to provide the weighing results transmitted via the digital interface of a weighing module or an analog data processing device.

T.2.2.6 Digital display

A digital display can be realized as a primary display or as a secondary display:

- a) Primary display: Either incorporated in the indicator housing or in the terminal housing or realized as a display in a separate housing (i.e. terminal without keys), e.g. for use in combination with a weighing module;
- b) Secondary display: Additional peripheral device (optional) which repeats the weighing result and any other primary indication, or provides further, non-metrological information.

The terms “primary display” and “secondary display” should not be confused with the terms “primary indication” and “secondary indication” (T.1.3.1 and T.1.3.2).

T.2.2.7 Weighing module

Part of the weighing instrument that comprises all mechanical and electronic devices (i.e. load receptor, load-transmitting device, load cell, and analog data processing device or digital data processing device) but not having the means to display the weighing result. It may optionally have devices for further processing (digital) data and operating the instrument.

T.2.3 Electronic parts

T.2.3.1 Electronic device

Device employing electronic sub-assemblies and performing a specific function.

Electronic devices are usually manufactured as separate units and are capable of being tested independently.

NOTE An electronic device, as defined above, may be a complete instrument (e.g. an instrument for direct sales to the public), a module (e.g. indicator, analog data processing device, weighing module) or a peripheral device (e.g. printer, secondary display).

T.2.3.2 Electronic sub-assembly

Part of an electronic device, employing electronic components and having a recognizable function of its own.

EXAMPLES: A/D converter, display.

T.2.3.3 Electronic component

Smallest physical entity that uses electron or hole conduction in semi-conductors, gases or in a vacuum.

EXAMPLES: Electronic tube, transistor, integrated circuit.

T.2.3.4 Digital device

Electronic device that only performs digital functions and provides a digitized output or display.

EXAMPLES: Printer, primary or secondary display, keyboard, terminal, data storage device, personal computer.

T.2.3.5 Peripheral device

Additional device which repeats or further processes the weighing result and other primary indications.

EXAMPLES: Printer, secondary display, keyboard, terminal, data storage device, personal computer.

T.2.3.6 Protective interface

Interface (hardware and/or software) which only allows the introduction of such data into the data processing device of an instrument, module or electronic component, which cannot

- display data which are not clearly defined and which could be taken for a weighing result,
- falsify displayed, processed or stored weighing results or primary indications, or
- adjust the instrument or change any adjustment factor, except releasing an adjustment procedure with incorporated devices or, in the case of class I instruments with external adjustment weights as well.

T.2.4 Displaying device (of a weighing instrument)

Device providing the weighing result in visual form.

T.2.4.1 Displaying component

Component that displays the equilibrium and/or the result.

- on an instrument with one position of equilibrium it displays only the equilibrium.
- on an instrument with several positions of equilibrium it displays both the equilibrium and the result.

T.2.4.2 Scale mark

Line or other mark on a displaying component corresponding to a specified value of mass.

T.2.5 Auxiliary indicating devices**T.2.5.1 Rider**

Detachable poise of small mass that may be placed and moved either on a graduated bar integral with the beam or on the beam itself.

T.2.5.2 Device for interpolation of reading (vernier or nonius)

Device connected to the displaying component and sub-dividing the scale of an instrument, without special adjustment.

T.2.5.3 Complementary displaying device

Adjustable device by means of which it is possible to estimate, in units of mass, the value corresponding to the distance between a scale mark and the displaying component.

T.2.5.4 Indicating device with a differentiated scale division

Digital indicating device of which the last figure after the decimal sign is clearly differentiated from other figures.

T.2.6 Extended displaying device

Device temporarily changing the actual scale interval, d , to a value less than the verification scale interval, e , following a manual command.

T.2.7 Supplementary devices

T.2.7.1 Leveling device

Device for setting an instrument to its reference (horizontal) position.

T.2.7.2 Zero-setting device

Device for setting the indication to zero when there is no load on the load receptor.

T.2.7.2.1 Non-automatic zero-setting device

Device for setting the indication to zero by an operator.

T.2.7.2.2 Semi-automatic zero-setting device

Device for setting the indication to zero automatically following a manual command.

T.2.7.2.3 Automatic zero-setting device

Device for setting the indication to zero automatically without the intervention of an operator.

T.2.7.2.4 Initial zero-setting device

Device for setting the indication to zero automatically at the time the instrument is switched on and before it is ready for use.

T.2.7.3 Zero-tracking device

Device for maintaining the zero indication within certain limits automatically.

T.2.7.4 Tare device

Device for setting the indication to zero when a load is on the load receptor

- without altering the weighing range for net loads (additive tare device), or
- reducing the weighing range for net loads (subtractive tare device).

It may function as

- a non-automatic device (load balanced by an operator),
- a semi-automatic device (load balanced automatically following a single manual command), or
- an automatic device (load balanced automatically without the intervention of an operator).

T.2.7.4.1 Tare-balancing device

Tare device without indication of the tare value when the instrument is loaded.

T.2.7.4.2 Tare-weighing device

Tare device that stores the tare value and that is capable of displaying or printing it whether or not the instrument is loaded.

T.2.7.5 Preset tare device

Device for subtracting a preset tare value from a gross or net weight value and indicating the result of the calculation. The weighing range for net loads is reduced accordingly.

T.2.7.6 Locking device

Device for immobilizing all or part of the mechanism of an instrument.

T.2.7.7 Auxiliary verification device

Device permitting separate verification of one or more main devices of an instrument.

T.2.7.8 Selection device for load receptors and load-measuring devices

Device for attaching one or more load receptors to one or more load-measuring devices, whatever intermediate load-transmitting devices are used.

T.2.8 Software

T.2.8.1 Legally relevant software

Programs, data, type-specific and device-specific parameters that belong to the measuring instrument or module, and define or fulfill functions which are subject to legal control.

EXAMPLES: Final results of the measurement, i.e. gross, net and tare / preset tare value (including the decimal sign and the unit), identification of the weighing range and the load receptor (if several load receptors have been used), software identification.

T.2.8.2 Legally relevant parameter

Parameter of a measuring instrument or a module subject to legal control. The following types of legally relevant parameters can be distinguished: type-specific parameters and device-specific parameters.

T.2.8.3 Type-specific parameter

Legally relevant parameter with a value that depends on the type of instrument only. Type-specific parameters are part of the legally relevant software. They are fixed at type approval of the instrument.

EXAMPLES: Parameters used for mass calculation, stability analysis or price calculation and rounding, software identification.

T.2.8.4 Device-specific parameter

Legally relevant parameter with a value that depends on the individual instrument. Device-specific parameters comprise calibration parameters (e.g. span adjustment or other adjustments or corrections) and configuration parameters (e.g. maximum capacity, minimum capacity, units of measurement, etc.). They are adjustable or selectable only in a special operational mode of the instrument. Device-specific parameters may be classified as those that should be secured (unalterable) and those that may be accessed (settable parameters) by an authorized person.

T.2.8.5 Long-term storage of measurement data

Storage used for keeping measurement data ready after completion of the measurement for later legally relevant purposes (e.g. conclusion of a trading transaction at a later date, when the customer is not present for the determination of the amount, or for special applications identified and legislated by the state).

T.2.8.6 Software identification

Sequence of readable characters of software that is inextricably linked to the software (e.g. version number, checksum).

T.2.8.7 Software separation

Unambiguous separation of software into legally relevant software and non-legally relevant software. If no software separation exists, the whole software is to be considered as legally relevant.

T.2.9 Metrologically relevant

Any device, module, part, component or function of a weighing instrument that may influence the weighing result or any other primary indication.

T.3 Metrological characteristics of an instrument**T.3.1 Weighing capacity****T.3.1.1 Maximum capacity (Max)**

Maximum weighing capacity, not taking into account the additive tare capacity.

