OIML TC9/SC2

First committee draft revision

Discontinuous totalizing automatic weighing instruments (totalizing hopper weighers)

Part 1: Metrological and technical requirements - Tests

Organisation Internationale de Métrologie Légale

INTERNATIONAL RECOMMENDATION

OIML R 107-1

November 2005

EXPLANATORY NOTE

This working draft revision of OIML R 107-1 developed by the OIML subcommittee TC 9/ SC 2 *Automatic weighing instruments*, following consultations in 2004 for the need to update the technical and metrological specifications in the Recommendation in line with developments in field of legal metrology.

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FOREWORD

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Bureau International de Métrologie Légale
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TERMINOLOGY (Terms and definitions)

The terminology used in this Recommendation conforms to the *International Vocabulary of Basic and General Terms in Metrology* (VIM) [1], the *OIML Certificate System for Measuring Instruments* [2] and the *Vocabulary of Legal Metrology* (VIML) [3]. In addition, for the purposes of this Recommendation, the following definitions apply.

T.1 GENERAL DEFINITIONS

T.1.1 Weight

The material measure of mass that is regulated in regard to its physical and metrological characteristics and used (as standard weights or mass) for the type examination or verification of an instrument in accordance with the metrological and technical requirements of OIML R111 [4].

T.1.2 Mass

The property of a body that causes it to have weight in a gravitational field.

T.1.3 Load

Weight to be borne or conveyed at any one time

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T.1.4 Weighing

The process of determining the mass of a body.

T.1.5 Weighing instrument

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

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 automatic or nonautomatic.

T.1.6 Automatic weighing instrument

An instrument that weighs without the intervention of an operator and follows a predetermined program of automatic processes characteristic of the instrument.

T.1.7 Non-automatic weighing instrument

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

T.1.8 Discontinuous totalizing automatic weighing instrument (totalizing hopper weigher)

An automatic weighing instrument that weighs a bulk product by dividing it into discrete loads, determining the mass of each discrete load in sequence, summing the weighing results and delivering the discrete loads to bulk.

T.1.9 Electronic instrument

An instrument equipped with electronic devices.

T.1.10 Control instrument

Weighing instrument used to determine the conventional true value of the mass of the test loads during material tests.

Control instruments used for testing may be:

- separate from the instrument being tested, or
- integral, when a nonautomatic (static) weighing mode is provided by the instrument being tested, which allows the weighing cycle to be interrupted as described in 6.2.1.2.1.

T.1.11 Conventional true value (of a quantity)

A value attributed to a particular quantity (mass of a body) and accepted, by convention, as having an uncertainty appropriate for a given purpose. [VIM 1.20]

T.1.12 Metrological authority

An authorized representative of the legal metrology authority or accredited organisations, issuing, testing, approving organisations; with responsibility for ascertaining and confirming that the instrument satisfies all or some of the requirements of this Recommendation.

T.1.13 Accuracy of the instrument

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The ability of the instrument to give responses close to a true value [VIM 5.18].

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Note: Accuracy is a qualitative concept.

T.2 CONSTRUCTION

Note: In this Recommendation 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

The 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, with an indicating device.

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T.2.2 Module

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

Note: Typical modules of an automatic weighing instrument are: load cell, indicator, analogue or digital processing device, terminal, weighing module, remote display, software.

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). See OIML R 60 [8].

T.2.2.2 Indicator

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

T.2.2.3 Analogue data processing device

Electronic device of an instrument that performs the analogue-to-digital conversion of the output signal of the load cell, and 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 more keys 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 to operate the instrument.

T.2.2.5 Weighing module

That part of the weighing instrument that comprises all mechanical and electronic devices (i.e. load receptor, load-transmitting device, load cell, and analogue or digital data processing device)

but not having the means to display the weighing result. It may optionally have devices for further processing data and operating the instrument.

T.2.2.6 Terminal (Computer)

Digital device that has one or more keys to operate the instrument, and a display to indicate the weighing results transmitted via the digital interface of a weighing module or an analogue data processing device.

T.2.2.7 Remote display

Terminal without keys that can be used for the primary indications or for their repetition.

T.2.2.8 Software

T.2.2.8.1 Metrologically relevant software

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

Examples of metrologically relevant software are: final results of the measurement including the decimal sign and the unit, identification of the weighing range and the load receptor (if several load receptors have been used).

The following types of metrologically relevant software can be distinguished: type-specific and device-specific.

T.2.2.8.2 Type-specific

Metrologically relevant parameter with a value that depends on the type of instrument only. They are fixed at type approval of the instrument.

Examples of type-specific parameters are: parameters used for weight calculation, stability analysis or price calculation and rounding, software identification

T.2.2.8.3 Device-specific

Metrologically relevant parameter with a value that depends on the individual instrument. Such parameters comprise calibration parameters (e.g. span 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 may be classified as those that should be secured (unalterable) and those that may be accessed (settable parameters) by an authorised person.

T.2.2.8.4 Software identification

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

T.2.2.8.5 Metrological software version

A designation that specifically defines the metrological software version used in a measuring instrument, system, or peripheral/auxiliary device with field programmable or downloadable metrological software.

T.2.2.8.6 Software storage

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, or for special applications specified in accordance with national legislation).

T.2.3 Electronic parts

T.2.3.1 Electronic device

A device comprised of electronic subassemblies and performing a specific function. An electronic device is usually manufactured as a separate unit and is capable of being independently tested.

T.2.3.2 Electronic component

The smallest physical entity that uses electron or hole conduction in semiconductors, gases, or in a vacuum.

T.2.3.3 Digital device

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

Examples: Printer, remote display, keyboard, terminal, data storage device, personal computer

T.2.3.4 Interface

An interface comprises all mechanical, electrical and software devices at the data interchange point between an instrument and peripheral devices or other instruments.

T.2.3.4.1 Protective interface

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

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

T.2.4 Totalisation indicating devices

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Electronic sub-assembly¶
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A part of an electronic device comprised of electronic components and having a recognizable function of its own.¶
¶

The part of the instrument that indicates the sum of consecutive loads weighed and discharged to bulk.

T.2.4.1 Principal totalisation indicating device

The part of the instrument that indicates the sum of consecutive loads weighed and discharged to bulk. This indicating device is not ressetable to zero by the user.

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T.2.4.2 Partial totalisation indicating device

The part of the instrument that indicates the sum of a limited number of consecutive loads delivered to bulk.

T.2.4.3 Supplementary totalisation indicating device

An indicating device with a scale interval greater than that of the principal totalisation indicating device and indicating the sum of consecutive loads weighed over a fairly long period of time.

T.2.5 Control indicating device

An indicating device that enables the use of the instrument as a control instrument to weigh discrete loads for control purposes.

T.2.6 Ancillary devices

T.2.6.1 Zero-setting device

The means used to set the weight indicating device to zero when the load receptor is empty.

T.2.6.2 Nonautomatic zero-setting device

A zero-setting device that must be operated manually.

T.2.6.3 Semi-automatic zero-setting device

A zero-setting device that operates automatically following a manual command.

T.2.6.4 Automatic zero-setting device

A zero-setting device that operates automatically and without the intervention of an operator.

T.2.6.5 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.2.6.6 Zero-tracking device

Device for maintaining the zero indication within certain limits automatically.

T.2.7 Printing device

The means to print the value of each discrete load weighed in the load receptor, and/or the sum of consecutive loads weighed and discharged to bulk.

T.2.8 Air-enclosed integrated system

An automatic weighing instrument fitted with the appropriate safety and dust control features.

T.3 METROLOGICAL CHARACTERISTICS

T.3.1 Scale interval

A value expressed in units of mass that is the difference between:

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

T.3.1.1 Totalisation scale interval (d_t)

The scale interval of a principal totalisation indicating device.

T.3.1.2 Control scale interval (d)

The scale interval on a control indicating device.

T.3.2 Weighing cycle

The sequence of weighing operations that includes the following:

- one delivery of a load to the load receptor,
- a single weighing operation,
- the discharge to bulk of a single discrete load.

T.3.3 Automatic weighing range

The range from minimum capacity to maximum capacity.

T.3.3.1 Maximum capacity (Max)

The largest discrete load that can be weighed automatically.

T.3.3.2 Minimum capacity (Min)

The smallest discrete load that can be weighed automatically.

T.3.3.3 Final weighing value

Deleted: T.3.3.3 Target load¶
¶
The preset value of the load in the load receptor that causes the flow to stop in each weighing cycle.¶

Weighing value that is achieved when an automatic operation is ended and there are no disturbances taking effect on the indication.

T.3.3.4 Stable equilibrium

The condition of the instrument such that the printed or stored weighing values show no more than two adjacent values; with one of them being the final weighing value.

T.3.4 Minimum totalized load ($\sum_{min}$)

The value of the smallest bulk load that can be totalized without exceeding the maximum permissible error when the automatic operation is comprised of discrete loads, each within the automatic weighing range.

T.3.5 Warm-up time

The time between the moment that power is applied to an instrument and the moment at which the instrument is capable of complying with the requirements.

T.3.6 Nonautomatic (static) operation

A static weighing mode for test purposes.

T.3.7 Sensitivity

For a given value of the measured mass, the quotient of the change of the observed variable and the corresponding change of the measured mass M:

$$k = \Delta l / \Delta M$$

T.3.8 Discrimination

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

T.3.9 Discrimination threshold

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 detectable change in the indication.

T.3.10 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.3.11 Durability

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

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T.3.7 . Automatic operation¶

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The instrument weighs without the intervention of the operator and follows a pre-determined program of automatic processes characteristic of the instrument. The instrument may weigh either statically or dynamically in automatic operation.¶

¶

T.3.8 . . Instrument that weighs statically¶

¶

An instrument that operates with a stable equilibrium based measuring system during the weight determining process, while the load transport system stops.¶

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T.3.9 . . Instrument that weighs dynamically¶

¶

An instrument that operates with a fixed time based measuring system during the weight determining process while the load transport system is in motion.¶

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T.4 INDICATIONS AND ERRORS

T.4.1 Methods of indication

T.4.1.1 Analogue indication

An indication allowing the determination of an equilibrium position to a fraction of the scale interval.

T.4.1.2 Digital indication

An indication in which the scale marks are a sequence of aligned figures that do not permit interpolation to a fraction of a scale interval.

T.4.2 Errors

T.4.2.1 Error (of indication)

The indication of an instrument minus the (conventional) true value of the mass.

T.4.2.2 Rounding error of digital indication

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

T.4.2.3 Intrinsic error

The error of an instrument under reference conditions.

T.4.2.4 Initial intrinsic error

The intrinsic error of an instrument as determined prior to performance tests and durability evaluations.

T.4.2.5 Fault

The difference between the error of indication and the intrinsic error of a weighing instrument.

Note 1: Principally, a fault is the result of an undesired change of data contained in or flowing through an electronic instrument.

Note 2: From the definition it follows that in this Recommendation a “fault” is a numerical value.

T.4.2.6 Significant fault

A fault greater than 1 d_t.

The following are not considered to be significant faults:

- faults that result from simultaneous and mutually independent cause in the instrument or in

its checking facility,

- faults that imply the impossibility of performing any measurement,
- transitory faults that are momentary variations in the indications which cannot be interpreted, memorized or transmitted as a measurement result,
- faults that are so serious that they will inevitably be noticed by those interested in the measurement.

T.4.2.7 Span stability

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

T.4.2.8 Maximum span stability error

A span stability error greater than one half of the absolute value of the maximum permissible error applicable to the load.

T.4.2.9 Maximum permissible errors (MPE)

Extreme values of an error permitted by specifications, regulations, etc. for a given instrument. [VIM 5.21]

T.5 INFLUENCES AND REFERENCE CONDITIONS

T.5.1 Influence quantity

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

T.5.1.1 Influence factor

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

T.5.1.2 Disturbance

An influence quantity having a value that falls within the limits specified in this International Recommendation but that falls outside the rated operating conditions of the instrument.

T.5.2 Rated operating conditions

Conditions of use, giving the ranges of the measurand and of the influence quantities for which the metrological characteristics are intended to lie within the maximum permissible errors specified in this Recommendation. [VIM 5.5]

T.5.3 Reference conditions

A set of specified values of influence factors fixed to ensure valid inter-comparison of the results of measurements. [VIM 5.7]

T.6 TESTS

T.6.1 Material test

A test carried out on a complete instrument using the type of material that it is intended to weigh.

T.6.2 Simulation test

A test carried out on a complete instrument or part of an instrument in which any part of the weighing operation is simulated.

T.6.3 Performance test

A test to verify that the equipment under test (EUT) is capable of accomplishing its intended functions.

T.6.4 Span stability test

A test to verify that the EUT is capable of maintaining its performance characteristics over a period of use.

DISCONTINUOUS TOTALIZING AUTOMATIC WEIGHING INSTRUMENTS (TOTALIZING HOPPER WEIGHERS)

1 GENERAL

1.1 Scope

This International Recommendation specifies the requirements and test methods for discontinuous totalizing automatic weighing instruments (totalizing hopper weighers), hereafter referred to as "instruments".

It is intended to provide standardized requirements and test procedures to evaluate the metrological and technical characteristics of an instrument in a uniform and traceable way. A standardized test report format is given as Part 2 of this Recommendation, OIML R 107-2.

1.2 Application

This Recommendation applies to discontinuous automatic weighing instruments having a load receptor in the form of a hopper.

This Recommendation does not apply to the following types of instruments:

- "weighing-in-motion" instruments;
- instruments that totalize the bulk load by multiplying the weight of a preset constant load by the number of weighing cycles.

In this Recommendation, instruments which in normal use, could be operated in a non-automatic weighing mode shall also comply with the relevant requirements of OIML R 76-1 [5].

1.3 Terminology

The terminology given in the terminology section shall be considered as a part of this Recommendation.

2 METROLOGICAL REQUIREMENTS

2.1 Accuracy classes

Instruments are divided into four accuracy classes as follows:

0.2 0.5 1 2

The accuracy classes shall be specified in accordance with the maximum permissible errors in 2.2 and marked on the instrument in accordance with the descriptive markings in 3.7.

Accuracy classes shall be specified for intended usage, i.e. nature of the product(s) to be weighed, type of installation and other specified operating conditions in accordance with 5.1 and 5.2.

Note: The use of accuracy classes for certain applications may be determined by national prescription.

2.2 Maximum permissible errors

2.2.1 Automatic weighing

The maximum permissible errors for each accuracy class shall be the appropriate values in Table 1 rounded to the nearest totalisation scale interval (d_t). Maximum permissible errors apply to loads not less than the minimum totalized load ($\sum_{min}$). (See the example below).