T.3.1.2 Minimum capacity (Min)

Value of the load below which the weighing results may be subject to an excessive relative error.

T.3.1.3 Self-indication capacity

Weighing capacity within which equilibrium is obtained without the intervention of an operator.

T.3.1.4 Weighing range

Range between the minimum and maximum capacities.

T.3.1.5 Extension interval of self-indication

Value by which it is possible to extend the range of self-indication within the weighing range.

T.3.1.6 Maximum tare effect ($T = + \dots$, $T = - \dots$)

Maximum capacity of the additive tare device or the subtractive tare device.

T.3.1.7 Maximum safe load (L_{im})

Maximum static load that can be carried by the instrument without permanently altering its metrological qualities.

T.3.2 Scale divisions**T.3.2.1 Scale spacing (instrument with analog indication)**

Distance between any two consecutive scale marks.

T.3.2.2 Actual scale interval, d

Value, expressed in units of mass of

- the difference between the values corresponding to two consecutive scale marks, for analog indication, or
- the difference between two consecutive indicated values, for digital indication.

T.3.2.3 Verification scale interval, e

Value, expressed in units of mass, used for the classification and verification of an instrument.

T.3.2.4 Scale interval used for numbering

Value of the difference between two consecutive numbered scale marks.

T.3.2.5 Number of verification scale intervals, n

Quotient of the maximum capacity and the verification scale interval:

$$n = \text{Max} / e$$

T.3.2.6 Multi-interval instrument

Instrument having one weighing range which is divided into partial weighing ranges each with different scale intervals, with the partial weighing range determined automatically according to the load applied, both on increasing and decreasing loads.

T.3.2.7 Multiple range instrument

Instrument having two or more weighing ranges with different maximum capacities and different scale intervals for the same load receptor, each range extending from zero to its maximum capacity.

T.3.3 Reduction ratio, R

The reduction ratio of a load transmitting device is:

$$R = F_M / F_L$$

where

F_M = force acting on the load measuring device;

F_L = force acting on the load receptor.

T.3.4 Type

Definitive model of a weighing instrument or module (including a family of instruments or modules) of which all of the elements affecting its metrological properties are suitably defined

T.3.5 Family [adapted from OIML B 3: 2003, 2.3]

Identifiable group of weighing instruments or modules belonging to the same manufactured type that have the same design features and metrological principles for measurement (for example the same type of indicator, the same type of design of load cell and load transmitting device) but which may differ in some metrological and technical performance characteristics (e.g. Max, Min, e , d , accuracy class, etc.).

The concept of a “family” primarily aims to reduce the testing required at type examination. It does not preclude the possibility of listing more than one family in one Certificate.

T.4 Metrological properties of an instrument**T.4.1 Sensitivity**

For a given value of the measured mass, the quotient of the change, ΔI , of the observed variable, I , and the corresponding change, Δm , of the measured mass, m .

T.4.2 Discrimination

Ability of an instrument to react to small variations of load.

The discrimination threshold, for a given load, is the value of the smallest additional load that, when gently deposited on or removed from the load receptor, causes a perceptible change in the indication.

T.4.3 Repeatability

Ability of an instrument to provide results that agree one with the other when the same load is deposited several times and in a practically identical way on the load receptor under reasonably constant test conditions.

T.4.4 Durability

Ability of an instrument to maintain its performance characteristics over a period of use.

T.4.5 Warm-up time

Time between the moment power is applied to an instrument and the moment at which the instrument is capable of conforming to the requirements of this standard.

T.4.6 Final weight value

Weight value that is achieved when the instrument is completely at rest and balanced, with no disturbances affecting the indication.

T.5 Indications and errors

T.5.1 Methods of indication

T.5.1.1 Balancing by weights

Value of metrologically controlled weights that balances the load (taking into account the reduction ratio of the load).

T.5.1.2 Analog indication

Indication enabling the evaluation of the equilibrium position to a fraction of the scale interval.

T.5.1.3 Digital indication

Indication in which the scale marks are composed of a sequence of aligned figures that do not permit interpolation to fractions of the scale interval.

T.5.2 Weighing results

NOTE The definitions in T.5.2 apply only when the indication has been zero before the load has been applied to the instrument.

T.5.2.1 Gross value, G or B

Indication of the weight value of a load on an instrument, with no tare or preset tare device in operation.

T.5.2.2 Net value, N

Indication of the weight value of a load placed on an instrument after operation of a tare device.

T.5.2.3 Tare value, T

Weight value of a load, determined by a tare weighing device.

T.5.3 Other weight values

T.5.3.1 Preset tare value, PT

Numerical value, representing a weight, that is introduced into the instrument and is intended to be applied to other weighings without determining individual tares.

“Introduced” includes procedures such as: keying in, recalling from a data storage device, or inserting via an interface.

T.5.3.2 Calculated net value

Value of the difference between a measured weight value (gross or net) and a preset tare value.

T.5.3.3 Calculated weight value

Calculated sum or difference of more than one measured weight value and/or calculated net value.

T.5.4 Reading**T.5.4.1 Reading by simple juxtaposition**

Reading of the weighing result by simple juxtaposition of consecutive figures giving the weighing result, without the need of calculation.

T.5.4.2 Overall inaccuracy of reading

On an instrument with analog indication, this is equal to the standard deviation of the same indication, the reading of which is carried out under normal conditions of use by several observers.

It is customary to make at least ten readings of the result.

T.5.4.3 Rounding error of digital indication

Difference between the indication and the result the instrument would give with analog indication.

T.5.4.4 Minimum reading distance

Shortest distance that an observer is able freely to approach the displaying device to take a reading under normal conditions of use.

This approach is considered to be free for the observer if there is a clear space of at least 0,8 m in front of the displaying device (see Figure 2).

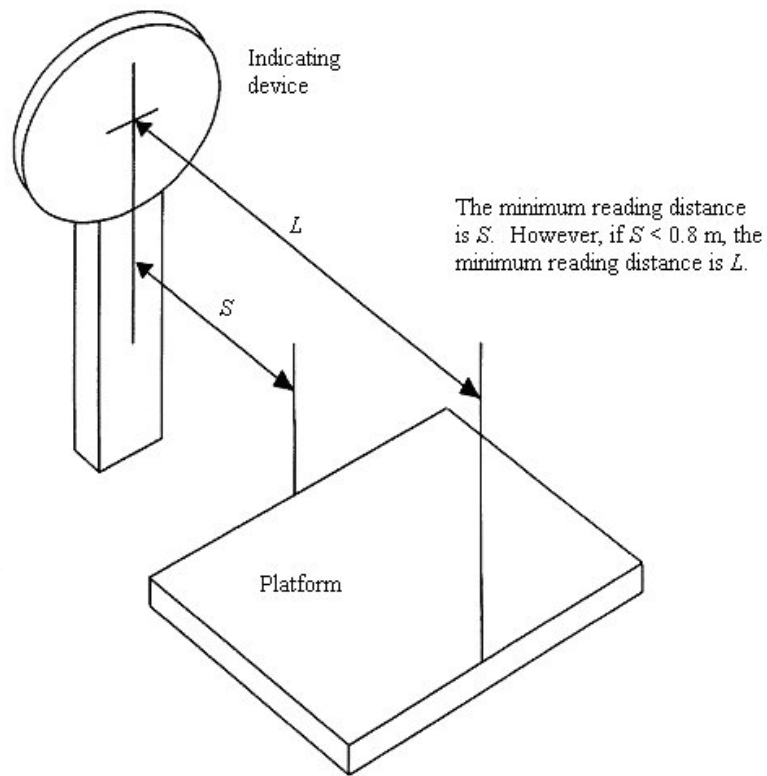
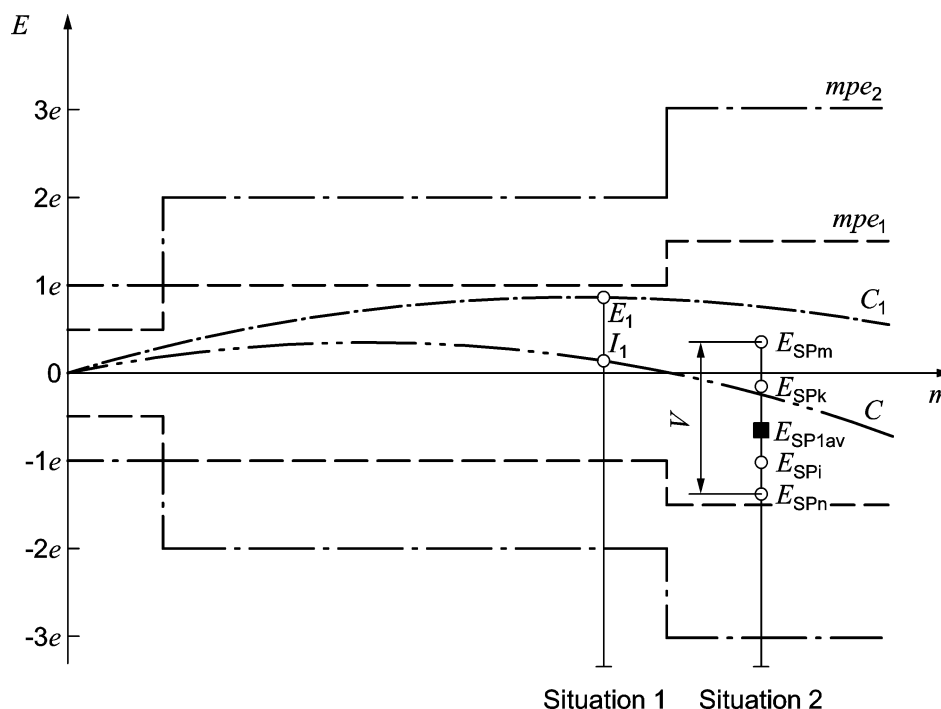