Table 1

Accuracy class	Maximum permissible errors Percentage of the mass of the totalised load		Minimum value of minimum totalized load ($\sum_{min}$) shall not be less than:
	Initial verification	In-service	
0.2	±0.10 %	±0.2 %	1 000 x d_t and Min
0.5	±0.25 %	±0.5 %	400 x d_t and Min
1	±0.50 %	±1.0 %	200 x d_t and Min
2	±1.00 %	±2.0 %	100 x d_t and Min
Note: The value of the totalisation scale interval (d_t) is defined in 2.4			

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Deleted: 2.2.1.1 Minimum value of minimum totalised load ($\sum_{min}$)¶
¶
The minimum value of $\sum_{min}$ shall not be less than:¶
¶
<#>the value determined in accordance with Table 1, and ¶
<#>the minimum capacity (Min).¶

For example*:

Instrument: Accuracy class = 0.5,
Maximum capacity (Max) = 1000 kg,
Minimum capacity (Min) = 200 kg;
d_t = 0.2 kg (see 2.4);

Therefore; $\sum_{min} \geq 400 \times d_t = 400 \times 0.2$ kg = 80 kg, and
$\sum_{min} \geq$ Min = 200 kg

Result: Minimum value of minimum totalized load, $\sum_{min}$ = 100 kg

2.2.2 Influence quantities

The maximum permissible errors applied in tests to assess the effect of influence quantities shall be as specified in Table 2.

Table 2

Maximum permissible errors	Load (m) expressed in totalisation scale intervals
±0.5 d_t	0 ≤ m ≤ 500
±1.0 d_t	500 < m ≤ 2 000
±1.5 d_t	2 000 < m ≤ 10 000

Digital indications and printed results shall be corrected for the rounding error, and the error shall be determined with an accuracy of at least 0.2 d_t.

2.3 Form of the scale interval

The scale intervals of the indicating and printing devices shall be in the form of 1×10^k, 2×10^k, or 5×10^k, "k" being a positive or negative whole number or zero.

2.4 Totalisation scale interval (d_t)

The totalisation scale interval shall be:

– not less than 0.01 % of the minimum capacity, and
– not greater than 0.2 % of maximum capacity

2.5 Agreement between indicating and printing devices

For the same load, the difference between the weighing results provided by any two devices having the same scale interval shall be as follows:

- zero for digital indicating or printing devices;
- not greater than the absolute value of the maximum permissible error for automatic weighing for analogue devices.

2.6 Units of measurement

The units of mass to be used on an instrument are the:

- gram (g),
- kilogram (kg)
- tonne (t).

2.7 Influence factors

2.7.1 Temperature

2.7.1.1 Temperature limits

Instruments shall comply with the appropriate metrological and technical requirements at temperatures from – 10 °C to + 40 °C.

Depending on local environmental conditions, however, the limits of the temperature range may differ from the above provided that the:

- lower temperature limit shall be -40 °C, -25 °C, -10 °C, or +5 °C,
- higher temperature shall be 30 °C, 40 °C, 55 °C, 70 °C, or 85 °C,
- temperature range is specified in the descriptive markings.

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2.7.1.2 Temperature effect on no-load indication

The indication at zero or near zero shall not vary by more than one totalisation scale interval for a difference in ambient temperature of 5 °C.

2.7.2 Electrical power supply

An electronic instrument shall comply with the appropriate metrological and technical requirements, if the voltage of the power supply varies from the nominal voltage, U_{nom}, or from the upper and lower limits of the voltage range (U_{min}, U_{max}) marked on the instrument at:

- AC mains power supply: lower limit = U_{nom} or U_{min} x 0.85 %, upper limit = U_{nom} or U_{max} x 1.10 %;
- external or plug-in power supply (AC or DC), including rechargeable battery power supply: lower limit = minimum operating voltage, upper limit = U_{nom} or U_{max} x1.20 %;
- 12 V or 24 V road vehicle battery power: lower limit = 9 V (12 V battery) or 16 V (24 V battery), 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-operated electronic instruments and instruments with external or plug-in power supply (AC or DC) shall either continue to function correctly or not indicate any weight values if the voltage is below the manufacturer's specified value, the latter being larger or equal to the minimum operating voltage.

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Deleted: minimum operating voltage

3 TECHNICAL REQUIREMENTS

3.1 Suitability for use

An instrument shall be designed to suit the method of operation and the loads for which it is intended. It shall be of adequately robust construction in order that it maintains its metrological characteristics.

3.2 Security of operation

3.2.1 Fraudulent use

An instrument shall have no characteristics likely to facilitate its fraudulent use.

3.2.2 Accidental breakdown and maladjustment

An instrument shall be so constructed that an accidental breakdown or maladjustment of control elements likely to disturb its correct functioning cannot take place without its effect being evident.

3.2.3 Purging of load receptor

The design of the load receptor and the operation of the instrument shall be such that the weighing results are not adversely affected by any variation in the quantity of the load remaining in the load receptor after discharge during a weighing cycle.

3.2.4 Automatic weighing conditions

An automatic operation shall be interrupted, printing shall be prevented or marked with a clear warning and a warning signal shall be given in the following cases:

a) if the maximum capacity (Max) in each weighing range has been exceeded by more than 9 d_t,
b) if the value of the load to be weighed and discharged to bulk is less than minimum capacity (Min), unless processed as the last discrete load of the transaction.

3.2.5 Operational adjustments

It shall not be possible to make operating adjustments nor to reset the indicating devices during an automatic weighing operation, with the exception of the possibility to interrupt the weighing cycle in the case of 3.2.4 (a) and during testing as described in 6.2.1.2.1.

3.2.6 Controls

Controls shall be so designed that they cannot normally come to rest in positions other than those intended by design, unless during the manoeuvre all indications are made impossible. Keys shall be marked unambiguously.

3.2.7 Dust extraction

The operation of a dust extractor shall not affect the result of the measurement.

3.2.8 Securing of components and pre-set controls

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Means shall be provided for securing components, interfaces, software devices and pre-set controls to which access or adjustment is prohibited. National legislation may specify the sealing that is required.

Components and pre-set controls may be secured by passwords or similar software means provided that any access to the secured controls or functions becomes automatically evident, e.g. by automatically updating a code number the value of which at the time of the last verified set-up had been durably marked on the instrument in accordance with the requirements of 3.7.4.

3.2.9 Adjustment

An instrument may be fitted with an automatic or a semi-automatic span adjustment device. This device shall be incorporated inside the instrument. External influence upon this device shall be practically impossible after securing.

3.3 Indication, storage and printing of weighing results

Instruments shall include a principal totalisation indicating device and may include a supplementary totalisation indicating device, partial totalisation indicating devices, memory storage, indicating and printing devices.

3.3.1 Quality of indication

All weighing indicating and printing devices shall allow reliable, simple and unambiguous reading of the results under conditions of normal use:

- the overall inaccuracy of reading of an analogue indicating device shall not exceed 0.2 d_t,
- the figures forming the results shall be of a size, shape and clarity for reading to be easy.

The scales, numbering and printing shall permit the figures which form the results to be read by simple juxtaposition.

3.3.2 Form of the indication

3.3.2.1 Unit of mass

Weighing results shall contain the names or symbols of the units of mass in which they are expressed.

For any one indication of weight, only one unit of mass may be used.

The unit of mass shall be chosen so that the weight values have not more than one non-significant zero to the right. For values with decimal sign, the non-significant zero is allowed only in the third position after the decimal sign.

The units of mass shall be indicated in small letters (lower case) as shown in 2.6.

3.3.2.2 Scale interval

Except for a supplementary totalisation indicating device, the scale intervals of all totalisation indicating devices shall be the same.

The form of the scale interval shall be as specified in 2.3.

All indicating and printing devices of an instrument shall, within any one weighing range have the same scale interval for any given load.

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The scale interval of a supplementary totalisation indicating device shall be in high resolution mode with at least ten times higher resolution of the totalisation scale interval indicated in the descriptive markings.

3.3.2.3 Digital zero indication

Where the scale interval is changed automatically the decimal sign shall maintain its position in the display.

A decimal fraction shall be separated from its integer by a decimal sign (comma or dot), with the indication showing at least one figure to the left of the sign and all figures to the right.

The decimal sign shall be on one line with the bottom of the figures (example: 0.705 kg).

A digital zero indication shall include the display of a zero for all places that are displayed to the right of a decimal point and at least one place to the left. When no decimal values are displayed, a zero shall be displayed for each place of the displayed division, (i.e. at least one active decade plus any fixed zeros must be displayed).

Examples of the number of zeros required:

Capacity	Minimum Zero Indication (kg)
25 x 0.01	0.00
5000 x 1	00
100 000 x 20	0

3.3.3 Printing device

A totalisation indicating and printing device shall allow reliable, clear and unambiguous reading of the results by simple juxtaposition and shall bear the symbol of the appropriate unit of mass.

Printing shall be inhibited if the stability criteria in 3.3.7 are not fulfilled.

3.3.4 Memory storage device

The primary indications may be stored in a memory of the instrument for subsequent indication, printing, data transfer, totalising, etc. The storage of primary indications shall be inhibited if the stability criteria in 3.3.7 are not fulfilled.

3.3.5 Limits of indication, storage and printing

The following apply:

(a) it shall not be possible to reset the partial totalisation indicating device to zero unless the data storage device automatically stores or the printing device automatically prints the last total indicated before resetting to zero;
(b) an automatic storage or printout of the last total shall be generated if the automatic operation is interrupted and operating adjustments can be made.

3.3.6 Combined indicating devices

Two or more types of indicating devices may be combined so that the indication required can be displayed on demand provided that it is clearly identified.

3.3.7 Stable equilibrium

Equilibrium is deemed to be stable when in case of printing and/or data storage, the printed or stored weighing values show no more than two adjacent values; with one of them being the final weighing value (T.3.3.4).

During continuous or temporary disturbance of the equilibrium, the instrument shall not print, store or set to zero.

3.4 Software controlled instruments

The metrologically relevant software used in an instrument must be present in such a form in the instrument that alteration of the software is not possible without breaking a seal, or any change in the software can be signalled automatically by means of an identification code.

The software shall be assigned with a fixed version number or software identification. This version number shall be adapted in the case of every software change that may affect the functions and accuracy of the instrument. Software controlled instruments shall be capable of providing the software identification.

For instruments and modules with embedded software, the manufacturer shall describe or declare that the software of the instrument or module is embedded, i.e., it is used in a fixed hardware and software environment and cannot be modified or uploaded via any interface or by other means after securing and/or verification.

In addition to the documentation required in 5.1.1 the manufacturer shall submit the following software documentation:

- A description of the system hardware, e.g. block diagram, type of computer(s), type of network, if not described in the operating manual;
- A description of the software environment for the metrologically relevant software, e.g. the operating system, required drivers, etc;
- A description of all legally relevant software functions, legally relevant parameters, switches

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- A description of the relevant measuring algorithms (e.g. stable equilibrium, price calculation, rounding algorithms);
- Software identification that is clearly assigned to the metrologically relevant functions;
- A description of the relevant menus and dialogues;
- The securing measures foreseen (e.g. checksum, signature, audit trail)
- The complete set of commands and parameters - including a short description of each command and parameter - that can be exchanged between the metrologically relevant software and the associated software via the protective software interface, including a declaration of the completeness of the list;
- Securing measures (including a detailed description of the loading procedure and the securing measures against accidental or intentional changes), foreseen to provide for evidence of an intervention either from downloading of software via modem or internet or inadmissible uploading of metrologically relevant software;
- In case of long-term storage or transmission of data via networks: a description of the data sets and protection measures.

3.5 Instruments with control indicating devices

For instruments with control indicating devices, the load receptor shall have the facility to support a quantity of standard weights in accordance with Table 3.

Table 3

Maximum capacity (Max)	Minimum quantity of standard weights
Max ≤ 5 *t* 5 t < Max ≤ 25 *t* 25 *t* < Max ≤ 50 *t* 50 t < Max	Max 5 *t* 20 % Max 10 *t*

3.6 Ancillary devices

Ancillary devices shall not affect the indicated totalisation(s) representing a bulk load for a transaction.

3.6.1 Zero-setting

Instruments that do not tare-weigh after each discharge shall exclusively be used for well non-caking materials and materials not tending to adhesion and shall be provided with a zero-setting device. These devices may be:

- non-automatic, or
- semi-automatic, or
- automatic, or
- automatic as part of the weighing cycle

3.6.1.1 Accuracy of zero-setting device

After zero-setting the effect of zero deviation on the result of the weighing shall be not more than 0.25 d_t.

3.6.1.2 Maximum effect

The effect of any zero-setting device shall not alter the maximum weighing capacity of the instrument.

The overall effect of zero-setting devices shall not be more than 4 %, and of the initial zero-setting device not more than 20 %, of the maximum capacity.

A wider range is possible for the initial zero-setting device if tests show that the instrument complies with 2.2 for any load compensated by this device within the specified range.

3.6.1.3 Control of zero-setting devices

An interlock shall be provided to stop an automatic operation if the zero indication varies by or more than:

- 1 d_t on instruments with an automatic zero-setting device, or
- 0.5 d_t on instruments with a semi-automatic or non-automatic zero-setting device.

A semi-automatic zero-setting device shall function only when the instrument is in stable equilibrium (3.3.7),

A non-automatic or semi-automatic zero-setting device shall not be operable during automatic operation.

3.6.1.4 Stability of automatic zero-setting device

An automatic zero-setting device may operate at the start of automatic operation, as part of every automatic weighing cycle, or after a programmable time interval. A description of the operation of the automatic zero-setting device (e.g. the maximum programmable time interval) shall be included in the type approval certificate.

The automatic zero-setting device shall operate:

- only when the stability criteria in 3.3.7 are fulfilled, and
- sufficiently often to ensure that zero is maintained within 0.5 d_t.

Where the automatic zero-setting device operates as part of every automatic weighing cycle, it shall not be possible to disable this device or to set this device to operate at time intervals.

Where the automatic zero-setting device operates after a programmable time interval, the manufacturer shall specify the maximum time interval. The maximum programmable time interval:

- shall not be greater than the value necessary to ensure that the zero error is not greater than 0.5 d_t.
- may start again after zero tracking has taken place.

Deleted: An instrument whether or not equipped with an initial zero-setting device, may have a combined semi-automatic zero-setting and semi-automatic tare-balancing device operated by the same key.If an instrument has a zero-setting device and a tare-weighing device the control of the zero-setting device shall be separate from that of the tare-weighing device.¶
¶

Deleted: The maximum programmable time interval for automatic zero-setting

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The actual maximum programmable time interval for automatic zero-setting shall be specified considering the actual operating conditions of the instrument. The automatic zero-setting device shall either automatically set to zero after the allocated time or should stop the instrument so that a zero-setting operation can occur or be capable of generating information to draw attention to overdue zero setting.

3.7 Descriptive markings

Instruments shall bear the following markings.

3.7.1 Markings shown in full

- identification mark of the manufacturer
- identification mark of the importer (if applicable)
- serial number and type designation of the instrument
- product description
- Product density …kg/dm^3
- Load receptor (hopper) volume … dm^3
- control scale interval (if applicable) ... g or kg or t
- electrical supply voltage ... V
- electrical supply frequency ... Hz
- working fluid pressure or air pressure (if applicable) ... kPa or bar
- software identification

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3.7.2 Markings shown in code

- type approval sign in accordance with national requirements
- accuracy class 0.2, 0.5, 1 or 2
- maximum capacity Max = ... g or kg or t
- minimum capacity Min = ... g or kg or t
- minimum totalized load $\sum_{min}$ = ... g or kg or t
- totalisation scale interval d_t = ... g or kg or t

3.7.3 Supplementary markings

Depending upon the particular use of the instrument, supplementary markings may be required on type approval by the metrological authority issuing the type approval certificate (for example: securing code, date of manufacture).

Additional markings may be required on initial verification to specify types of products and related weighing conditions.

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3.7.4 Presentation of descriptive markings

Descriptive markings shall be indelible and of a size, shape and clarity that permit legibility under normal conditions of use.

Descriptive markings shall be shown in an official language in accordance with national legislation.

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They shall be grouped together in a clearly visible place on the instrument, either on a descriptive plate or sticker fixed permanently near the indicating device, or on a non removable part of the instrument itself. In case of a plate or sticker which is not destroyed when removed, a means of securing shall be provided, e.g. a non removable control mark that can be applied.

It shall be possible to seal the plate bearing the markings, unless it cannot be removed without being destroyed.

As an alternative all applicable markings above may be shown on a programmable display which is controlled by software provided that:

- At least Max, Min and d_i shall be displayed as long as the instrument is switched on.
- The other marking may be shown on manual commend.
- It must be described in the type approval (OIML) certificate

In this case, means shall be provided for any access to reprogramming of the markings to be automatically and non-erasably recorded and made evident by an audit trail, e.g. by traceable access software such as an event logger providing a record of the changes or an event counter providing non-resettable counter of any changes.

These programmable display markings need not be repeated on the data plate, if they are shown on or indicated near the display of the weighing result, with the exception of the following markings which shall be shown on the data plate:

- type and designation of the instrument,
- name or identification mark of the manufacturer,
- type approval number,
- electrical supply voltage,
- electrical supply frequency,
- pneumatic/hydraulic pressure, (if applicable).

3.8 Verification marks

3.8.1 Position

Instruments shall have a place for the application of verification marks. This place shall:

- be such that the part on which it is located cannot be removed from the instrument without damaging the marks,
- allow easy application of the mark without changing the metrological qualities of the instrument,
- be visible without the instrument or its protective covers having to be moved when it is in service.

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3.8.2 Mounting

Instruments required to bear verification marks shall have a verification mark support, at the place provided for above, which shall ensure the conservation of the marks. The type and method of sealing shall be determined by national prescription.

4 REQUIREMENTS FOR ELECTRONIC INSTRUMENTS

4.1 General requirements

Electronic instruments shall comply with the following requirements, in addition to the applicable requirements of all other clauses of this Recommendation.

4.1.1 Rated operating conditions

Electronic weighing instruments shall be so designed and manufactured that they do not exceed the maximum permissible errors under rated operating conditions.

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4.1.2 Disturbances

Electronic instruments shall be so designed and manufactured that when they are exposed to disturbances, either

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a) significant faults do not occur, or
b) significant faults are detected and acted upon.

Note: A fault equal to or less than the value specified in T.4.2.6 (1 d_t) is allowed irrespective of the value of the error of indication.

4.1.3 Durability

The requirements in 4.1.1 and 4.1.2 shall be met durably in accordance with the intended use of the instrument.

4.1.4 Evaluation for compliance

A type of an electronic instrument is presumed to comply with the requirements in 4.1.1, 4.1.2, and 4.1.3 if it passes the examination and tests specified in Annex A.

4.1.5 Application of requirements for disturbances

The requirements in 4.1.2 may be applied separately to:

a) each individual cause of significant fault, and/or
b) each part of the electronic instrument.

The choice of whether 4.1.2 a) or b) is applied is left to the manufacturer.

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4.2 Functional requirements

4.2.1 Acting upon a significant fault

When a significant fault has been detected, a visual or audible indication shall be provided and shall continue until the user takes action or the fault disappears.

Means shall be provided to retain any totalized load information contained in the instrument when a significant fault occurs.

4.2.2 Indicator display test

Upon switch-on (switch-on of indication), a special procedure shall be performed that shows all relevant signs of the indicator in their active and non-active state sufficiently long to be checked by the operator. This is not applicable for non-segmented displays, on which failures become evident, for example screen-displays, matrix-displays, etc.

4.2.3 Influence quantities

An electronic instrument shall comply with the requirements of 2.7 and shall also comply with appropriate metrological and technical requirements at:

(a) a relative humidity of 85 % at the upper limit of the temperature range, or
(b) under conditions of high humidity of between 93 to 95 % when combined with cyclic temperature changes.

Note: The requirement in (b) is applicable to cases where condensation is likely to occur or when the instrument is to be installed in high cyclic temperature environments.

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4.2.4 Disturbances

When an electronic instrument is subjected to the disturbances specified in Annex A, either of the following shall apply:

a) the difference between the weight indication due to the disturbance and the indication without the disturbance (intrinsic error) shall not exceed the value specified in T.4.2.6 (1 d_t);
b) the instrument shall detect and act upon a significant fault.

4.2.5 Warm-up time

During the warm-up time of an electronic instrument, there shall be no indication or transmission of the weighing result and automatic operation shall be inhibited.

4.2.6 Interface

An electronic instrument may be equipped with interfaces permitting the coupling of the instrument to any peripheral devices or other instruments.

An interface shall not allow the metrological functions of the instrument and its measurement data to be inadmissibly influenced by the peripheral devices (for example computers), by other interconnected instruments, ancillary devices or by disturbances acting on the interface.

Functions that are performed or initiated via an interface shall meet the relevant requirements and conditions of Clause 3.

A protective interface shall prevent the introduction into the instrument data that can influence the instruments metrological properties or measurement results.

An interface through which the functions mentioned above cannot be performed or initiated, need not be secured. Other interfaces shall be secured as per 3.2.8.

An interface intended to be connected to a peripheral device to which the requirements of this Recommendation apply, shall transmit data relating to primary indications in such a manner that the peripheral device can meet the requirements.

4.2.7 AC mains supply failure

An instrument that operates from the AC mains shall, in the event of a supply failure, retain the metrological information contained in the instrument at the time of failure for at least 24 hours. A switch-over to an emergency power supply shall not cause a significant fault.

4.2.8 Voltage variations of external or plug-in (AC or DC)supply, or battery power supply

Instrument with external or plug-in (AC or DC) voltage supply, or battery power supply shall, whenever the voltage drops out of the specified operating voltage range (see 2.7.2), either continue to function correctly or show an error message or is automatically put out of service.

Deleted: Note: An "interface" comprises all mechanical, electrical and software devices at the data interchange point between an instrument and peripheral devices or other instruments.¶
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Deleted: It shall not be possible to introduce into an instrument, through an interface, instructions, software programs or data intended or suitable to:¶
¶
<#>Display data that are not clearly defined and could be mistaken for a weighing result,¶
<#>Falsify displayed, processed or stored weighing results,¶
<#>Adjust the instrument or change any adjustment factor.¶
¶

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4.3 Examination and tests

The examination and testing of an electronic weighing instrument is intended to verify compliance with the applicable requirements of this Recommendation and especially with the requirements in Clause 4.

4.3.1 Examination

An electronic weighing instrument shall be examined to obtain a general appraisal of the design and construction.

4.3.2 Performance tests

An electronic weighing instrument or electronic device, as appropriate, shall be tested as specified in Annex A to determine its correct functioning.

Tests are to be conducted on the whole instrument except when the size and/or configuration of the instrument does not lend itself to testing as a unit. In such cases, the separate electronic devices shall be subjected to testing. It is not intended that electronic devices be further dismantled for separate testing of components. In addition, an examination shall be carried out

on the fully operational weighing instrument or, if necessary, on the electronic devices in a simulated set-up that sufficiently represents the weighing instrument. The equipment shall continue to function correctly as specified in Annex A.

4.3.3 Span stability tests

The instrument shall be subjected to span stability tests at various intervals, i.e. before, during and after being subjected to performance tests.

When the instrument is subjected to span stability test specified in Annex A.8:

- the maximum allowable variation in the errors of indication shall not exceed half the absolute value of the maximum permissible error in 2.2.2 Table 2 for the test load applied on any of the n measurements;
- where the differences of the results indicate a trend more than half the allowable variation specified above, the test shall be continued until the trend comes to rest or reverses itself, or until the error exceeds the maximum allowable variation.

5 METROLOGICAL CONTROLS

The metrological controls of instruments shall, in agreement with national legislation, consist of the following:

- type evaluation;
- initial verification;
- subsequent verification;
- in-service inspection.

Tests should be applied uniformly by the legal metrology services and should form a uniform program. Guidance for the conduct of type evaluation and initial verification is provided in OIML International Documents D 19 [6] and D 20 [7], respectively.

5.1 Type approval

5.1.1 Documentation

The application for type evaluation shall include documentation comprising:

- metrological characteristics of the instrument;
- a standard set of specifications for the instrument;
- a functional description of the components and devices;
- drawings, diagrams and general software information (if applicable), explaining the construction and operation;

- detailed software information (if applicable) for software-controlled operation;
- any document or other evidence demonstrating that the design and construction of the instrument complies with the requirements of this Recommendation.

Note: Adherence to requirements for which no test is available, such as software-based operations, may be demonstrated by a specific declaration of the manufacturer (e.g. for interfaces as per 4.2.6, and for password protected access to set-up and adjustment operations as per 3.2.8.

5.1.2 General requirements

Type evaluation shall be carried out on at least one and normally, not more than three instruments that represent the definitive type. At least one of the instruments shall be completely installed at a typical site and at least one of the instruments or the major component of an instrument shall be submitted in a form suitable for simulation testing in a laboratory. The evaluation shall consist of the tests specified in 5.1.3.

5.1.3 Type evaluation

The submitted documents shall be examined and tests carried out to verify that the instruments comply with:

- the metrological requirements in Clause 2, particularly with reference to maximum permissible errors, when the instrument is operated in accordance with the manufacturer's specifications for range and product(s);
- the technical requirements in Clause 3 including the requirement for security of operation in 3.2. Additionally electronic instruments shall comply with the requirements in Clause 4.

The appropriate metrological authority:

- shall conduct the tests in a manner that prevents unnecessary commitment of resources;
- shall permit, when the same instrument is involved, the result of these tests to be assessed for initial verification;
- is advised to accept, with the consent of the applicant, test data obtained from other metrological authorities without repeating the tests;
- shall ensure that an instrument specified by the manufacturer as capable of being operated as a nonautomatic weighing instrument meets the relevant requirements of OIML R 76-1 [5] for class III or class IIII instruments.

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5.1.3.1 Operational tests

Tests shall be done as follows in accordance with the test methods in Clause 6.

For the purposes of testing, the applicant may be required to furnish the metrological authority with the material, handling equipment, qualified personnel, and a control instrument.

Accuracy requirements shall be applied in accordance with the appropriate parts of Clause 2.

5.1.3.2 Influence quantity tests

Influence factors shall be applied to the complete instrument or simulator as specified in Annex A.7, in accordance with:

- Subclause 2.7 for all instruments,
- Clause 4 for electronic instruments.

5.1.3.3 Apportioning of errors

Where modules of an instrument or system are tested separately the following requirements apply.

Deleted: it is necessary to separately test

The error limits applicable to a module 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 2.2.2 The fractions for any module have to be taken for at least the same accuracy class as for the complete instrument incorporating the module.

The fractions p_i shall satisfy the following equation:

$$p_1^2 + p_2^2 + p_3^2 + \ldots \leq I$$

Deleted: $P_1^2 + P_2^2 + P_3^2 + \ldots \leq 1$¶

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 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 or electronic devices equipped with an analogue component), 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.

If the metrological characteristics of the load cell have been evaluated in accordance with the requirements of OIML R 60 [8], or any other applicable OIML Recommendation, that evaluation shall be used to aid type evaluation if so requested by the applicant.

Note: As the requirements of this subclause only apply to the instrument submitted for type evaluation and not to those subsequently submitted for verification, the means by which it will be possible to determine whether the appropriate accuracy requirement has been met will be decided mutually between the metrological authority and the applicant. For example:

- an adaptation of the totalisation indicating device to give higher resolution than that of the totalisation scale interval;
- the use of change point weights;
- any other means mutually agreed upon.

5.1.4 Place of testing

Instruments submitted for type approval may be tested either:

- on the premises of the metrological authority to which the application has been submitted, or

- in any other suitable place agreed between the metrological authority concerned and the applicant.

5.1.5 Type approval certificate and determination of classes

The type approval certificate shall state the accuracy class, as specified at type approval stage and be determined by compliance with the metrological requirements at initial verification of each instrument.

5.2 Initial verification

5.2.1 General requirements

Instruments shall be tested to verify that they comply with the requirements in Clause 2 (except 2.7) and Clause 3 for any product(s) for which they are intended and when operated under normal conditions of use.

Tests shall be carried out by the metrological authority, in-situ, with the instrument fully assembled and fixed in the position in which it is intended to be used. The installation of an instrument shall be so designed that the weighing operation will be the same whether for the purposes of testing or for normal operation.

5.2.2 Operational tests

Instruments shall be tested in their normal mode of automatic operation and in accordance with the test methods in Clause 6.

The appropriate metrological authority shall conduct the tests in a manner that prevents an unnecessary commitment of resources. In appropriate situations and to avoid duplicating tests previously performed on the instrument for type evaluation under 5.1.3, the authority may use the results of observed tests for initial verification.

The metrological authority may require the applicant to supply the material, equipment, qualified personnel, and a control instrument to perform the tests.

Accuracy requirements shall be applied in accordance with the appropriate part(s) of 2.2.

5.2.3 Determination of accuracy class

The metrological authority shall:

(a) apply the accuracy class requirements in accordance with the appropriate parts in 2.2.1 for initial verification.
(b) verify that the accuracy classes marked in accordance with 3.7 are equal to the accuracy class determined as above.

Note: The accuracy class that was achieved at type approval stage may not be achieved at initial verification if the loads used are significantly less stable or of different dimensions. In this case a lower accuracy class shall be marked in accordance with 2.2.1 and 3.7.

Marking of a higher accuracy class than was achieved at type approval stage is not permitted.

5.2.4 Nonautomatic weighing instruments

When an instrument can be operated under normal conditions of use (except emergency operating mode as a nonautomatic weighing instrument), it shall meet the relevant requirements of OIML R 76-1 [5] for class III or class IIII nonautomatic weighing instruments.

5.3 Subsequent metrological control

5.3.1 Subsequent verification

Subsequent verification shall be carried out in accordance with the same provisions as in 5.2 for initial verification.