Figure 2

T.5.5 Errors



Key

m = mass to be measured

E = error of indication (T.5.5.1)

mpe_1 = maximum permissible error on verification or conformity testing

mpe_2 = maximum permissible error in service

C = characteristic under reference conditions

C_1 = characteristic due to influence factor or disturbance

(For the purposes of this illustration it is supposed that the influence factor or the disturbance has an influence on the characteristic which is not erratic)

E_{SP} = error of indication evaluated during span stability test

I = intrinsic error (T.5.5.2)

V = variation in the errors of indication during span stability test

Situation 1: shows the error E_1 of an instrument due to an influence factor or a disturbance. I_1 is the intrinsic error. The fault (T.5.5.5) due to the influence factor or disturbance applied equals $E_1 - I_1$.

Situation 2: shows the average value, E_{SP1av} , of the errors at the first measurement of the span stability test, some other errors (E_{SPi} and E_{SPk}) and the extreme values of the errors E_{SPm} and E_{SPn} , all these errors being evaluated at different moments during the span stability test. The variation, V , in the errors of indication during the span stability test equals $E_{SPm} - E_{SPn}$.

Figure 3

T.5.5.1 Error (of indication)

Indication of an instrument minus the (conventional) true value of the corresponding mass.

T.5.5.2 Intrinsic error

Error of an instrument determined under reference conditions.

T.5.5.3 Initial intrinsic error

Intrinsic error of an instrument as determined prior to the performance and span stability tests.

T.5.5.4 Maximum permissible error, mpe

Maximum difference, positive or negative, allowed by regulation between the indication of an instrument and the corresponding true value, as determined by reference standard masses or standard weights, with the instrument being at zero at no-load, in the reference position.

T.5.5.5 Fault

Difference between the error of indication and the intrinsic error of an instrument.

NOTE Principally, a fault is the result of an undesired change of data contained in or flowing through an electronic instrument.

T.5.5.6 Significant fault

Fault greater than e .

NOTE For a multi-interval instrument, the value of e is that appropriate to the partial weighing range.

The following are not considered to be significant faults, even when they exceed e :

- faults arising from simultaneous and mutually independent causes in the instrument;
- faults implying the impossibility to perform any measurement;
- faults being so serious that they are bound to be noticed by all those interested in the result of measurement; or
- transitory faults, being momentary variations in the indication which cannot be interpreted, memorized or transmitted as a measurement result.

T.5.5.7 Durability error

Difference between the intrinsic error over a period of use and the initial intrinsic error of an instrument.

T.5.5.8 Significant durability error

Durability error greater than e .

NOTE 1 A durability error can be due to mechanical wear and tear or due to drift and ageing of electronic parts. The concept of significant durability error applies only to electronic parts.

NOTE 2 For a multi-interval instrument, the value of e is that appropriate to the partial weighing range.

Errors, occurring after a period of instrument use, are not considered to be significant durability errors, even when they exceed e , if they are clearly the result of the failure of a device/component, or of a disturbance and for which the indication

- cannot be interpreted, memorized, or transmitted as a measurement result,
- implies the impossibility to perform any measurement, or
- is so obviously wrong that it is bound to be noticed by all those interested in the result of measurement.

T.5.5.9 Span stability

Capability of an instrument to maintain the difference between the indication at maximum capacity and the indication at zero over a period of use within specified limits.

T.6 Influences and reference conditions

T.6.1 Influence quantity

Quantity that is not the subject of the measurement but which influences the values of the measurement and or the indication of the instrument.

T.6.1.1 Influence factor

Influence quantity having a value within the specified rated operating conditions of the instrument.

T.6.1.2 Disturbance

Influence quantity having a value within the limits specified in this standard, but outside the specified rated operating conditions of the instrument.

T.6.2 Rated operating conditions

Conditions of use, giving the range of values of influence quantities for which the metrological characteristics are intended to lie within the specified maximum permissible errors.

T.6.3 Reference conditions

Set of specified values of influence factors, fixed to ensure valid inter-comparison of the results of measurements.

T.6.4 Reference position

Position of the instrument at which its operation is adjusted.

T.7 Performance test

Test to verify whether the equipment under test (EUT) is capable of performing its intended functions.

T.8 Index of terms defined

The numbers in brackets refer to important chapters of this standard.

Actual scale interval	(3.4.3, 3.5.3.2, 3.8.2.2, A.4.8.2).....	T.3.2.2
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Calculated weight value	(4.6.11).....	T.5.3.3
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Fault	(5.1, 5.2)	T.5.5.5
Final weight value	(4.4.2)	T.4.6
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Initial zero-setting device	(4.5.1, 4.5.4, A.4.4.2)	T.2.7.2.4
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T.9 Abbreviations and symbols

This standard concerns metrological terms as well as technical and physical terms. Therefore, ambiguity of abbreviations and symbols is not excluded. However, with the following explanations, any confusion should be avoided.