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5.3.2 In-service inspection

In-service inspection shall be carried out in accordance with the same provisions as in 5.2 for initial verification, with the exception that the in-service maximum permissible errors in 2.2.1 Table 1 shall be applied.

6 TEST METHODS

6.1 General test procedure

In-situ material tests shall be carried out as follows:

(a) In accordance with the descriptive markings;
(b) Under the rated operating conditions for the instrument;
(c) Tests shall be conducted in accordance with either the separate verification method in A.5.2, or the integral verification method in A.5.3.
(d) Not less than three material tests shall be conducted, one at maximum capacity (Max), one at minimum capacity (Min), and one close to the minimum totalized load ($\sum_{min}$) marked on the instrument;
(e) With test load(s) that is representative of the range and type of products for which the instrument is likely to be used or product(s) for which the instrument is intended;
(f) Each test shall be conducted at the maximum rate of weighing cycles per hour;
(g) A minimum of five cycles per test shall be conducted.
(h) Equipment near the instrument, including conveyors, dust collection systems etc. that are in use when the instrument is in normal operation, shall be in use during the tests;
(i) If the instrument can divert weighed material through alternative discharge facilities the test program shall be performed for each alternative unless it can be established that the weigh hopper is not affected for example by different air flow.

6.2 Control instruments and test standards

A control instrument and standard weights for determining the conventional true value of the mass of each test load shall be available for testing. The control instrument may either be separate or integral.

6.2.1 Accuracy of control instruments and test weights

When an instrument is used for tests as an integral control instrument, or when it is verified as a separate control instrument, the maximum permissible errors of this instrument shall be 1/3 of the maximum permissible errors for automatic weighing in 2.2.1 for the applied load. If weights are used, the effect of their errors shall not exceed 1/5 of the maximum permissible errors for automatic weighing in 2.2.1 for the same load.

6.2.1.1 Separate control instrument (A.5.2)

An instrument other than the instrument being verified is used to determine the conventional true value of the mass of the test load.

6.2.1.2 Integral control instrument (A.5.3)

The instrument being verified is used as the control instrument in nonautomatic (static) operation to determine the conventional true value of the mass of the test load.

6.2.1.2.1 Interruption of the automatic operation (A.5.3.3)

The integral control instrument uses a special facility (e.g. a test-stop program) to automatically interrupt automatic weighing operation twice as specified in A.5.3.3 during each weighing cycle in order to weigh and discharge a subdivision of the test load.

If the integral control instrument is installed as an air-enclosed system (T.2.8) interruption of the automatic operation during consecutive weighing cycles may not be possible and tests shall be conducted as specified in A.5.3.5.

6.2.3 Conventional true value of the mass of the test load with the separate or integral verification method

(a) With the separate verification method, the test load shall be weighed on a control instrument and the result shall be considered as the conventional true value of the mass of the test load.

(b) With the integral verification method, for each discharge, the tare weight value subtracted from the gross weight value is the net weight of the material discharged. A summation of the net weight values of all the discharges in the test load shall be the conventional true value of the mass of the test load.

Note: When using the integral control verification method, a subdivision of the test load is unavoidable and this may also be true when using the separate control verification method. When calculating the conventional true value of the mass of the test load, it is necessary to consider the increased uncertainty due to subdividing the test load.

6.2.4 Indicated weight with the separate or integral verification method

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¶
After the load receptor has been loaded and the instrument has automatically processed a gross weight, the automatic operation shall be interrupted. When the load receptor has stabilized, the gross weight indicated or determined by balancing with standard weights shall be recorded and the instrument switched back to automatic operation.¶
¶
<#>Post-discharge (tare) weight interrupt and indication¶
¶
After the load has been discharged and the instrument has automatically processed a tare weight, the automatic operation shall be interrupted. When the discharged load receptor has stabilized, the tare weight indicated or determined by balancing with standard weights shall be recorded and the instrument switched back to automatic operation.¶

(a) With the separate verification method, a test load shall be weighed as an automatic bulk to bulk weighing operation and the indicated weight on the principal totalisation indicating device shall be observed and recorded.

(b) With the integral verification method, a partial totalisation indicating device with standard weights increments shall be used to assess the rounding error. Alternatively, the weight shall be indicated with a higher resolution of at least ten times the scale interval resolution on an appropriately designed control indicating device (T.2.5).

6.2.5 Error for automatic weighing with the separate or integral verification method

The error for automatic weighing shall be the difference between the conventional true value of the mass of the test load as specified in 6.2.3 as appropriate for the separate or the integral verification method, and the indicated weight observed and recorded as specified in 6.2.4 as appropriate for the separate or the integral verification method.

The maximum permissible error for automatic weighing shall be as specified in 2.2.1 Table 1 for initial verification and as appropriate for the class of instrument.

6.2.6 Use of an appropriately designed control instrument

When a load receptor cannot be loaded with sufficient standard weights to verify and determine the rounding error of the control instrument indicating device or partial indicating device, then the instrument shall be subjected to material tests by the separate verification method. For this method an appropriately designed control instrument shall be available so that the material tests can be effectively and efficiently conducted.

6.3 Mode of operation for performance testing

6.3.1 Span stability testing

For span stability testing the instrument shall be tested in nonautomatic (static) operation. A single static test load near maximum capacity shall be used.

6.3.2 Disturbance testing

For disturbance testing the instrument shall be tested in nonautomatic (static) operation. Each test shall be performed with one small static test load.

6.3.3 Warm-up test

The warm-up test shall be performed in nonautomatic (static) operation. A single static test load near maximum capacity shall be used.

ANNEX A (MANDATORY)

TEST PROCEDURES FOR DISCONTINUOUS TOTALIZING AUTOMATIC WEIGHING INSTRUMENTS

Meaning of symbols:

I = Indication
L = Load
ΔL = Additional load to next changeover point
$P = I + 0.5\ d - \Delta L$ = Indication prior to rounding
$E = P - L$ = error
E_0 = Error calculated at zero
E_c = Corrected error
MPE = Maximum permissible error
EUT = Equipment under test

A.1 EXAMINATION FOR TYPE APPROVAL

A.1.1 Documentation (5.1.1)

Review the documentation that is submitted, including necessary photographs, drawings, diagrams, general software information, relevant technical and functional description of main components, devices, operational manual, etc. to determine if it is adequate and correct.

A.1.2 Comparing construction with documentation (5.1.1)

Examine the various devices of the instrument to ensure compliance with the documentation.

A.1.3 Metrological characteristics

Note metrological characteristics according to the checklist given in the test report format, OIML R 107-2.

A.1.4 Technical requirements

Check for conformity with the technical requirements according to the checklist given in the test report format, OIML R 107-2.

A.1.5 Functional requirements

Check for conformity with the functional requirements according to the checklist given in the test report format, OIML R 107-2.

A.2 EXAMINATION FOR INITIAL VERIFICATION

A.2.1 Compare construction with documentation

Examine the instrument for conformity with the approved type.

A.2.2 Descriptive markings (3.7)

Check the descriptive markings according to the requirements of the type approval.

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A.2.3 Securing and verification marks (3.2.8 and 3.8)

Check the arrangements for securing and verification marks according to the requirements of the type approval.

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A.3 GENERAL REQUIREMENTS FOR ELECTRONIC INSTRUMENTS UNDER TEST

A.3.1 Electrical power supply

Unless otherwise specified for each test power-up the equipment under test (EUT) for a time-period equal to or greater than the warm-up time specified by the manufacturer and maintain the EUT energized for the duration of the test.

A.3.2 Zero-setting

Adjust the EUT as closely as practicable to zero prior to each test and do not readjust at any time during the test, except to reset if a significant fault has occured.

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Status of automatic zero facilities shall be as specified for each test.

A.3.3 Temperature

Except for the temperature test (A.7.3.1) and the humidity test (A.7.3.3), the test shall be performed at a steady ambient temperature, usually normal room temperature unless otherwise specified. The temperature is deemed to be steady when the differences between the extreme temperatures noted during the test does not exceed one-fifth of the temperature range of the instrument without being greater than 5 °C and the rate of change does not exceed 5 °C per hour.

The handling of the instrument shall be such that no condensation of water occurs on the instrument.

A.3.4 Recovery

After each test, allow the instrument to recover sufficiently before the following test.

A.3.5 Preloading

Before each weighing test the instrument shall be pre-loaded to Max, except for the tests in A.5.4 (warm-up) and A.7.3.2 (temperature effect on no-load).

A.3.6 Test standards (6.2)

A.3.6.1 Control instruments

A control instrument meeting the requirements of 6.2.1 shall be used to perform the material tests. Where necessary, standard weights meeting the requirements of 6.2.1 may be used to assess the rounding error.

A.3.6.2 Use of standard weights to assess rounding error

A.3.6.2.1 General method to assess error prior to rounding

For instruments with digital indication having scale interval *d*, changeover points may be used to interpolate between scale intervals i.e. to determine the indication of the instrument, prior to rounding, as follows.

At a certain load, L, the indicated value, I, is noted. Additional weights of for example 0.1 d are successively added until the indication of the instrument is increased unambiguously by one scale interval (I + *d*). The additional load ΔL added to the load receptor gives the indication, P, prior to rounding by using the following formula:

$$P = I + 0.5\,d - \Delta L$$

The error E prior to rounding is:

$$E = P - L = I + 0.5\,d - \Delta L - L$$

Example: an instrument with a scale interval, *d*, of 1 kg is loaded with 100 kg and thereby indicates 100 kg. After adding successive weights of 0.1 kg, the indication changes from 100 kg to 101 kg at an additional load of 0.3 kg. Inserted in the above formula these observations give:

$$P = (100 + 0.5 - 0.3)\ kg = 100.2\ kg$$

Thus, the true indication prior to rounding is 100.2 kg, and the error is:

$$E = (100.2 - 100)\ kg = 0.2\ kg$$

A.3.6.2.2 Correction for error at zero

Evaluate the error at zero load, (E_0) and the error at load *L*, (*E*), by the method of A.3.6.2.1.

The corrected error prior to rounding, (E_c) is:

$$E_c = E - E_0$$

Example: if, for the example in A.3.6.2.1, the error calculated at zero load was:

$$E_0 = +0.4\ kg,$$

The corrected error is:

$$E_c = 0.2\ kg - (+0.4\ kg) = -0.2\ kg$$

A.4 TEST PROGRAM

A.4.1 Type evaluation (5.1)

All tests in A.5 to A.8 shall normally be applied for type evaluation, using the test methods in Clause 6. Tests in A.5.4 (warm-up) may be omitted if the integral instrument is not to be used as the control indicating device for material testing.

A.4.2 Initial verification (5.2)

Tests in A.2 and A.5, except for A.5.4 (warm-up) shall be applied for initial verification. The types of test loads used shall comply with 6.1 (e).

A.5 METROLOGICAL TESTS

A.5.1 General

Metrological performance tests shall be applied to the complete instrument under normal operating conditions unless otherwise specified by the manufacturer or when the size and/or configuration of the instrument does not lend itself to testing as a unit. In such cases, the separate modules of the instrument shall be subjected to testing and errors apportioned in accordance with 5.1.3.3.

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A.5.1.1 Materials test procedure (6.1, A.9)

The test procedure shall be as follows.

(1) Start up the automatic weighing system, including the surrounding equipment which is normally in use when the instrument is itself in use.
(2) Run the system for five weigh cycles (or more if necessary) to ensure normal working conditions.
(3) Halt the automatic weighing system and record the indication of totalized weight.
(4) Run the weighing system for a number of weighing cycles as specified for each test in 6.1, ensuring that the processed material can be weighed on the control instrument (integral or separate) in accordance with one of the alternative verification methods of A.5.2 or A.5.3.
(5) Halt the weighing system, and record the final indication of totalized weight.
(6) Determine the indicated totalized weight for the test from the difference between the indications at start (3) and finish (5).
(7) Repeat the above procedure for further tests as specified in 6.1.
(8) Determine the material test error from the difference between the indicated totalized weight as determined in (6) and the total weight of material determined using the control instrument as in (4).

A.5.2 Separate verification method (6.2.1.1 and A.9.2.3)

The separate control instrument is used to weigh the material either before or after it is weighed

on the discontinuous totalising automatic weighing instrument.

A.5.2.1 Calculation of error for automatic weighing with separate verification (6.2.5)

When calculating the error with the separate verification process, it is necessary to consider the scale interval of the control indicating device and the number of subdivisions of the test load.

The weight values on the separate control instrument are observed and recorded. The error for automatic weighing shall be the difference between the conventional true value of the mass of the test load determined on the separate control instrument (6.2.3 (a)) and the values obtained from the principal totalisation indication (6.2.4 (a)).

This is the value that shall be used for comparison with the appropriate maximum permissible error for automatic weighing in 2.2.1.

A.5.3 Integral verification method (6.2.1.2 and A.9.2.1)

The integral control instrument is used for static weighing of material tests loads by use of a special facility (e.g. a test-stop program) to interrupt automatic weighing operation during the automatic process.

A.5.3.1 Integral verification weighing test performance

The integral verification weighing performance may be determined as follows, prior to the material tests, for determining the errors in material testing.

Apply test loads from zero up to and including Max, and similarly remove the test loads back to zero. When determining the initial intrinsic error, at least 10 different test loads shall be selected, and for other weighing tests at least 5 shall be selected. The test loads selected shall include Max and Min so that the errors may be determined for the nominal hopper loads that will be used in the material tests.

Determine the error at each test load using the procedure in A.3.6.2 if necessary to obtain the accuracy requirements of A.3.6.1.

When loading or unloading weights the load shall be progressively increased or decreased.

Errors of indication shall be recorded and taken into account when determining the errors in material testing.

A.5.3.2 Substitution material

Apply test loads from zero up to and including the maximum portion of standard weights.

Determine the error (A.3.6.2) and then remove the weights so that the no-load indication is reached.

Substitute the previous weights with substitution material until the same changeover point as used for the determination of the error is reached. Repeat the above procedure until Max of the

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The standard operational test is used for a number of different tests:¶
¶
<#>static temperatures,¶
<#>temperature effect on no-load indication¶
<#>power voltage variation,¶
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instrument is reached.

Unload in reverse order to zero, i.e. unload the weights and determine the changeover point. Load the weights back on and remove the substitution material until the same changeover point is reached. Repeat this procedure until no-load indication is reached.

Similar equivalent procedures may be applied.

A.5.3.3 Interruption of automatic weighing during operational tests

A.5.3.3.1 Interruption before emptying (automatic gross weighing)

(a) The gross weight indication of the loaded receptor is observed and recorded after interruption of automatic operation and completion of the automatic gross weighing but before discharge of the receptor.

(b) The static control weighing indication of the loaded receptor is observed and recorded after complete stabilisation of the instrument and auxiliary equipment following stage (a) above. If necessary, standard weights may be used to interpolate between scale intervals. The static control indication shall be corrected for the errors determined in A.5.3.1 (for increasing loads).

A.5.3.3.2 Interruption after emptying (automatic tare weighing)

(c) The tare weight indication of the empty receptor is observed and recorded after interruption of automatic operation following the discharge of the receptor and completion of the automatic tare weighing but before the receptor is loaded again.

(d) The static control weighing indication of the empty receptor is observed and recorded after complete stabilisation of the instrument following (a). The static indication shall be corrected for the errors determined in A.5.3.1 (for decreasing loads).

The tests in A.5.3.3.1 and A.5.3.3.2 are repeated for the specified number of weighing cycles as specified in 6.1.

A.5.3.4 Calculation of error for automatic weighing with integral verification (6.2.5)

When calculating the error with the integral verification process, it is necessary to consider the scale interval of the control indicating device and the number of subdivisions of the test load.

A.5.3.4.1 Determining the conventional true value of the mass of the test load (6.2.3 (b))

The weight values obtained under static conditions on the control indicating device or those values obtained by balancing with standard weights are noted and totalized. For each weighing cycle, the net value is the difference between the values obtained in A.5.3.3.1 (b) and in A.5.3.3.2 (d). The conventional true value of the mass of the total test load is determined by summation of the net weights obtained at each cycle.

A.5.3.4.2 Indicated totalised weight (6.2.4 (b))

The weight values obtained automatically on the principal totalisation indicating device are noted and totalized. For each weighing cycle, the net value is the difference between the values

obtained in A.5.3.3.1 (a) and in A.5.3.3.2 (c).

The error for automatic weighing shall be the difference between the conventional true value of the mass of the test load in A.5.3.4.1 and the values obtained from the totalisation indication in A.5.3.4.2.

This is the value that shall be used for comparison with the appropriate maximum permissible error for automatic weighing in 2.2.1.

A.5.3.5 Air-enclosed integrated instruments (6.2.1.2.1, A.9.2.2)

If the instrument is installed in an air-enclosed system, the moving mass of material causes air turbulence that can affect the weighing results. To ensure that such an instrument is tested in normal conditions of use, the automatic operation shall not be interrupted during consecutive weighing cycles so that at least one receptor shall be discharged in automatic mode. In this case it is necessary to observe and record the indications according to A.5.3.3.1 (a) or A.5.3.3.2 (c) or the net weight indicated by the instrument during automatic weighings, shall be used to determine the discharged mass which corresponds to the weight value of the test mass.

Deleted: made in A.5.3.3.1 (b) and A.5.3.3.2 (a) to be displayed or recorded so that a separate total may be derived for the automatic weighings which have also been carried out under static conditions.

A.5.4 Warm-up (4.2.5)

This test is to verify that metrological performance is maintained in the period immediately after switch on. The method is to check that automatic operation is inhibited until a stable indication is obtained and to verify that zero and span errors comply with the requirements during the first 30 minutes of operation. Zero-tracking and automatic zero-setting shall be disabled, unless if the zero operates as part of every automatic weighing cycle then this function shall be enabled or simulated as part of the test.

Note: For instruments that do not tare weigh after each discharge it is not necessary to calculate the zero variation error.

Other test methods which verify that metrological performance is maintained during the first 30 minutes of operation may be used.

(1) Disconnect the instrument from the supply for a period of at least 8 hours prior to the test.
(2) Reconnect the instrument and switch on while observing the load indicator.
(3) Check that it is not possible to initiate automatic weighing until the indicator has stabilized (4.2.2).
(4) As soon as the indication has stabilized, set the instrument to zero if this is not done automatically.
(5) Determine the error at zero by the method of Annex A.3.6.2.1, and specify this error as E_{0I} (error of initial zero-setting) at first and as E_0 (zero-setting error) when repeating this step.
(6) Apply a static load close to Max. Determine the error by the method of A.3.6.2.1 and A.3.6.2.2.
(7) Verify that:
- zero indication error (E_{0I}) is not greater than 0.25 d_i (3.6.1.1),
- span error is not greater than the maximum permissible error specified in 2.2.2 Table 2 for initial verification.

(8) Repeat steps (5) and (6) after 5, 15 and 30 minutes.

(9) After each time interval verify that:

- zero variation error ($E_0 - E_{0l}$) is not greater than 0.25 $d_i \cdot P_i$,
- span error is not greater than the maximum permissible error specified in 2.2.2 Table 2 for initial verification

A.5.5 Zero-setting (3.6.1)

A.5.5.1 Modes of zero-setting

It is normally only necessary to test the range and accuracy of zero-setting in one mode. If zero is set as part of the automatic weighing cycle then this mode shall be tested. To test automatic zero it is necessary to allow the instrument to operate through the appropriate part of the automatic cycle and then to halt the instrument before testing.

The range and accuracy of zero-setting shall be tested by applying loads as specified below in nonautomatic (static) operation to the load receptor after the instrument is halted.

A.5.5.2 Range of zero-setting

A.5.5.2.1 Initial zero-setting

(a) *Positive range*
With the load receptor empty, set the instrument to zero. Place a test load on the load receptor and switch the instrument off and then back on. Continue this process until, after placing a load on the load receptor and switching the instrument off and on, it does not reset to zero. The maximum load that can be re-zeroed is the positive portion of the initial zero-setting range.

(b) *Negative range*

(1) Remove any load from the load receptor and set the instrument to zero. Then, if possible, remove any non-essential components of the load receptor. If, at this point, the instrument can be reset to zero by switching it off and back on, the mass of the non essential components is used as the negative portion of the initial zero-setting range.

(2) If the instrument cannot be reset to zero with the non-essential components removed, add weights to any live part of the scale until the instrument indicates zero again.

(3) Then remove weights and, after each weight is removed, switch the instrument off and back on. The maximum load that can be removed while the instrument can still be reset to zero by switching it off and on is the negative portion of the initial zero-setting range.

(4) The initial zero-setting range is the sum of the positive and negative portions.

(5) Alternatively, if it is not possible to test the negative range of initial zero setting by removing parts of the instrument, the instrument may be temporarily re-calibrated with a test load applied before proceeding to step (3) above. (The test load applied for the temporary re-calibration should be greater than the permissible negative portion of the initial zero setting range which can be calculated from the result of the positive range test).

(6) If it is not possible to test the negative portion of the initial zero-setting range by these methods then only the positive part of the initial zero-setting range need be considered.
(7) Reassemble or recalibrate the instrument for normal use after the above tests

The zero-setting range is the sum of the positive and negative portions.

A.5.5.2.2 Nonautomatic and semi-automatic zero-setting

This test is conducted in the same manner as described in A.5.5.2.1, except that the zero-setting device is used rather than switching the instrument on and off.

A.5.5.2.3 Automatic zero-setting

Remove the non-essential parts of the load receptor or re-calibrate the instrument as described in A.5.5.2.1 and place weights on the live part of the scale until it indicates zero.

Remove weights in small amounts and after each weight is removed allow the instrument to operate through the appropriate part of the automatic cycle so as to see if the instrument is reset to zero automatically.

The maximum load that can be removed so the instrument can still be reset to zero is the zero-setting range.

A.5.5.3 Accuracy of zero-setting

(1) Set the instrument to zero.
(2) Add weights to the load receptor to determine the additional load at which the indication changes from zero to one totalisation scale interval above zero.
(3) Calculate the error at zero according to the description in A.3.6.2.1.

A.5.5.4 Stability of zero and frequency of automatic zero-setting (3.6.1.4)

This test is applicable for instruments with programmable automatic zero-setting and does not need to be performed for instruments that have automatic zero-setting as part of every automatic weighing cycle or instruments that do tare weigh after each discharge.

To verify that an automatic zero-setting facility will operate sufficiently often to ensure that zero error is not greater than 0.5 d_t, apply the following method:

(1) Determine the maximum permissible time interval as specified by the manufacturer in accordance with 3.6.2,
(2) Allow the instrument to be reset to zero automatically.
(3) After an interval close to the maximum permissible zero-setting interval established in (1) but before a further automatic zero-setting, carry out the test of A.5.5.3, but without zero-setting.
(4) Steps (2) and (3) shall also be carried out as soon the instrument is operable after switch-on, i.e. immediately after the normal warm-up time.

A.6 ADDITIONAL FUNCTIONALITY

A.6.1 Test for the stability of equilibrium (3.3.7)

Check the documentation of the manufacturer; whether the following stable equilibrium functions are described in detail and sufficiently:

- The basic principle, the function and the criteria for stable equilibrium.
- All adjustable and not adjustable parameters of the stable equilibrium function (time interval, number of measuring cycles, etc.).
- Securing of these parameters.
- Definition of the most critical adjustment of the stable equilibrium.

Test of the stable equilibrium by manually disturbing the equilibrium by one single action (e.g. by operation of a test switch) and initiate the command for printing, data storage, or other function, as soon as possible. In the case of printing or data storage, read the indicated value 5 seconds after printing. Stable equilibrium is considered to be achieved when no more than two adjacent values are indicated, one of which being the printed value. In the case of zero-setting check the accuracy as per A.5.5.3. Perform the test 5 times.no functions can be performed that require stable equilibrium, e.g. printing, storing, zero or tare operations.

Check whether under continuous disturbance of the equilibrium no functions can be performed that require stable equilibrium, e.g. printing, storing, or zero operations.

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A.6.2 Agreement between indicating and printing devices (2.4)

During the tests verify that for the same load, the difference between any two indicating devices having the same scale interval is as follows:

- zero for digital indicating or printing devices;
- not greater than the maximum permissible error for analogue devices.

A.6.3 Adjustments in automatic operating mode (3.2.5)

Verify that it is not possible to make operating adjustments nor to reset the indicating devices during an automatic weighing operation.

A.6.4 Securing of components and pre-set controls (3.2.8)

Verify that it is not possible to make unauthorised adjustments or resetting of components, interfaces, software devices and pre-set controls without any access becoming automatically evident.

A.6.5 Printing and indication of weighing results (3.3)

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For printing and indication of weighing results, verify that:

- the principle totalisation device cannot be reset to zero,
- the partial totalisation device cannot be reset to zero unless the printing device automatically records the total. Test by disabling the printer and attempting to reset the partial totalisation

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device;

- an automatic printout of the total is generated if the automatic operation is interrupted,
- printing is inhibited if the stability criteria in 3.3.7 are not fulfilled.

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A.6.6 Retention of total after power failure (4.2.7)

Switch off power to the instrument while the principle totalisation device is indicating a total of not less than $\sum_{min}$. Verify that this total is retained for at least 24 hours.

A.6.7 Voltage variations in external or plug-in (AC or DC) mains power, including in-line rechargeable battery power supply (4.2.8)

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Reduce supply voltage until the instrument ceases to operate or ceases to give a weight indication. Verify that no malfunction or significant fault occurs before the instrument is thus put out of service. Measure and record the voltage value when the instrument ceases to operate or ceases to give a weight indication and compare this measured value with the manufacturer's specified value.

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A.6.8 Zero offset interlock (3.6.1.3)

A.6.8.1 Positive offset

Set the instrument to zero by the method used for the tests in A.5.5.2. Add a load to the load receptor of > d_t, for instruments with an automatic zero-setting device, or > 0.5 d_t, for instruments without an automatic zero-setting device. Confirm that automatic operation is no longer possible.

A.6.8.2 Negative offset

Add a load to the load receptor of > d_t, for instruments with an automatic zero-setting device, or > 0.5 d_t, for instruments without an automatic zero-setting device.

Set the instrument to zero by the method used for the tests in A.5.5.2. Remove the test weights and confirm that automatic operation is no longer possible.

A.7 INFLUENCE FACTOR AND DISTURBANCE TESTS

A.7.1 General

Influence factor and disturbance tests are intended to verify that electronic instruments can perform and function as intended in the environment and under the conditions specified. Each test indicates, where appropriate, the reference condition under which the intrinsic error is determined.

The influence factors or disturbances tests shall be applied to a complete instrument under normal operation. Where it is not possible to apply the influence factors or disturbances to an instrument under normal operation, the instrument shall be subjected to the influence factors or disturbances under static conditions or simulated operation as defined herein. The minimum requirements for simulators are listed under the test equipment heading for each test. The permissible effects of the influence factors or disturbances, under these conditions, are specified

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for each case.

When the effect of one influence factor is being evaluated, all other factors are to be held relatively constant, at a value close to normal. After each test the instrument shall be allowed to recover sufficiently before the following test.

Where parts of the instrument are examined separately, errors shall be apportioned in accordance with 5.1.3.3.

After each test the instrument shall be allowed to recover sufficiently before the following test.

The operational status of the instrument or simulator shall be recorded for each test.

When an instrument is connected in other than a normal configuration, the procedure shall be mutually agreed on by the metrological authority and the applicant.

A.7.2 Simulator requirements

A.7.2.1 General

Simulators shall be designed to enable verification of the accuracy of the weighing function and the integrity of the totalisation storage and indicating function. The automatic process control and data processing functions should be verified where possible.

Where possible the simulator should include all electronic devices of the weighing and weight processing system. It should also include the load cell and a means to apply standard test loads. Where this is not possible, e.g. for high capacity instruments, then a load cell simulator may be used or alternatively the load cell interface may be modified to incorporate a scaling factor to give the design output for a small test load.

Repeatability and stability of a load cell simulator should make it possible to determine the performance of the instrument with at least the same accuracy as when the instrument is tested with weights.

A.7.2.2 Interface (4.2.6)

Susceptibility that would result from the use of electronic interfaces to other equipment shall be simulated in the tests. For this purpose it is sufficient to connect 3 m of interface cable terminated to simulate the interface impedance of the other equipment.

A.7.2.3 Documentation

Simulators shall be defined in terms of hardware and functionality by reference to the instrument under test, and by any other documentation necessary to ensure reproducible test conditions and this information shall be attached to or traceable from the test report.

A.7.2.4 Weighing function

The weighing function may be verified by observation of the control indicating device, if available, during application of the influence factors or disturbances.

Alternatively the totalisation indicator may be observed while the total is being incremented by continually adding the result of weighing a static load during application of the influence factors or disturbances. This may be achieved by special test software or by manual intervention or combinations thereof. Other methods which enable the weighing function to be verified may be used as appropriate. The maximum permissible errors, in terms of mass, will be the same regardless of the method used.

A.7.2.5 Totalisation storage and indication function

The simulator must display a recorded total of not less than the minimum totalized load, $\sum_{min}$. It must be verified that the recorded total is retained during and after application of influence factors or disturbances. Transient errors that are not possible to record and temporary failure of indication when disturbances are applied are acceptable.