α	temperature coefficient of cable material	C.3.3.2.4
ρ	specific resistance of cable material	C.3.3.2.4
A	cross-section of a single wire	C.3.3.2.4, F.1, F.4
A	A load cell classification	F.2, Table
AC	alternating current	3.9.3, etc.
A/D	analog-to-digital	T.2.2
ADC	relevant analog components, including Analog/Digital-Converter	T.2.2, Figure 1, 5.5.2.1, Table 14
B	A load cell classification	F.2, Table
B	gross weight value	T.5.2.1, 4.6.11
C	A load cell classification	F.2, Table F.1, F.4
C	mark for calculated weight value, when printed	4.6.11
C	rated output of a load cell	F.2, F.4
CH	additional load cell classification: cyclic temperature humidity tested	F.2,
CRC	cyclic redundancy check	5.5.3.3
d	(actual) scale interval	T.3.2.2, T.2.6, 6.9.3
D	A load cell classification	F.2, Table
DC	direct current	3.9.3, etc.
DL	dead load of load receptor	F.1, F.2.4, F.4
DR	Minimum dead load output return ,	F.2, F.4
DSD	data storage device	5.5.3
D_{max}	maximum load of the measuring range (maximum test load)	A.4.1.10
D_{min}	minimum load of the measuring range (minimum test load)	A.4.1.10
e	verification scale interval	T.2.6, 3.1.2, 3.2
e_1, e_i, e_r	verification scale interval, rules for indices	3.2, F.1, F.4
E	error of indication	T.5.5.3, Figure 3, A.4.4.3

E_{in}	intrinsic error	T.5.5.3
E_{max}	maximum capacity of the load cell	F.2, F.4
E_{min}	minimum dead load for the load cell	F.2, F.4
EMC	electromagnetic compatibility	B.3.7
EUT	equipment under test	T.7, 3.10.4, Annex B
G	gross weight value	T.5.2.1, 4.6.11
i	variable indices	3.3, etc.
i, i_x	scale spacing	T.3.2.1, 4.3.2, 6.2.2.2
i_0	minimum scale spacing	4.3.2, 6.9.3
I	indicated weight value	A.4.4.3 (Evaluation of errors), A.4.8.2
I/O	input output	B.3.2
IZSR	initial zero setting range	F.1, F.4
k	variable exponent	3.4.2, 4.2.2.1
l, L	length of cable	C.3.3.2.4, F.1, F.4
L	reading distance	T.5.4.4, 4.3.2
L	Load	A.4.4.3 (Evaluation of errors)
LC	load cell	Annex F
Lim	maximum safe load	7.1.3.1
m	mass	3.5.1, etc.
Max	maximum capacity of the weighing instrument	T.3.1.1, F.1, F.4
Max_1, Max_i, Max_r	maximum capacity of the weighing instrument, rules for indices	3.3, F.1, F.4
Min	minimum capacity of the weighing instrument	T.3.1.2
mpe	maximum permissible error	T.5.5, T.5.5.4, 3.5 etc.
n, n_i	number of verification scale intervals	T.3.2.5, F.4
n_{max}	maximum number of verification scale intervals	3.10.4.6, etc.
n_{WI}	maximum number of verification scale intervals of the weighing instrument	F.1, F.4
n_{ind}	maximum number of verification scale intervals for an indicator	F.3, F.4
n_{LC}	maximum number of load cell verification intervals	F.2, F.4
N, NET, Net, net	net value	T.5.2.2, 4.6.5, 4.6.11
N	number of load cells	F.1, F.4
NH	additional load cell classification: not humidity tested	F.2
NUD	correction for non uniform distributed load	F.1, F.4
p, p_i	apportioning factor of mpe	3.10.2.1
p_{ind}, p_{LC}, p_{con}	fraction of mpe for indicator, load cell and conducting elements	3.10.2.1, F.4
P	indication prior to rounding	A.4.4.3 (Evaluation of errors)
P	price to pay	4.14.2
PLU	price look up (unit, storage)	4.13.4
PT	preset tare	T.2.7.5, 4.7
Q	correction factor	F.1, F.4
R	reduction ratio of a load transmitting device	T.3.3
R_{cable}	resistance of a single wire	C.3.3.2.4
R_L, R_{Lmin}, R_{Lmax}	load resistance for an indicator	F.3, F.4
R_{LC}	input resistance of a load cell	F.2, F.4
SH	additional load cell classification: static temperature humidity tested	F.2

T	tare value	T.5.2.3, 4.6.5, 4.6.11
T^+	additive tare	7.1.1, etc.
T^-	subtractive tare	7.1.1, etc.
$T_{\min}, T_{\max}$	lower limit of temperature range, upper limit of temperature range	C.3.3.2.4
u_m	unit of measurement	2.1, 4.12.1
$\Delta u_{\min}$	minimum input voltage per verification scale interval	C.2.1.1, F.3, F.4
U	unit price	4.14.2
U	nominal voltage of power supply	3.9.3, A.5.4
$U_{\min}, U_{\max}$	voltage range of power supply	3.9.3, A.5.4
U_{exc}	load cell excitation voltage	F.4
$U_{\min}$	minimum input voltage for indicator	F.3, F.4
U_{MRmin}	measuring range minimum voltage for indicator	F.3
U_{MRmax}	measuring range maximum voltage for indicator	F.3
$v_{\min}$	minimum load cell verification interval	F.2, F.4
V	variation in the error	Figure 3
W	Weight	4.14.2
$W1, W2$	weighing instrument 1, weighing instrument 2	7.1
WI	weighing instrument	F.1
WR	weighing range	T.3.1.4, 4.6.12
Y	ratio to minimum load cell verification interval: $Y = E_{\max} / v_{\min}$	F.4
Z	ratio to minimum load cell dead load output return: $Z = E_{\max} / (2 \times \text{DR})$	F.4

Non-automatic weighing instruments

1 Scope

This European Standard specifies the metrological and technical requirements for non-automatic weighing instruments.

It is intended to provide standardized requirements and testing procedures to evaluate the metrological and technical characteristics in a uniform and traceable way.

2 Principles of the European Standard

2.1 Units of measurement

The units of mass to be used on an instrument are

- the kilogram, kg,
- the milligram, mg,
- the gram, g, and
- the tonne, t.

For special applications, e.g. trade with precious stones, the metric carat (1 carat = 0,2 g) may be used as the unit of measurement. The symbol for the carat is ct.

2.2 Principles of the metrological requirements

The requirements apply to all instruments irrespective of their principles of measurement.

Instruments are classified in accordance with

- the verification scale interval, representing absolute accuracy, and
- the number of verification scale intervals, representing relative accuracy.

The maximum permissible errors are in the order of magnitude of the verification scale interval. They apply to gross loads and when a tare device is in operation they apply to the net loads. The maximum permissible errors do not apply to calculated net values when a preset tare device is in operation.

A minimum capacity (Min) is specified to indicate that use of the instrument below this value is likely to give rise to considerable relative errors.

2.3 Principles of the technical requirements

General technical requirements apply to all types of instruments, whether mechanical or electronic, and are supplemented or modified with additional requirements for instruments used for specific applications or designed for a special technology. They are intended to specify the performance, not the design of an instrument, so that technical progress is not impeded.

In particular, functions of electronic instruments not covered by this standard should be allowed provided that they do not interfere with the metrological requirements, and if suitability for use and appropriate metrological control is ensured.

Testing procedures are provided to establish conformity of instruments with the requirements of this standard. They should be applied to facilitate exchange and acceptance of test results by metrological authorities.

2.4 Application of requirements

The requirements of this standard apply to all devices performing the relevant functions, whether they are incorporated in an instrument or manufactured as separate units. Examples are

- load-measuring device,
- displaying device,
- printing device,
- preset tare device, and
- price-calculating device.

2.5 Terminology

The terminology given in chapter Terminology shall be considered as a binding part of this standard.

3 Metrological requirements

3.1 Principles of classification

3.1.1 Accuracy classes

The accuracy classes for instruments and their symbols ¹⁾ are given in Table 1. Please note that the class denominations used in this standard do not include the oval around the number for improved clarity of the standard's text.

Table 1

Name	Symbol marked on instrument	Denomination used in this standard
Special accuracy	⓪	I
High accuracy	Ⓛ	II
Medium accuracy	Ⓜ	III
Ordinary accuracy	ⓂⓂ	IIII

3.1.2 Verification scale interval

The verification scale interval for different types of instruments is given in Table 2.