In case of purely digital totalisation device(s), the totalisation device(s) need not to be tested during influence factor testing. The operation of the totalisation device(s) shall at least once be checked during normal operating conditions

A.7.3 Influence factor tests

Summary of tests

Test	Conditions applied	§
Static temperatures	MPE(*)	A.7.3.1
Temperature effect on no load indication	MPE	A.7.3.2
Damp heat tests	MPE	A.7.3.3
Voltage variation in AC mains supply	MPE	A.7.3.4
Voltage variation in external or plug-in (AC or DC) power supply	MPE	A.7.3.5
Voltage variation in rechargeable and non-rechargeable battery power supply (DC)	MPE	A.7.3.6
Voltage variation in 12 V and 24 V road vehicle batteries	MPE	A.7.3.7

(*) maximum permissible errors as specified in 2.2.2

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A.7.3.1 Static temperature tests (2.7.1.1)

Static temperature tests are carried out according to basic standard IEC Publication 60068-2-1 [9], IEC Publication 60068-2-2 [10] and IEC 60068-3-1 [11], and according to Table 4.

Table 4 -Static temperature test

Environmental Phenomena	Test specification	Test set-up
Temperature	Reference temperature of 20 °C	IEC 60068-2-2 IEC 60068-2-1 IEC 60068-3-1
	Specified high temperature for 2 hours	
	Specified low temperature for 2 hours	
	Temperature of 5 °C, if the specified low temperature is ≤ 0 °C	
	Reference temperature of 20 °C	
Note: Use IEC 60068-3-1 for background information.		

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Supplementary information to the IEC test procedures	
Object of the test:	To verify compliance with the provisions in 2.7.1.1 under conditions of dry heat (non condensing) and cold.
Test procedures in brief:	
Precondition:	16 hours.
Condition of the EUT:	Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Power is to be "on" for the duration of the test.
Stabilization:	2 hours at each temperature under «free air» conditions. «Free air» conditions mean a minimum air circulation to keep the temperature at a stable level.
Temperature:	As specified in 2.7.1.1
Temperature sequence:	Reference temperature of 20 °C; Specified high temperature; Specified low temperature; A temperature of 5 °C, if the specified low temperature is ≤ 0 °C; Reference temperature of 20 °C.
Number of test cycles:	At least one cycle.
Weighing test:	Adjust the EUT as close to zero indication as practicable prior to the test (if an automatic zero tracking device is connected, adjust it to a value near zero). The EUT shall not be readjusted at any time during the test. The EUT shall display a recorded total not less than the minimum totalized load, $\sum_{min}$, but observe A.7.2.5. After stabilization at the reference temperature and again at each specified temperature, apply at least five different test loads or simulated loads and record: a) date and time; b) temperature; c) relative humidity; d) test load; e) indications (as applicable); f) errors; g) functional performance.
Maximum allowable variations:	All functions shall operate as designed. All errors shall be

within the maximum permissible errors specified in Table 2.

A.7.3.2 Temperature effect on the no-load indication (2.7.1.2)

No reference to international standards can be given at the present time. This test should therefore be conducted as described below.

This test does not need to be performed for instruments that have automatic zero setting as part of every automatic weighing cycle or that do tare weigh after each discharge.

The instrument is set to zero, the temperature is then changed from 20 °C to the prescribed highest and lowest temperature, to 5 °C and to reference 20 °C. After stabilization the error of the zero indication is determined at each temperature level. The change in zero indication per 5 °C is calculated. The changes of these errors are calculated for any two consecutive temperatures of this test.

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This test may be performed together with the temperature test (A.7.3.1). The errors at zero shall then be additionally determined immediately before changing to the next temperature and after the 2-hour period after the instrument has reached stability at this temperature.

Note: Pre-loading is not allowed before these measurements.

Automatic zero-setting or zero-tracking if available shall not be in operation.

Maximum allowable variations: The change in zero indication shall not vary by more than one totalisation scale interval for a temperature difference of 5 °C.

Condition of EUT: Normal power «on» for a time period equal to or greater than the warm-up time specified by the manufacturer. Power is to be «on» for the duration of the test.

A.7.3.3 Damp heat tests (4.2.3)

Either the steady-state test (A.7.3.3.1) or the cyclic test (A.7.3.3.2) shall be prescribed depending upon the type of the EUT and its application (see 4.2.3).

A.7.3.3.1 Damp heat, steady-state

Damp heat, steady state tests are carried out according to basic standard IEC Publication 60068-2-78 [12] and IEC Publication 60068-3-4 [13], and according to Table 5.

Table 5 - Damp heat, steady state test

Environmental phenomena	Test specification	Test set-up
Damp heat, Steady state.	Upper limit temperature and relative humidity of 85% for 48 hours.	IEC 60068-2-78 IEC 60068-3-4
Note: Use IEC 60068-3-4 for guidance for damp heat tests.		

Supplementary information to the IEC test procedures

Object of the test:	To verify compliance with the provisions in 4.1.1 under conditions of high humidity and constant temperature.
Precondition:	None required.
Condition of the EUT:	Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Power is to be "on" for the duration of the test. Adjust the EUT as close to zero indication as practicable prior to the test (if an automatic zero tracking device is connected, adjust it to a value near zero). The EUT shall not be readjusted at any time during the test. The EUT shall display a recorded total not less than the minimum totalized load, $\sum_{min}$, but observe A.7.2.5. The handling of the EUT shall be such that no condensation of water occurs on the EUT.
Stabilization:	3 hours at reference temperature and 50 % humidity; 2 days (48 hours) at the upper limit temperature as specified in 2.7.1.1.
Temperature-humidity 48 hour sequence:	(a) reference temperature of 20 °C at 50 % humidity; (b) upper limit temperature at 85 % humidity; (c) reference temperature of 20 °C at 50 % humidity.
Number of test cycles:	At least one cycle.
Weighing test and test sequence:	After stabilization of the EUT at reference temperature and 50 % humidity, apply at least five different test loads or simulated loads (A.5.1.3.1) and record: a) date and time; b) temperature; c) relative humidity; d) test load; e) indications (as applicable); f) errors; g) functional performance. Increase the temperature in the chamber to the upper limit and increase the relative humidity to 85 %. Maintain the EUT at no load for a period of 2 days (48 hours). Following the 2 days, apply at least five test loads and record the data as indicated above. Allow full recovery of the EUT

before any other tests are performed.

Maximum allowable variations: All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 2.2.2 Table 2.

A.7.3.3.2 Damp heat, cyclic (condensing)

Damp heat, cyclic tests are carried out according to basic standard IEC Publication 60068-3-4 [13] and IEC Publication 60068-2-30 [14], and according to Table 6.

Note: This test applies to cases where condensation is likely to occur or when the instrument is to be installed in high cyclic temperature environments.

Table 6 - Damp heat, cyclic test

Environmental phenomena	Test specification	Test set-up
Damp heat, cyclic	Temperature variations for 24 hours. Maintaining relative humidity at 93 % during temperature changes from lower limit of 25 °C to upper limit temperature of 40 °C, and at relative humidity of 93 % at the upper temperature phrases.	IEC 60068-2-30 IEC 60068-3-4

Supplementary information to the IEC test procedures:

Object of the test: To verify compliance with the provisions in 4.1.1 under conditions of high humidity and cyclic temperature changes.

Test procedures in brief:

Precondition: None required.

Condition of the EUT: Normal power "off" for the duration of the test unless otherwise specified.

The EUT shall display a recorded total not less than the minimum totalized load, $\sum_{min}$, but observe A.7.2.5.

The handling of the EUT shall be such that condensation should occur on the EUT during the temperature rise.

Stabilisation: All parts of the EUT are within 3 °C of their final temperature.

Temperature-humidity
24 hour cycle sequence: (a) Temperature rise from 25 ° at 93 % humidity C during the first 3 hours.

(b) Temperature maintained at the upper limit of 40 °C and 93 % humidity until 12 hours from start of the cycle.
(c) Temperature lowered to 25 °C at 93 % humidity within 3-6 hours.
(d) Temperature maintained at 25 °C at 93 % humidity until the 24-hour cycle is completed.

Number of test cycles: At least one cycle.

Test information: After stabilisation of the EUT at reference temperature, apply at least five different test loads or simulated loads (A.5.1.1) and record:

a) date and time;
b) temperature;
c) relative humidity;
d) power supply voltage;
e) test loads;
f) indications (as applicable);
g) errors;
h) functional performance.

Allow full recovery of the EUT before any other tests are performed.

Maximum allowable variations: All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 2.2.2 Table 2.

A.7.3.4 AC mains voltage variation (2.7.2, 4.2.6)

AC mains voltage variation tests are carried out according to basic standard IEC Publication 61000-4-1 [15] and IEC Publication 61000-4-11 [16], and according to Table 7.

Table 7 - AC mains voltage variations

Environmental phenomena	Test specification		Test set-up
AC mains voltage variation	U_{nom}		IEC 61000-4-1 IEC 61000-4-11
	Upper limit	U_{nom} or U_{min} x 1.10 %	
	Lower limit	U_{nom} or U_{min} x 0.85 %	
	U_{nom}		
Note: In the case of three-phase mains power, the voltage variation shall apply for each of the phase successively.			

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Supplementary information to the IEC test procedures

Object of the test: To verify compliance with the provisions in 4.1.1 under

conditions of AC mains voltage variations.

Test procedures in brief:

Precondition: None required.

Condition of the EUT: Normal power supplied and “on” for a time period equal to or greater than the warm-up time specified by the manufacturer. Power is to be “on” for the duration of the test. Adjust the EUT as close to zero indication as practicable prior to the test. If it has an automatic zero setting function then the instrument should be set to zero after applying each level of voltage.

The EUT shall display a recorded total not less than the minimum totalized load, $\sum_{min}$, but observe A.7.2.5.

Number of test cycles: At least one cycle.

Weighing test: The EUT shall be tested at no load and with one test load or simulated load between 50 % and maximum capacity of the EUT.

Test sequence: Stabilize the power supply at the reference voltage within the defined limits and record:

a) date and time;
b) temperature;
c) relative humidity;
d) power supply voltage;
e) test loads;
f) indications (as applicable);
g) errors;
h) functional performance.

Repeat the test weighing for each of the voltages defined in IEC 61000-4-11 section 5 (noting the need in certain cases to repeat the test weighing at both ends of the voltage range) and record the indications.

Maximum allowable variations: All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 2.2.2 Table 2.

A.7.3.5 Voltage variations in external or plug-in (AC / DC) mains, including in-line rechargeable battery (2.7.2, 4.2.8)

Tests of external or plug-in mains power (AC / DC), including in-line rechargeable battery power shall be conducted in accordance with A.7.3, with the exception of A.7.3.4, which is to be replaced by the test according to basic standard IEC Publication 60654-2 [17] and according to Table 8.

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Table 8 – Voltage variations in external or plug-in (AC or DC) mains power supply, including in-line rechargeable battery

Environmental phenomena	Test specification		Test set-up
Voltage variations in external or plug-in (AC / DC) mains power lines	U_{nom}		I EC 60654-2
	Upper limit	U_{nom} or U_{max} × 1.20%	
	Lower limit	minimum operating voltage (see 2.7.2)	
	U_{nom}		
Note: In case a voltage-range is marked, use the average value as nominal U_{nom}			

Supplementary information to the IEC test procedures:

Object of the test:	To verify compliance with the provisions in 4.1.1 under conditions of voltage variations in external or plug-in mains power, including in-line rechargeable battery power.
Test procedure in brief:	The test consists of exposure to the specified power condition when operating under normal atmospheric conditions with one test load or simulated load.
Preconditioning:	None
Condition of the EUT	Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test. The EUT shall display a recorded total not less than the minimum totalized load, $\sum_{min}$, but observe A.7.2.5.
Number of test cycles:	At least one cycle.
Weighing test :	Stabilize the power at the reference voltage within the defined limits and record the following data at no load and with one load or simulated load: (a) date and time; (b) temperature; (c) relative humidity; (d) power supply; (e) test load; (f) indications (as applicable); (g) errors;

(h) functional performance

Reduce the voltage to the EUT until the instrument ceases to function properly according to the specifications and metrological requirements, and record the indications

Maximum allowable variations: All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 2.2.2 Table 2.

A.7.3.6 Voltage variation in 12 V and 24 V road vehicle batteries (2.7.2)

This test is conducted in accordance with ISO 16750-2 [23] and according to Table 10.

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Table 10 - Voltage variation in 12 V and 24 V road vehicle batteries

Environmental phenomena	Test specification			Test set-up
	U_{nom}	Upper limit	Lower limit	
Voltage variation in 12 V and 24 V road vehicle batteries	12 V	16 V	9 V	ISO 16750-2
	24 V	32 V	16 V	
Note: The nominal voltage (U_{nom})) of the electrical system in road vehicles is usually 12 V or 24 V. But the practical voltage at the battery-connection points can vary considerably.				

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Supplementary information to the ISO test procedures:

Object of the test: To verify compliance with the provisions in 4.1.1 under conditions of voltage variation in 12 V and 24 V road vehicle batteries.

Test procedure in brief: The test consists of exposure to the specified condition of the battery when the former is operating under normal atmospheric conditions with one test load or simulated load.

Preconditioning: None

Condition of the EUT: Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test.

The EUT shall display a recorded total not less than the minimum totalized load, $\sum_{min}$, but observe A.7.2.5.

Number of test cycles: At least one cycle.

Weighing test: Stabilize the power supply at nominal battery voltage and record the following data at no load and with one load or simulated load:

a) date and time;
b) temperature;
c) relative humidity;
d) power supply voltage;
e) test load;
f) indications (as applicable);
g) errors;
h) functional performance.

Reduce the power voltage to the EUT until the instrument ceases to function properly according to the specifications and metrological requirements, and record the indications.

Maximum allowable variations: All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 2.2.2 Table 2.

A.7.4 Disturbance tests (4.1.2)

Summary of tests

Test	Condition applied	§
Short time power reduction	sf (*)	A.7.4.1
Electrical fast transients on I/O circuits and communication lines and on mains power lines	sf	A.7.4.2
Electrical surges on I/O circuits and communication lines and on mains power lines	sf	A.7.4.3
Electrostatic discharge	sf	A.7.4.4
Electromagnetic susceptibility	sf	A.7.4.5
Electrical transient conduction for 12 V and 24 V batteries	sf	A.7.4.6

(*) value of the significant fault (see T.4.2.5)

Prior to any test, the rounding error shall be set as close as possible to zero.

If there are interfaces on the instrument (or simulator), the use of these interfaces to other equipment shall be simulated in the tests. For this purpose, either an appropriate peripheral device or 3 m of interface cable to simulate the interface impedance of the other equipment, shall be connected to each different type of interface.

A.7.4.1 Mains power short time power reductions

Short time power reduction (voltage dips and short interruptions) tests are carried out according to basic standard IEC Publication 61000-4-11 [16] and according to Table 11.

Table 11- Short time power reductions

Environmental phenomena	Test specification	Test set-up
Voltage dips and short interruptions	Interruption from reference voltage to zero voltage for one half cycle Interruption from reference voltage to 0 % of reference voltage for two half cycles These mains voltage interruptions shall be repeated ten times with a time interval of at least 10 seconds	IEC 61000-4-11
Note: Because the EUT is an integrating instrument, the test pulses shall be continuously applied during the measuring time.		