Table 2

Type of instrument	Verification scale interval
Graduated, without auxiliary indicating device	$e = d$
Graduated, with auxiliary indicating device	e is chosen by the manufacturer according to the requirements in 3.2 and 3.4.2
Non-graduated	e is chosen by the manufacturer according to the requirements in 3.2

3.2 Classification of instruments

The verification scale interval, number of verification scale intervals and the minimum capacity, in relation to the accuracy class of an instrument, are given in Table 3.

¹⁾ Ovals of any shape, or two horizontal lines joined by two half-circles are permitted.

Table 3

Accuracy class	Verification scale interval, e	Number of verification scale intervals, $n = \text{Max}/e$		Minimum capacity, Min (Lower limit)
		minimum	maximum	
Special (I)	$0,001 \text{ g} \leq e^a$	50 000 ^b	—	100 e
High (II)	$0,001 \text{ g} \leq e \leq 0,05 \text{ g}$	100	100 000	20 e
	$0,1 \text{ g} \leq e$	5 000	100 000	50 e
Medium (III)	$0,1 \text{ g} \leq e \leq 2 \text{ g}$	100	10 000	20 e
	$5 \text{ g} \leq e$	500	10 000	20 e
Ordinary (III)	$5 \text{ g} \leq e$	100	1 000	10 e
^a It is not normally feasible to test and verify an instrument to $e < 1 \text{ mg}$, due to the uncertainty of the test loads. ^b See exception in 3.4.4.				

The minimum capacity is reduced to 5 e for instruments in classes II and III for determining a conveying tariff

On multiple range instruments the verification scale intervals are $e_1, e_2, \dots, e_r$ with $e_1 < e_2 < \dots < e_r$. Similar subscripts are also used with the terms Min, n and Max.

On multiple range instruments, each range is treated as if it were an instrument with one range.

For special applications that are clearly marked on the instrument, an instrument may have weighing ranges in classes I and II, or in classes II and III. The instrument as a whole shall then conform to the more severe requirements of 3.9 applicable to either of the two classes.

3.3 Additional requirements for multi-interval instruments

3.3.1 Partial weighing range

Each partial range (index $i = 1, 2, \dots$) is defined by

- its verification scale interval, $e_i, e_{i+1} > e_i$,
- its maximum capacity, Max_i , and
- its minimum capacity, $\text{Min}_i = \text{Max}_{i-1}$ (for $i = 1$, the minimum capacity is $\text{Min}_1 = \text{Min}$).

The number of verification scale intervals, n_i , for each partial range is equal to Max_i / e_i .

3.3.2 Accuracy class

e_i and n_i in each partial weighing range, and Min_1 shall conform to the requirements given in Table 3 in accordance with the accuracy class of the instrument.

3.3.3 Maximum capacity of partial weighing ranges

With the exception of the last partial weighing range, the requirements in Table 4 shall be complied with according to the accuracy class of the instrument.

Table 4

Class	I	II	III	III
Max_i / e_{i+1}	$\geq 50\,000$	$\geq 5\,000$	≥ 500	≥ 50

Example for a multi-interval instrument:

Maximum capacity, $\text{Max} = 2 / 5 / 15$ kg, class III.

Verification scale interval, $e = 1 / 2 / 10$ g

This instrument has one Max and one weighing range from $\text{Min} = 20$ g to $\text{Max} = 15$ kg. The partial weighing ranges are:

- $\text{Min} = 20$ g, $\text{Max}_1 = 2$ kg, $e_1 = 1$ g, $n_1 = 2\,000$,
- $\text{Min}_2 = 2$ kg, $\text{Max}_2 = 5$ kg, $e_2 = 2$ g, $n_2 = 2\,500$,
- $\text{Min}_3 = 5$ kg, $\text{Max}_3 = \text{Max} = 15$ kg, $e_3 = 10$ g, $n_3 = 1\,500$.

The maximum permissible errors on verification (mpe) (see 3.5.1) are

- for $m = 0$ g to 500 g $\text{mpe} = \pm 0,5 e_1 = \pm 0,5$ g,
- for $m > 500$ g to $2\,000$ g $\text{mpe} = \pm 1 e_1 = \pm 1$ g,
- for $m > 2\,000$ g to $4\,000$ g $\text{mpe} = \pm 1 e_2 = \pm 2$ g,
- for $m > 4\,000$ g to $5\,000$ g $\text{mpe} = \pm 1,5 e_2 = \pm 3$ g,
- for $m > 5\,000$ g to $15\,000$ g $\text{mpe} = \pm 1 e_3 = \pm 10$ g.

Whenever the variation of the indication, due to certain influence factors is limited to a fraction or multiple of e , this means, in a multi-interval instrument, that e is to be taken in accordance with the load applied; particularly at or near zero, load $e = e_1$.

3.3.4 Instrument with a tare device

Requirements concerning the ranges of a multi-interval instrument apply to the net load, for every possible value of the tare.

3.4 Auxiliary indicating devices

3.4.1 Type and application

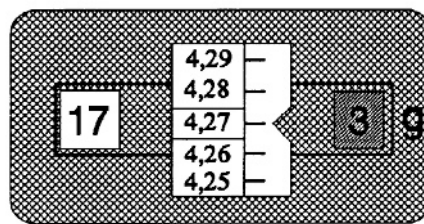
Only instruments of classes I and II may be fitted with an auxiliary indicating device, which shall be

- a device with a rider,
- a device for interpolation of reading,
- a complementary displaying device (see Figure 4), or
- an indicating device with a differentiated scale division (see Figure 5).

These devices are permitted only to the right of the decimal sign.

A multi-interval instrument shall not be fitted with an auxiliary indicating device.

NOTE Extended displaying devices (see T.2.6 and 4.4.3) are not regarded as auxiliary indicating devices.



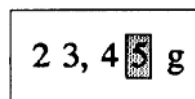
indication: 174.273 g

last figure: 3

$d = 1 \text{ mg}$

$e = 10 \text{ mg}$

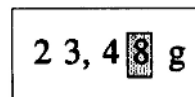
Figure 4 – Example of a complementary displaying device



last differentiated figure: 5

$d = 0,01 \text{ g}$ or $0,05 \text{ g}$

$e = 0,1 \text{ g}$



last differentiated figure: 8

$d = 0,01 \text{ g}$ or $0,02 \text{ g}$

$e = 0,1 \text{ g}$

Figure 5 – Examples of indicating devices each with a differentiated scale division

3.4.2 Verification scale interval

The verification scale interval, e , is determined by the expression:

$$d < e \leq 10 d \text{ (see Table 5)}$$

$$e = 10^k \text{ kg}$$

k being a positive or negative whole number, or zero.

For a self- or semi-self-indicating instrument, see 4.2.2.1.

Table 5 – Example values of e , calculated following this rule

$d =$	0,1 g	0,2 g	0,5 g
$e =$	1 g	1 g	1 g
$e =$	$10d$	$5d$	$2d$

This requirement does not apply to an instrument of class I with $d < 1 \text{ mg}$, where $e = 1 \text{ mg}$, as shown in the following table.

Table 6– Example values of e where $d < 1 \text{ mg}$

$d =$	0,01 mg	0,02 mg	0,05 mg	$< 0,01 \text{ mg}$
$e =$	1 mg	1 mg	1 mg	1 mg
$e =$	$100 d$	$50 d$	$20 d$	$> 100 d$

3.4.3 Minimum capacity

The minimum capacity of the instrument is determined in accordance with the requirements in Table 3. However, in the last column of this Table, the verification scale interval, e , is replaced by the actual scale interval, d .

3.4.4 Minimum number of verification scale intervals

For an instrument of class I with $d < 0,1$ mg, n may be less than 50 000.

3.5 Maximum permissible errors

3.5.1 Values of maximum permissible errors on conformity assessment

The maximum permissible errors for increasing or decreasing loads are given in Table 7.

Table 7

Maximum permissible errors	For loads, m , expressed in verification scale intervals, e			
	Class I	Class II	Class III	Class IIII
$\pm 0,5 e$	$0 \leq m \leq 50\,000$	$0 \leq m \leq 5\,000$	$0 \leq m \leq 500$	$0 \leq m \leq 50$
$\pm 1,0 e$	$50\,000 < m \leq 200\,000$	$5\,000 < m \leq 20\,000$	$500 < m \leq 2\,000$	$50 < m \leq 200$
$\pm 1,5 e$	$200\,000 < m$	$20\,000 < m \leq 100\,000$	$2\,000 < m \leq 10\,000$	$200 < m \leq 1\,000$

NOTE 1 The absolute value of the maximum permissible error is $0,5 e$, $1,0 e$ or $1,5 e$, i.e. it is the value of the maximum permissible error without the positive or negative sign.

NOTE 2 For multi-interval instruments, refer to 3.3 (including the example).

3.5.2 Values of maximum permissible errors in service

The maximum permissible errors in service shall be twice the maximum permissible errors on verification.

3.5.3 Basic rules concerning the determination of errors

3.5.3.1 Influence factors

Errors shall be determined under normal test conditions. When the effect of one factor is being evaluated, all other factors are to be kept relatively constant, at a value close to normal.

3.5.3.2 Elimination of rounding error

The rounding error included in any digital indication shall be eliminated if the actual scale interval is greater than $0,2 e$.

3.5.3.3 Maximum permissible errors for net values

The maximum permissible errors apply to the net value for every possible tare load, except preset tare values.

3.5.3.4 Tare weighing device

The maximum permissible errors for a tare weighing device are the same, for any tare value, as those of the instrument, for the same value of load.

3.6 Permissible differences between results

Regardless of the maximum permissible variation between the weighing results, the error of any single weighing result shall by itself not exceed the maximum permissible error for the given load.

3.6.1 Repeatability

The difference between the results of several weighings of the same load shall not be greater than the absolute value of the maximum permissible error of the instrument for that load.

3.6.2 Eccentric loading

The indications for different positions of a load shall conform to the maximum permissible errors, when the instrument is tested in accordance with 3.6.2.1 to 3.6.2.4.

NOTE If an instrument is designed in such a way that loads may be applied in different manners, it may be appropriate to apply more than one of the following tests.

3.6.2.1 Unless otherwise specified hereafter, a load corresponding to $1/3$ of the sum of the maximum capacity and the corresponding maximum additive tare effect shall be applied.

3.6.2.2 On an instrument with a load receptor having n points of support, with $n > 4$, the fraction $1/(n - 1)$ of the sum of the maximum capacity and the maximum additive tare effect shall be applied to each point of support.

3.6.2.3 On an instrument with a load receptor subject to minimal off-centre loading (e.g. tank, hopper, etc.) a test load corresponding to $1/10$ of the sum of the maximum capacity and the maximum additive tare effect shall be applied to each point of support.

3.6.2.4 On an instrument used for weighing rolling loads (e.g. vehicle scale, rail suspension instrument), a test load corresponding to the usual rolling load, the heaviest and the most concentrated one which may be weighed; but not exceeding 0,8 times the sum of the maximum capacity and the maximum additive tare effect shall be applied at different points on the load receptor.

3.6.3 Multiple indicating devices

For a given load the difference between the indications of multiple indicating devices including tare weighing devices, shall be not greater than the absolute value of the maximum permissible error, but shall be zero between digital displaying and printing devices.

3.6.4 Different positions of equilibrium

The difference between two results obtained for the same load when the method of balancing the load is changed (in the case of an instrument fitted with a device for extending the self-indication capacity) in two consecutive tests, shall not exceed the absolute value of the maximum permissible error for the applied load.

3.7 Test standards

3.7.1 Weights

In principle, the standard weights or standard masses used for the type examination or verification of an instrument shall conform to the metrological requirements of OIML R 111. They shall not have an error greater than $1/3$ of the maximum permissible error of the instrument for the applied load. If they belong to class E_2 or better, their uncertainty (rather than their error) is allowed to be not greater than $1/3$ of the maximum permissible error of the instrument for the applied load, provided that the actual conventional mass and the estimated long-term stability is taken into account.

3.7.2 Auxiliary verification device

When an instrument is fitted with an auxiliary verification device, or when it is verified with a separate auxiliary device, the maximum permissible errors of this device shall be $1/3$ of the maximum permissible errors for the applied load. If weights are used, the effect of their errors shall not exceed $1/5$ of the maximum permissible errors of the instrument to be verified for the same load.

3.7.3 Substitution of standard weights at verification

When testing instruments at the place of use (application), instead of standard weights any other constant load may be used, provided that standard weights of at least $1/2$ Max are used.

If the repeatability error is not greater than $0,3 e$, the portion of standard weights may be reduced to $1/3$ Max.

If the repeatability error is not greater than $0,2 e$, this portion may be reduced to $1/5$ Max.

The repeatability error has to be determined with a load (weights or any other load) of about the value where the substitution is made, by placing it 3 times on the load receptor.

3.8 Discrimination

3.8.1 Non-self-indicating instruments

An extra load equivalent to $0,4$ times the absolute value of the maximum permissible error for the applied load, but not less than 1 mg, when gently placed on or withdrawn from the instrument at equilibrium shall produce a visible displacement of the indicating element.

3.8.2 Self- or semi-self-indicating instruments

3.8.2.1 Analog indication

An extra load equivalent to the absolute value of the maximum permissible error for the applied load, but not less than 1 mg, when gently placed on or withdrawn from the instrument at equilibrium shall cause a permanent displacement of the indicating element corresponding to not less than $0,7$ times the extra load.

3.8.2.2 Digital indication

An additional load equal to $1,4$ times the actual scale interval, when gently placed on or withdrawn from the instrument at equilibrium shall change the indication unambiguously. This applies only to instruments with $d \geq 5$ mg.

3.9 Variations due to influence quantities and time

An instrument shall conform, unless otherwise specified and as far as applicable, to 3.5, 3.6 and 3.8 under the conditions of 3.9. Tests shall not be combined unless otherwise specified.

3.9.1 Tilting

3.9.1.1 Instruments liable to be tilted

For an instrument of class II, III or IIII liable to be tilted, the influence of tilting shall be determined under the effect of a lengthwise tilting and a transverse tilting equal to the limiting value of tilting as defined in a) to d) below.

The absolute value of the difference between the indication of the instrument in its reference position (not tilted) and the indication in the tilted position (= limiting value of tilting in any direction) shall not exceed

- at no load, two verification scale intervals (the instrument having first been adjusted to zero at no load in its reference position) except instruments of class II, and
- at self indication capacity and at maximum capacity, the maximum permissible error (the instrument having been adjusted to zero at no load both in the reference and in the tilted position).

a) If the instrument is fitted with a leveling device and a level indicator, the limiting value of tilting shall be defined by a marking (e.g. a ring) on the level indicator which shows that the maximum permissible tilt has been exceeded when the bubble is displaced from a central position and the edge touches the marking. The limiting value of the level indicator shall be obvious, so that tilting is easily noticed. The level indicator shall be fixed firmly on the instrument in a place clearly visible to the user and representative of the tilt sensitive part.

NOTE If in exceptional circumstances, technical reasons forbid the level indicator to be fixed in a visible place this can be accepted only if the level indicator is easily accessible to the user without tools (e.g. below the removable load receptor), and if there is a legible notice provided on the instrument in a clearly visible place that points the user to the level indicator.

b) If the instrument is fitted with an automatic tilt sensor the limiting value of tilting is defined by the manufacturer. The tilt sensor shall release a display switch-off or other appropriate alarm signal (e.g. lamp, error signal) and shall inhibit the printout and data transmission if the limiting value of tilting has been exceeded (see also 4.18). The automatic tilt sensor may also compensate the effect of tilting.

c) If neither a) nor b) applies, the limiting value of tilting is 50/1 000 in any direction.

d) Mobile instruments intended to be used outside in open locations (e.g. on roads) shall either be fitted with an automatic tilt sensor or a Cardanic (gimbal type) suspension of the tilt sensitive part(s). In case of an automatic tilt sensor, b) applies, whereas in the case of a Cardanic suspension, c) applies, but the manufacturer may define a limiting value of tilting larger than 50/1 000 (see also 4.18).