Deleted: The reference voltage (rated voltage) shall be as defined in IEC 61000-4-11 section 5.

Supplementary information to the IEC test procedures

Object of the test: To verify compliance with the provisions in 4.1.2 under conditions of short time mains voltage interruptions and reductions while observing the indications for one static test load.

Test procedures in brief:

Precondition: None

Condition of the EUT: The performance of the test generator shall be verified before connecting the EUT.

Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test. Zero-setting functions shall not be in operation and are not to be adjusted at any time during the test except to re-set if a significant fault has been indicated.

Number of test cycles: At least one cycle.

Weighing test and test sequence: Stabilize all factors at nominal reference conditions. Apply one load or simulated load and record:

a) date and time;
b) temperature;
c) relative humidity;
d) power supply voltage;
e) test load;
f) indications (as applicable);

g) errors;
h) functional performance.

Interrupt the power supply to zero voltage for a period equal to one half cycle and conduct the test as detailed in IEC 61000-4-11 section 8.2.1. During interruption observe the effect on the EUT and record as appropriate.

Reduce the power supply to 0 % of reference voltage for a period equal to two half cycles and conduct the test as detailed in IEC 61000-4-11 section 8.2.1. During reductions observe the effect on the EUT and record, as appropriate.

Maximum allowable variations: The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed 1 d_t, or the EUT shall detect and act upon a significant fault.

A.7.4.2 Bursts (transients) on I/O circuits and communication lines and on mains power lines

Electrical bursts tests (fast transient tests) are carried out according to basic standard IEC 61000-4-4 [18] and according to Tables 12.1 and 12.2, for 2 minutes with a positive polarity and for 2 minutes with a negative polarity.

Table 12.1: Ports for signal lines and control lines

Environmental phenomena	Test specification	Test set-up
Fast transient common mode	0.5 kV (peak) 5/50 ns T_1/T_h 5 kHz rep. frequency	IEC 61000-4-4
Note: Applicable only to ports or interfacing with cables whose total length exceed 3 m according to the manufacturer's functional specification.		

Table 12.2: Input and output AC and DC power ports

Environmental phenomena	Test specification	Test set-up
Fast transient common mode	1 kV (peak) 5/50 ns T_1/T_h 5 kHz rep. frequency	IEC 61000-4-4
Note: DC power ports, not applicable to battery-operated appliance that cannot be connected to the mains while in use.		

Supplementary information to the IEC test procedures

Object of the test: To verify compliance with the provisions in 4.1.2 under conditions where fast transients are superimposed on the I/O circuits and communication lines and the mains voltage while observing the indications for one static test load.

Test procedures in brief:

Precondition: None required.

Condition of the EUT: Normal power supplied and “on” for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test. Zero-setting functions shall not be in operation and are not to be adjusted at any time during the test except to re-set if a significant fault has been indicated.

Stabilization: Before any test stabilize the EUT under constant environmental conditions.

Weighing test: Stabilize all factors at nominal reference conditions.

Apply one load or simulated load and record the following with and without the transients:

a) date and time;
b) temperature;
c) relative humidity;
d) test load;
e) indications (as applicable);
f) errors;
g) functional performance.

Maximum allowable variations: The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed 1 d_t, or the EUT shall detect and act upon a significant fault.

A.7.4.3 Surges on signal, data and control lines and on mains power lines

Electrical surge tests are carried out according to IEC 61000-4-5 [19] and according to Table 13.

Note: This test also applies to instruments in outdoors and/or indoors installations connected to long signal lines (lines longer than 30 m or those lines partially or fully installed outside the buildings regardless of their length.

Table 13 – Surges on I/O circuits and communication lines and on mains power lines

Environmental phenomena	Test specification	Test set-up
Electrical surges	1.0 kV (peak) line to line 3 positive and 3 negative surges applied synchronously with AC mains voltage in angles 0°, 90°, 180° and 270°,	IEC 61000-4-5

	and 3 positive and 3 negative surges applied on other signal lines.	
Notes:	(1) The test consists of exposure to surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impendence load and minimum time interval between two successive pulses are defined in IEC 61000-4-5. (2) The duration of the test shall not be less than one minute for each amplitude and polarity. The injection network depends on the lines the surge is coupled to and is defined in IEC 61000-4-5. (3) Beacuse the EUT is an integrating instrument, the test pulses shall be continuously applied during the measuring time.	

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Supplementary information to the IEC test procedures:

Object of the test: To verify compliance with the provisions in 4.1.2 under conditions where electrical surges are applied on the I/O circuits and communication lines and on the mains power lines while observing the indications for one static test load.

Test procedures in brief:

Precondition: None

Condition of the EUT: The performance of the generator shall be verified before connecting the EUT.

Normal power supplied and «on» for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test. Zero-setting functions shall not be in operation and are not to be adjusted at any time during the test except to re-set if a significant fault has been indicated.

Stabilisation: Before any test stabilise the EUT under constant environmental conditions.

Weighing test: With the single static load in place record the following with and without electrical surges:

a) date and time;
b) temperature;
c) relative humidity;
d) test load;
e) indications (as applicable);
f) errors;

g) functional performance.

Maximum allowable variations: The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed 1 d_t, or the EUT shall detect and act upon a significant fault.

A.7.4.4 Electrostatic discharge test

Electrostatic discharge tests are carried out according to basic standard IEC 61000-4-2 [20], with test signals and conditions as given in Table 14.

Table 14 - Electrostatic discharge test

Environmental phenomena	Test specification		Test set-up
Electrostatic discharge	Test voltage	Levels(1)	IEC 61000-4-2
	contact discharge	6 kV	
	air discharge	8 kV	
Notes: 1) Tests shall be performed at the specified lower levels in IEC 61000-4-2 up to and including the level specified above. 2) The 6 kV contact discharge shall be applied to conductive accessible parts. Metallic contacts, e.g. in battery compartments or in socket outlets are excluded from this requirement.			

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Contact discharge is the preferred test method. 20 discharges (10 with positive and 10 with negative polarity) shall be applied on each accessible metal part of the enclosure. The time interval between successive discharges shall be at least 10 seconds. In the case of a non-conductive enclosure, discharges shall be applied on the horizontal or vertical coupling planes as specified in IEC 61000-4-2. Air discharges shall be used where contact discharges cannot be applied. Tests with other (lower) voltages than those given in Table 14 are not required.

Supplementary information to the IEC test procedures

Object of the test: To verify compliance with the provisions in 4.1.2 under conditions where electrostatic discharges are applied while observing the indications for one static test load.

Test procedures in brief:

Precondition: None required.

Condition of the EUT: Normal power supplied and «on» for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test. Zero-setting functions shall not be in operation and are not to be adjusted at any time

during the test except to re-set if a significant fault has been indicated.

Stabilization: Before any test stabilize the EUT under constant environmental conditions.

Weighing test: Stabilize all factors at nominal reference conditions.

Apply one load or simulated load between 50 % and maximum capacity of the EUT and record the following with and without electrostatic discharge:

a) date and time;
b) temperature;
c) relative humidity;
d) test load;
e) indications (as applicable);
f) errors;
g) functional performance.

Maximum allowable variations: The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed 1 d_t, or the EUT shall detect and act upon a significant fault.

A.7.4.5 Electromagnetic susceptibility test

A.7.4.5.1 Radiated radio frequency, electromagnetic fields

Radiated, radio frequency, electromagnetic field immunity tests are carried out in accordance to IEC 61000-4-3 [21] and according to Table 15.

The unmodulated carrier of the test signal is adjusted to the indicated test value. To perform the test the carrier is in addition modulated as specified.

Table 15 - Radiated electromagnetic susceptibility

Environmental phenomena	Test specification			Test set-up
	Frequency ranges MHz	Severity Levels (V/m)		
		Residential, commercial and light industrial environment	Industrial environment	
Electromagnetic field of general origin	80 to 800[1] 26 to 800[2] 960 to 1400	3 V/m	10 V/m	IEC 61000-4-3
Electromagnetic field caused by digital radio telephones	800 to 960 1400 to 2000	10 V/m		IEC 61000-4-3

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Modulation	80 % AM, 1 kHz sine wave
Notes	(1) IEC 61000-4-3 only specifies test levels above 80 MHz. For frequencies in the lower range the test methods for conducted radio frequency disturbances are recommended (A.7.4.5.2). (2) However, for EUT having no mains or other input port available the lower limit of the radiation test should be 26 MHz.

Supplementary information to the IEC test procedures

Object of the test:	To verify compliance with the provisions in 4.1.2 under conditions of specified electromagnetic fields applied while observing the indications for one small test load.
Test procedures in brief:	
Precondition:	None required.
Condition of the EUT:	Normal power supplied and «on» for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test. Zero-setting functions shall not be in operation and are not to be adjusted at any time during the test except to re-set if a significant fault has been indicated.
Stabilization:	Before any test stabilize the EUT under constant environmental conditions.
Weighing test:	Stabilize all factors at nominal reference conditions.
	Apply one load or simulated load and record the following with and without electromagnetic fields: a) date and time; b) temperature; c) relative humidity; d) test load; e) indications (as applicable); f) errors; g) functional performance.
Maximum allowable variations:	The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed 1 d_t, or the EUT shall detect and act upon a significant fault.

Deleted: between 50 % and maximum capacity of the EUT

A.7.4.5.2 Conducted radio frequency, electromagnetic fields

Conducted, radio-frequency, electromagnetic field immunity tests are carried out in accordance to IEC 61000-4-6 [22] and according to Table 16.

The unmodulated carrier of the test signal is adjusted to the indicated test value. To perform the test the carrier is in addition modulated as specified.

Table 16 - Conducted electromagnetic susceptibility

Environmental phenomena	Test specification			Test set-up
Conducted EM field	Frequency range MHz	Severity Levels (e.m.f)		IEC 61000-4-6
		Residential, commercial and light industrial environment	Industrial environment	
	0.15 to 80	3 V	10 V	
Modulation	80 % AM, 1 kHz sine wave			
Note: This test is not applicable when the EUT has no mains or other input port.				

Coupling and decoupling devices shall be used for appropriate coupling of the disturbing signal (over the entire frequency range, with a defined common-mode impedance at the EUT port) to the various conducting cables connected to the EUT.

Supplementary information to the IEC test procedures:

Object of the test: To verify compliance with the provisions in 4.1.2 under conditions of specified conducted electromagnetic fields while observing the weight indication for one small static test load.

Test procedures in brief:

Precondition: None required.

Condition of the EUT: Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test. Zero-setting functions shall not be in operation and are not to be adjusted at any time during the test except to re-set if a significant fault has been indicated.

Stabilisation: Before any test stabilise the EUT under constant environmental conditions.

Weighing test: With the single static load in place record the following with and without electromagnetic fields:

a) date and time;
b) temperature;

c) relative humidity;
d) test load;
e) indications (as applicable);
f) errors;
g) functional performance.

Maximum allowable variations: The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed 1 d_t, or the EUT shall detect and act upon a significant fault.

A.7.4.6 Electrical transient conduction test for instruments powered by road vehicle 12 V and 24 V batteries

A.7.4.6.1 Conduction along supply lines of 12 V and 24 V batteries

For this test refer to ISO 7637-2 [24] and according to Table 17.

Table 17 - Conduction along 12 V and 24 V supply lines

Environmental phenomena	Test specification			Test set-up
Conduction along 12 V and 24 V supply lines	Test pulse	Pulse voltage U_s		ISO 7637-2
		U_{nom} = 12 V	U_{nom} = 24 V	
	2a	+50 V	+50 V	
	2b[1]	+10 V	+20 V	
	3a	-150 V	-200 V	
	3b	+100 V	+200 V	
	4	-7 V	-16 V	
Note:	Test pulse 2b is only applicable if the instrument is connected to the battery via the main (ignition) switch of the car, i.e. if the manufacturer has not specified that the instrument is to be connected directly (or by its own main switch) to the battery.			

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Supplementary information to the ISO test procedures

Applicable standards: ISO 7637-2
§ 5.6.2: Test pulse 2a + b,
§ 5.6.3: Test pulse 3a + 3b,
§ 5.6.4: Test pulse 4

Object of the test: To verify compliance with the provisions in 4.1.2 under the following conditions while observing the weight indication for one small static test load :

– transients due to a sudden interruption of currents in a device connected in parallel with the device under test due to the inductance of the wiring harness (pulse 2a);
– transients from DC motors acting as generators after the

ignition is switched off (pulse 2b);
– transients on the supply lines, which occur as a result of the switching processes (pulses 3a and 3b);
– voltage reductions caused by energizing the starter-motor circuits of internal combustion engines (pulse 4).

Test Procedures in brief:

Preconditioning:	None
Condition of the EUT	Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable prior to the test. Zero-setting functions shall not be in operation and are not be adjusted at any time during the test except to re-set if a significant fault has been indicated.
Stabilisation	Before any test, stabilize the EUT under constant environmental conditions.
Weighing test:	The test consists of exposure of the EUT to conducted disturbances (on the power voltage by direct brief coupling on supply lines) of the strength and character as specified in Table 17. With the static load in place record: a) date and time; b) temperature; c) relative humidity; d) test load; e) indications (as applicable); f) errors; g) functional performance. Repeat the test weighing for the defined voltages and record the indications.
Maximum allowable variations:	The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed 1 d_t, or the EUT shall detect and act upon a significant fault.

A.7.4.6.2 Electrical transient conduction via lines other than supply lines

For this test refer to ISO 7637-3 Bibliography [23] and according to Table 18.

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Table 18 – Electrical transient conduction via lines other than supply lines

Environmental phenomena	Test specification			Test set-up
Electrical transient conduction via lines other than supply lines	Test pulse	Pulse voltage U_s		ISO 7637-3
		U_{nom} = 12 V	U_{nom} = 24 V	
	a	-60 V	-80 V	
	b	+40 V	+80 V	

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Supplementary information to the ISO test procedures:

Applicable standards	ISO 7637-3, § 4.5: Test pulses a and b
Object of the test	To verify compliance with the provisions in 4.1.2 under conditions of transients which occur on other lines as a result of the switching processes (pulses a and b). The test shall be performed with one small test load only.
Test procedure in brief:	
Preconditioning:	None
Condition of the EUT	Normal power "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable prior to the test. Zero-setting functions shall not be in operation and are not to be adjusted at any time during the test except to re-set if a significant fault has been indicated.
Stabilization	Before any test stabilize the EUT under constant environmental conditions
Weighing test:	The test consists of exposure of the EUT to conducted disturbances (bursts of voltage spikes by capacitive and inductive coupling via lines other than supply lines) of the strength and character as specified in Table 18. Record: a) date and time; b) temperature; c) relative humidity; d) test load; e) indications (as applicable); f) errors; g) functional performance. Repeat the test weighing for the defined voltages and record the indications.
Maximum allowable variations:	The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed 1 d_t, or the EUT shall detect and act upon a significant fault.
Note:	An instrument must comply with the provisions in 4.1.2 in any type of vehicle.