3.9.1.2 Other instruments

The following instruments are regarded as being not liable to be tilted so that the tilting requirements under 3.9.1.1 do not apply:

- class I instruments shall be fitted with a leveling device and a level indicator but these need not be tested, because these instruments require special environmental and installation conditions and skilled operating staff;
- instruments installed in a fixed position;
- freely suspended instruments, for example crane or hanging instruments.

3.9.2 Temperature

3.9.2.1 Prescribed temperature limits

If no particular working temperature is stated in the descriptive markings of an instrument, this instrument shall maintain its metrological properties within the following temperature limits:

$$- 10\text{ }^{\circ}\text{C} / + 40\text{ }^{\circ}\text{C}$$

3.9.2.2 Special temperature limits

An instrument for which particular limits of working temperature are stated in the descriptive markings shall conform to the metrological requirements within those limits.

The limits may be chosen in accordance with the application of the instrument.

The ranges within those limits shall be at least equal to

- 5 °C for instruments of class I,
- 15 °C for instruments of class II, and
- 30 °C for instruments of classes III and IIII.

3.9.2.3 Temperature effect on no-load indication

The indication at zero or near zero shall not vary by more than one verification scale interval for a difference in ambient temperature of 1 °C for instruments of class I and 5 °C for other classes.

For multi-interval instruments and for multiple range instruments this applies to the smallest verification scale interval of the instrument.

3.9.3 Power supply

An instrument shall comply with the metrological requirements if the voltage of the power supply differs from the nominal voltage, U_{nom} , or from the voltage range, U_{min} , U_{max} , of the instrument, at

- Public mains power (AC):
 - lower limit = 0,85 U_{nom} or 0,85 U_{min} ;
 - upper limit = 1,10 U_{nom} or 1,10 U_{max} ;
- External or plug-in power supply device (AC or DC), including rechargeable battery power supply if (re)charge of batteries during the operation of the instrument is possible:
 - lower limit = minimum operating voltage;
 - upper limit = 1,20 U_{nom} or 1,20 U_{max} .
- Non-rechargeable battery power supply (DC), including rechargeable battery power supply if (re)charge of batteries during the operation of the instrument is not possible:
 - lower limit = minimum operating voltage.
 - upper limit = U_{nom} or U_{max} .
- 12 V or 24 V road vehicle battery power supply:
 - lower limit = minimum operating voltage.
 - upper limit = 16 V (12 V battery) or 32 V (24 V battery).

NOTE The minimum operating voltage is defined as the lowest possible operating voltage before the instrument is automatically switched off.

Battery-powered electronic instruments and instruments with an external or plug-in power supply device (AC or DC) shall either continue to function correctly or not indicate any weight values if the voltage is below the manufacturers specified value, the latter being larger or equal to the minimum operating voltage.

3.9.4 Time

Under reasonably constant environmental conditions, an instrument of class II, III, or IIII shall conform to the following requirements.

3.9.4.1 Creep

When any load is kept on an instrument, the difference between the indication obtained immediately after placing a load and the indication observed during the following 30 min, shall not exceed $0,5 e$. However, the difference between the indication obtained at 15 min and that at 30 min shall not exceed $0,2 e$.

If these conditions are not met, the difference between the indication obtained immediately after placing a load on the instrument and the indication observed during the following four hours shall not exceed the absolute value of the maximum permissible error at the load applied.

3.9.4.2 Zero return

The deviation on returning to zero as soon as the indication has stabilized, after the removal of any load which has remained on the instrument for half an hour, shall not exceed $0,5 e$.

For a multi-interval instrument, the deviation shall not exceed $0,5 e_1$.

On a multiple range instrument, the deviation on returning to zero from Max_i shall not exceed $0,5 e_i$. Furthermore, after returning to zero from any load greater than Max_1 and immediately after switching to the lowest weighing range, the indication near zero shall not vary by more than e_1 during the following 5 min.

3.9.4.3 Durability

The durability error due to wear and tear shall not be greater than the absolute value of the maximum permissible error.

Adherence to this requirement is assumed if the instrument has passed the endurance test specified in A.6, which shall be performed only for instruments with $Max \leq 100 \text{ kg}$.

3.9.5 Other influence quantities and restraints

Where other influences and restraints, such as

- vibrations,
- precipitations and draughts, and/or
- mechanical constraints and restrictions.

are a normal feature of the intended operating environment of the instrument, the instrument shall conform to the requirements of Clauses 3 and 4 under those influences and restraints, either by being designed to operate correctly in spite of these influences, or by being protected against their action.

Instruments installed outdoors without suitable protection against atmospheric conditions may normally not conform to the requirements of Clauses 3 and 4 if the number of verification scale intervals, n , is relatively great. (In general, a value of $n = 3\,000$ can only be exceeded with very special measures. Furthermore, for road or rail weighbridges the verification scale interval should not be less than 10 kg). These limits should also apply to each weighing range of combinations of instruments or of multiple range instruments or to each partial weighing range of multi-interval instruments.

3.10 Type evaluation tests and examinations

3.10.1 Complete instruments

For type evaluation, the tests given in Annexes A and B shall be performed, to verify adherence to the requirements in 3.5, 3.6, 3.8, 3.9, 4.5, 4.6, 5.3, 5.4 and 6.1. The endurance test (A.6) shall be performed after all the other tests in Annexes A and B.

For software-controlled instruments, the additional requirements in 5.5 and Annex G apply.

3.10.2 Modules

Subject to agreement with the notified body, the manufacturer may define and submit modules to be examined separately. This is particularly relevant in the following cases:

- where testing the instrument as a whole is difficult or impossible;
- where modules are manufactured and/or placed on the market as separate units to be incorporated in a complete instrument; or
- where the applicant wants to have a variety of modules included in the approved type.

Where modules are examined separately in the process of type approval, the following requirements apply.

3.10.2.1 Apportioning of errors

The error limits applicable to a module, M_i , which is examined separately are equal to a fraction p_i of the maximum permissible errors or the allowed variations of the indication of the complete instrument as specified in 3.5. The fractions for any module have to be taken for at least the same accuracy class and at least the same number of verification scale intervals, as for the complete instrument incorporating the module.

The fractions p_i shall conform to the following equation:

$$p_1^2 + p_2^2 + p_3^2 + \dots \leq 1$$

The fraction p_i shall be chosen by the manufacturer of the module and shall be verified by an appropriate test, taking into account the following conditions:

- for purely digital devices p_i may be equal to 0;
- for weighing modules p_i may be equal to 1;
- for all other modules (including digital load cells) the fraction shall not exceed 0,8 and shall not be less than 0,3, when more than one module contributes to the effect in question.

Acceptable solution (see explanation in the introductory note to Clause 4):

For mechanical structures such as weighbridges, load transmitting devices and mechanical or electrical connecting elements evidently designed and manufactured in accordance with sound engineering practice, an overall fraction $p_i = 0,5$ may be applied without any test, e.g. when levers are made of the same material and when the chain of levers has two planes of symmetry (longitudinal and transversal), or when the stability characteristics of electrical connecting elements are appropriate for the signals transmitted, such as load cell output, impedance, etc.

For instruments incorporating the typical modules (see T.2.2) the fractions p_i may have the values given in Table 8. Table 8 takes into account that the modules are affected in a different manner depending on the different performance criteria.