A.8 SPAN STABILITY TEST (4.3.3)

Summary of test

Test	Characteristic under test	Condition applied
Span stability	Stability	1/2 absolute mpe(*)

(*) mpe: maximum permissible error on initial verification in 2.2.2 Table 2.

Note: the maximum permissible error for the zero point shall also be taken into consideration.

Test method:	Span stability.
Object of the test:	To verify compliance with the provisions in 4.3.3 after the EUT has been subjected to the performance tests.
Reference to standard:	No reference to international standards can be given at the present time.
Test procedures in brief:	The test consists of observing the variations of the error of the EUT or simulator under sufficiently constant ambient conditions (reasonable constant conditions in a normal laboratory environment) at various intervals: before, during, and after the EUT has been subjected to performance tests. The performance tests shall include the temperature test and, if applicable, the damp heat test; an endurance test shall not be included. Other performance tests listed in this Annex may be performed. The EUT shall be disconnected twice from the mains power supply (or battery supply where fitted) for at least 8 hours during the period of the test. The number of disconnections may be increased if so specified by the manufacturer or at the discretion of the approval authority in the absence of any specification. In the conduct of this test, the operating instructions for the instrument as supplied by the manufacturer shall be considered. The EUT shall be stabilized at sufficiently constant ambient conditions after switch-on for at least five hours, and at least 16 hours after the temperature and damp heat tests have been performed.
Test severities:	Test duration: 28 days or the time period necessary to conduct the performance tests, whichever is less. Time (t) between tests (days): $0.5 < t < 10$.
Test load:	near maximum capacity (Max); the same test weights shall be used throughout the test.
Maximum allowable variations:	The variation in the errors of indication shall not exceed half the absolute value of the maximum permissible error in 2.2.2 Table 2 for the test load applied on any of the n

	measurements.
Number of tests (n):	At least 8 except where the difference of the results indicates a trend more than half the allowable variation specified, the measurements shall be continued until the trend comes to rest or reverses itself, or until the error exceeds the maximum allowable variation.
Precondition:	None required.
Test equipment:	Verified mass standards or simulated load.
Condition of the EUT:	Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer.
Test sequence:	Stabilize all factors at nominal reference conditions. Adjust the EUT as close to zero as possible. Automatic zero-tracking shall be made inoperative and automatic built-in span adjustment device shall be made operative. • Initial measurement Determine the span error using the following method: (1) Determine the initial zero error (E_o) If necessary disable any automatic zero-setting or zero-tracking devices by placing a "zero weight" of for example 10 times the scale interval resolution on the load receptor. Note the indication at zero (I_0). Either by use of an indicator with a suitable higher resolution scale interval or using the change point weight method in A.3.6.2 (noting the total addition change point weight ΔL_0), determine and record the initial zero error (E_0). (2) Determine the error at near Max capacity (E_L) Carefully remove the change point weights (if used) and apply the test load (or simulated load) and note the indication (I_L). Either by use of an indicator with a suitable higher resolution scale interval or using the change point weight method in A.3.6.2 (noting the total addition change point weight ΔL), determine and record the error at near Max capacity (E_L). Record:

a) date and time;
b) temperature;
c) barometric pressure;
d) relative humidity;
e) value of 0.1 d_t;
f) test load;
g) total of added change point weights at zero load ΔL_0;
h) total of added change point weights at test load ΔL;
i) the following indications:
   - indication at zero (I_0);
   - indication of test load (I_L);

j) calculate:
   - initial zero error E_0;
   - error at test load (E_L);

k) change in location and apply all necessary corrections resulting from variations of temperature, pressure, etc. between the various measurements.

Immediately repeat steps (1) and (2) four more times and determine and record the average value of the error for the five tests.

- Subsequent measurements

After observing the time between measurements requirement repeat the test sequence (1) to (2) once recording the data above unless:

- either the result is outside the maximum allowable variation, or
- the range of the five readings of the initial measurement is more than 0.1 d_t, in which case continue four more times repeating steps (1) and (2) recording the data above and determine and record the average value of the error of the five tests.

The measurements shall continue until there are at least eight measurements except where the difference of the results indicates a trend more than half the allowable variation specified, the measurements shall be continued until the trend comes to rest or reverses itself, or until the error exceeds the maximum allowable variation.

A.9 PROCEDURE FOR IN-SITU TESTS

Meaning of symbols:

A_N	Net test load in automaticmode
S_N	Net test load in nonautomatic mode
A_G	Gross weight in automatic operation or alternatively discharged weight in discharged mode
A_T	Tare value in automatic operation, or in discharge mode the indication of the instrument after subtractive tare of the filled receptor
S_G	Gross load in nonautomatic mode
S_T	Tare load in nonautomatic mode
E	Error for automatic weighing
E_{CI}	Deviation of measurement of control instrument

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A.9.1 General

For type approval, tests shall be carried out in accordance with the requirements of this Recommendation, and especially the requirements in 2.2 for limits of error, and in 5.1 for type approval.

For initial verification, tests shall be carried out corresponding to the normal site operation of the instrument. In this case, limits of error in 2.2 for initial verification and the requirements in 5.2 for initial verification apply.

A.9.2 Control instrument

A.9.2.1 Integral control instrument (A.5.3)

Establish whether or not the instrument is to be used as an integral control instrument. If it is an integral control instrument then it shall comply with 6.2.1 and be tested, using the test methods in 6.2.1.2 and A.5.3. The automatic weighing cycle is conducted as follows:

- Interruption before emptying load receptor

(a) Determination of automatic gross weight value, A_G of the loaded receptor
Initiate automatic operation of the instrument and all essential auxiliary equipment. After the load receptor has been filled with material or test weights and completion of automatic gross weighing, the automatic operation shall be interrupted. However, before discharge of the load receptor, record the gross weight indication, A_G.

(b) Determination of static gross weight value, S_G of the loaded receptor
When the filled load receptor has stabilized to conditions comparable to those for nonautomatic testing, the static gross weight indication, S_G shall be recorded. The static indication of the control instrument shall be corrected by the previously determined error of the control instrument in A.5.3.1 (at increasing loading).

- Interruption after emptying load receptor

(c) Determination of automatic tare weight value, A_T after discharge of the load receptor
Following on from stage (b) above, initiate automatic operation of the instrument and all essential auxiliary equipment, and interrupt the automatic operation after discharge of the filled load receptor and completion of automatic tare weighing. However, before re-filling of the load receptor, the tare weight indication, A_T shall be recorded.

(d) Determination of static tare weight value, S_T of the empty load receptor
Switch off the instrument and all auxiliary equipment. When the empty load receptor has stabilized to conditions comparable to those for nonautomatic testing, the tare weight indication, S_T shall be recorded. The indication of the control instrument shall be corrected by the previously determined error of the control instrument A.5.3.1 (at decreasing loading).

Steps (a) to (d) shall be repeated for the specified number of weighing cycles and the required test mass.

A.9.2.2 Determination of the net weight value and calculation of the error for automatic weighing:

(a) For automatic mode:

$$A_N = \sum_{i=1}^{n} (A_G - A_T)$$

(b) For the nonautomatic mode (test instrument):

$$S_N = \sum_{i=1}^{n} ((S_G - E_{CI}) - (S_T - E_{CI}))$$

Taking into account the error of the control instrument at A_N or S_N, the error E of the weighing instrument at the corresponding test mass accumulated over a specified number of weighing cycles is:

$$E = A_N - S_N$$

A.9.2.2 Air-enclosed integrated instruments (A.5.3.5)

Air-enclosed discontinuous automatic weighing instruments produce air turbulence that can affect the weighing results. To ensure that such an instrument is tested in normal conditions of use, at least one receptor shall be dispensed in automatic mode, i.e., the automatic operation shall not be interrupted in (a) or (c) during consecutive weighing cycles. In this case the uninterrupted automatic weighing results according to (a) or (c) or the net weight registered by the instrument shall be displayed and recorded, in order to correctly calculate the discharged mass which corresponds to the weight value of the test mass.

In the case of discharge weighing the test is to be performed as mentioned above, while the indications have a different sign, i.e. the indication is zero for a loaded receptor, and the indication is positive after discharging the receptor.

Example:

Evaluation with the instrument using re-weighing (of the emptied receptor) and using discharge weighing, assuming:

- Error of control instrument is zero.
- A_T = indication of the weighing results of the single load in automatic mode
- S_T = indication of the weighing results of the single load in nonautomatic mode

Weighing instrument kg		Weighing instrument with discharge weighing kg	
A_G	400.0	A_T	0
S_G	400.05	P_T	-0.05
A_T	0	A_G	400.0
S_T	0.1	S_G	400.1
E	400.0 – 400.15 = -0.15	E	400.0 – 400.15 = -0.15

A.9.2.3 Separate control instrument

If the control instrument is separate from the instrument being verified then it shall comply with 6.2.1 and be tested, using the test methods in 6.2.1.1 and A.5.2, for the specified number of weighing cycles as follows:

(a) Start of the test

Initiate automatic operation of the instrument and all essential auxiliary equipment. After the load receptor has been filled with material and a minimum of five weighing cycles has been reached, interrupt the automatic operation and record the weight indication.

(b) End of the test

With the weighing instrument in automatic operation, conduct the necessary number of weighing cycles to obtain the required test mass, making sure that the test mass can be weighed using a separate control instrument. Interrupt the automatic operation again and record the new indicated weight.

(c) Determination of the weight value of the test mass and calculation of the error for automatic weighing

The weight indication from the weighing instrument is the difference between the indication at the start of the test in (a) and the indication at the end of the test in (b). The conventional true value of the test mass is determined by weighing the test mass on a separate control instrument.

The error for automatic weighing is the difference between weight indication from the instrument and the weight indication from the separate control instrument.

BIBLIOGRAPHY

Below are references to Publications of the International Electrotechnical Commission (IEC), the International Organisation for Standardization (ISO) and the OIML, where mention is made in this Recommendation. Use these or the most recent issue of the publication valid at the time of testing the instrument.

Ref.	Standards and reference documents	Description
[1]	International Vocabulary of Basic and General Terms in Metrology (VIM) (1993)	Vocabulary, prepared by a joint working group consisting of experts appointed by BIPM, IEC, IFCC, ISO, IUPAC, IUPAP and OIML
[2]	International Vocabulary of Terms in Legal Metrology, BIML, Paris (2000)	Vocabulary including only the concepts used in the field of legal metrology. These concepts concern the activities of the legal metrology service, the relevant documents as well as other problems linked with this activity. Also included in this Vocabulary are certain concepts of a general character which have been drawn from the VIM.
[3]	OIML B 3 (2003)	OIML Certificate System for Measuring Instruments (formerly OIML P1) Gives rules for issuing, registering and using OIML Certificates of conformity
[4]	OIML R111 (2004)	Weights of classes E1, E2, F1, F2, M1, M1–2, M2, M2–3 and M3 Gives the principal physical characteristics and metrological requirements for weights used with and for the verification of weighing instruments and weights of a lower class.
[5]	OIML R 76-1 Second Committee draft revision (2005)	Gives the principal physical characteristics and metrological requirements for the verification Nonautomatic weighing instruments
[6]	OIML D 19 (1988)	Pattern evaluation and pattern approval
[7]	OIML D 20 (1988)	Initial and subsequent verification of measuring instruments and processes
[8]	OIML R 60 (2000)	Metrological regulation for load cells
[9]	IEC 60068-2-1 (1990-05) with amendments 1 (1993-02) and 2 1994-06)	Basic environmental testing procedures - Part 2: Tests, Test Ad: Cold, for heat dissipating equipment under test (EUT), with gradual change of temperature.

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Ref.	Standards and reference documents	Description
[10]	IEC 60068-2-2 (1974-01) with amendments 1 (1993-02) and 2 (1994-05)	Basic environmental testing procedures, Part 2: Tests, Test Bd: Dry heat, for heat dissipating equipment under test (EUT) with gradual change of temperature.
[11]	IEC 60068-3-1 (1974)	Background information, section 1: Cold and dry heat tests.
[12]	IEC 60068-2-78 (2001-08)	Environmental testing, Part 2: Tests, Test Cb: Damp heat, steady state. Primarily for equipment.
[13]	IEC 60068-3-4 (2001-08)	Environmental testing – Part 3-4: Guidance for damp heat tests.
[14]	IEC 60068-2-30 (1980-01) with amendment 1 (1985-01)	Environmental testing - Part 2: Tests. Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle).
[15]	IEC 61000-4-1 (2004):	Basic EMC Publication Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques Section 1: Overview of IEC 61000-4 series
[16]	IEC 61000-4-11 (2004-03)	Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques - Section 11: Voltage dips, short interruptions and voltage variations immunity tests.
[17]	IEC 60654-2 (1979-01), with amendment 1 (1992-09)	Operating conditions for industrial-process measurement and control equipment - Part 2: Power.
[18]	IEC 61000-4-4 (2004-07)	Electromagnetic Compatibility (EMC) - Part 4: Testing and measurement techniques - Section 4: Electrical fast transient/burst immunity test. Basic EMC publication.
[19]	IEC 61000-4-5 (2001-04) consolidated Edition 1.1 (including amendment 1 and Correction 1)	Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques Section 5: Surge immunity test.
[20]	IEC 61000-4-2 (1995-01) with amendment 1 (1998-01) and amendment 2 (2000-11) Consolidated Edition: IEC 61000-4-2 (2001-04) Ed. 1.2.	Basic EMC Publication. Electromagnetic Compatibility (EMC) - Part 4: Testing and measurement techniques - Section 2: Electrostatic discharge immunity test. Basic EMC Publication.

Ref.	Standards and reference documents	Description
[21]	IEC 61000-4-3 consolidated Edition 2.1 (2002-09) with amendment 1 (2001-08)	Electromagnetic Compatibility (EMC) - Part 4: Testing and measurement techniques - Section 3: Radiated, radio-frequency, electromagnetic field immunity test.
[22]	IEC 61000-4-6 (2003-05) with amendment 1 (2004-10)	Electromagnetic Compatibility (EMC) - Part 4: Testing and measurement techniques - Section 6: Immunity to conducted disturbances, induced by radio-frequency fields.
[23]	ISO 16750-2 (2003)	Road vehicles - Environmental conditions and testing for electrical and electronic equipment – Part 2: Electrical loads
[24]	ISO 7637-2 (2004)	Road vehicles - Electrical disturbance by conduction and coupling - Part 2: Electrical transient conduction along supply lines only.
[25]	ISO 7637-3 (1995) with correction 1 (1995)	Road vehicles - Electrical disturbance by conduction and coupling - Part 3: Passenger cars and light commercial vehicles with nominal 12 V supply voltage and commercial vehicles with 24 V supply voltage - electrical transient transmission by capacitive and inductive coupling via lines other than supply lines.