Table 8

Performance criteria	Load cell	Electronic indicator	Connecting elements, etc.
Combined effect ^a	0,7	0,5	0,5
Temperature effect on no load indication	0,7	0,5	0,5
Power supply variation	—	1	—
Effect of creep	1	—	—
Damp heat	0,7 ^b	0,5	0,5
Span stability	—	1	—
^a Combined effects: non-linearity, hysteresis, temperature effect on span, repeatability, etc. After the warm-up time specified by the manufacturer, the combined effect error fractions apply to modules. ^b in accordance with OIML R 60 valid for SH tested load cells ($p_{LC} = 0,7$). The sign “—” means “not applicable”.			

3.10.2.2 Tests

As far as applicable the same tests shall be performed as for complete instruments. The applicable tests for indicators and analog data processing devices are given in Annex C, the applicable tests for digital data processing devices, terminals and digital displays are given in Annex D, and the applicable tests for weighing modules are given in Annex E.

Purely digital modules need not be tested for static temperatures (A.5.3), humidity (B.2), and for span stability (B.4). They need not be tested for disturbances (B.3) if conformity to the relevant IEC Standards is otherwise established to at least the same level as required in this standard.

For software-controlled modules the additional requirements in 5.5 and Annex G apply.

3.10.2.3 Compatibility

The compatibility of modules shall be established and declared by the manufacturer. For indicators and load cells this shall be done in accordance with Annex F.

For modules with digital output, compatibility includes the correct communication and data transfer via the digital interface(s), see F.5.

A representative complete instrument shall be submitted for testing of correct functioning if this is considered necessary by the notified body, e.g. to conduct tests that have not been performed such as tilting.

3.10.3 Peripheral devices

Peripheral recipient devices need to be examined and tested only once while being connected to a weighing instrument, and may be declared as suitable for connection to any verified weighing instrument having an appropriate and protective interface.

Purely digital peripheral devices need not be tested for static temperatures (A.5.3), humidity (B.2), and span stability (B.4). They need not be tested for disturbances (B.3) if conformity to the relevant IEC Standards is otherwise established to at least the same level as required in this standard.

3.10.4 Testing of a family of instruments or modules

Where a family of instruments or modules of various capacities and characteristics is presented for type examination, the following provisions apply for selecting the Equipment Under Test (EUT). For indicators, refer also to C.2.

3.10.4.1 Selection of EUTs

The selection of EUTs to be tested shall be such that their number is minimized but nevertheless sufficiently representative (see example in acceptable solution of 3.10.4.6).

Approval of the most sensitive EUTs implies approval of the variants with lower characteristics. Therefore, when a choice exists, the EUTs with the highest metrological characteristics shall be selected for test.

3.10.4.2 Variants within a family to be tested

For any family, at least the variant with the highest number of verification scale intervals (n) and the variant with the smallest verification scale interval, e , shall be selected as EUTs. Further EUTs may be required in accordance with 3.10.4.6. If a variant has both characteristics, one EUT may be sufficient.

3.10.4.3 Variants acceptable without testing

Variants other than the EUTs can be accepted without testing, if one of the following bulleted provisions is fulfilled (for comparable metrological characteristics):

- their capacities, Max , fall between two tested capacities. The ratio between the tested capacities shall not exceed 10; or
- all of the following conditions a), b), and c) are fulfilled:
 - a) $n \leq n_{\text{test}}$;
 - b) $e \geq e_{\text{test}}$;
 - c) $\text{Max} \leq 5 \times \text{Max}_{\text{test}} \times (n_{\text{test}} / n)$.

NOTE Max_{test} , n_{test} , and e_{test} are the characteristics of the EUT.

3.10.4.4 Accuracy class

If an EUT of a family has been tested completely for one accuracy class, it is sufficient for an EUT of a lower class if only partial tests are carried out that are not yet covered.

3.10.4.5 Other features to be considered

All metrologically relevant features and functions have to be tested at least once in an EUT as far as applicable and as many as possible in the same EUT.

For example, it is not acceptable to test the temperature effect on no-load indication on one EUT and the combined effect (see Table 8) on a different one. Variations in metrologically relevant features and functions such as different:

- housings;
- load receptors;
- temperature and humidity ranges;
- instrument functions;
- indications; etc.

may require additional partial testing of those factors which are influenced by that feature. These additional tests should preferably be carried out on the same EUT, but if this is not possible, tests on one or more additional EUTs may be performed under the responsibility of the notified body.

3.10.4.6 Summary of relevant metrological characteristics

The EUTs shall cover

- highest number of verification scale intervals, $n_{\max}$,
- lowest verification scale interval, $e_{\min}$,
- lowest input signal, $\mu\text{V}/e$ (when using analog strain gauge load cells),
- all accuracy classes,
- all temperature ranges,
- single range, multiple range or multi-interval instrument,
- maximum size of load receptor, if significant,
- metrologically relevant features (see 3.10.4.5),
- maximum number of instrument functions,
- maximum number of indications,
- maximum number of peripheral devices connected,
- maximum number of implemented digital devices,
- maximum number of analog and digital interfaces,
- several load receptors, if connectable to the indicator, and
- different types of power supply (mains and/or batteries).

Acceptable solution for the selection of EUTs of a family:

Table 9 – Selection of EUTs for a type of a non-automatic weighing instrument with two families

	Variant	Max	<i>e</i>	<i>d</i>	<i>n</i>	EUT
Family 1 Accuracy class II Temperature range: 10 °C / 30 °C	1.1	200 g	0,01 g	0,001 g	20 000	
	1.2	400 g	0,01 g	0,001 g	40 000	X
	1.3	2 000 g	0,05 g	0,05 g	40 000	
Family 2 Accuracy class III Temperature range: – 10 °C / 40 °C	2.1	1,5 kg	0,5 g	0,5 g	3 000	X
	2.2	3 kg	1 g	1 g	3 000	
	2.3	5 kg	2 g	2 g	2 500	
	2.4	15 kg	5 g	5 g	3 000	X
	2.5	60 kg	20 g	20 g	3 000	

This example covers only the various capacities and metrological characteristics of the EUTs in accordance with 3.10.4.2 to 3.10.4.4. The other metrologically relevant features in accordance with 3.10.4.5 shall in practice be taken into account, too, and may result in one or more additional EUTs.

Remarks on the selection:

- variants 1.2, 2.1 and 2.4 are selected as EUTs (marked in last column of Table 9);
- variant 1.1 needs not be tested, because it has the same *e* and *d* as variant 1.2. Only the value of Max is reduced to 200 g (see 3.10.4.3);
- variant 1.2 has the best metrological characteristics of family 1 and shall be tested completely in accordance with 3.10.4.2;
- variant 1.3 needs not be tested, because Max is not more than 5 times that for variant 1.2 (see 3.10.4.3);
- variant 2.1 has the best metrological characteristics of family 2, the smallest *e* and the greatest *n*. Therefore variant 2.1 shall be tested (see 3.10.4.4). It is sufficient to perform additionally only the applicable tests for class III. It is not necessary to repeat those tests which are the same for class II and class III and which have already been performed on variant 1.2;
- variants 2.2 and 2.3 need not be tested, because their values of Max are in between the tested variants 2.1 and 2.4 (see 3.10.4.3) and their metrological characteristics are less than or the same as for variants 2.1 and 2.4;
- variant 2.4 shall be tested, because the ratio between variant 2.5 and 2.1 is greater than 10 (see 3.10.4.3). For variant 2.4, it is sufficient to perform additionally some important tests such as: weighing test, temperature, eccentricity, discrimination, repeatability, etc. It is normally not necessary to repeat other tests (e.g. tilting, power supply, humidity, span stability, endurance, disturbance tests) which have already been performed on variants 1.2 and 2.1;
- variant 2.5 needs not be tested, because Max is not more than 5 times that for variant 2.4 (see 3.10.4.3).