ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE

INTERNATIONAL RECOMMENDATION

Automatic catchweighing instruments
Part 1: Metrological and technical requirements - Tests

Instruments de pesage trieurs-étiqueteurs à fonctionnement automatique
Partie 1: Exigences métrologiques et techniques - Essais

OIML R 51-1

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FOREWORD

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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, 1993 edition) and the *Vocabulary of Legal Metrology* (VML, 1978 edition). In addition, for the purposes of this Recommendation, the following definitions apply.

T.1 General definitions

T.1.1 Weighing instrument

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

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

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

T.1.2 Automatic weighing instrument

Instrument that weighs without the intervention of an operator and follows a pre-determined program of automatic processes characteristic of the instrument.

T.1.3 Automatic catchweighing instrument (catchweigher)

Automatic weighing instrument that weighs pre-assembled discrete loads or single loads of loose material.

T.1.3.1 Checkweigher

Catchweigher that sub-divides articles (i.e. objects) of different mass into two or more sub-groups according to the value of the difference between their mass and the nominal set point.

T.1.3.2 Weightgrader

Catchweigher that sub-divides articles of different mass into several sub-groups each characterized by a given mass range.

T.1.3.3 Weigh labeller

Catchweigher that labels individual articles.

T.1.3.4 Weigh price labeller

Catchweigher that prices and labels individual articles.

T.1.4 Electronic instrument

Instrument equipped with electronic devices.

T.1.5 Control instrument

Weighing instrument used to determine the mass of the test load(s).

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 Load receptor

Part of the instrument intended to receive the load.

T.2.2 Electronic parts

T.2.2.1 Electronic device

Device employing electronic sub-assemblies and performing a specific function. An electronic device is usually manufactured as a separate unit and is capable of being independently tested.

T.2.2.2 Electronic sub-assembly

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

T.2.3 Indicating device

The part of an instrument that displays the value of a weighing result in units of mass and may additionally display:

- the difference between the mass of an article and a reference value,
- the mean value and/or the standard deviation of a number of consecutive weighings.

T.2.4 Load conveyor

Device to move the loads on to and off the load receptor.

T.2.5 Setting device

Device for fixing the limits of mass of the sub-groups.

T.2.6 Nominal set point

Value expressed in units of mass preset by the operator by means of the setting device in order to establish the limit between consecutive sub-groups.

T.2.7 Adjustment range

The range of weight values about a set point outside which the weighing results may be subject to excessive relative error.

T.2.8 Counter

Device counting the number of loads which have moved on to the load receptor (movement counter) or indicating the number of the loads in each of the sub-groups (division counter).

T.2.9 Sorting device

Device by means of which the loads are automatically divided into physically separate sub-groups.

T.2.10 Zero-setting device

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

T.2.10.1 Nonautomatic zero-setting device

Device for setting the indication to zero by an operator.

T.2.10.2 Semi-automatic zero-setting device

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

T.2.10.3 Automatic zero-setting device

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

T.2.10.4 Zero-tracking device

Device for maintaining the zero indication within certain limits automatically.

T.2.11 Dynamic setting

Adjustment intended to eliminate the difference between the static load value and the dynamic load value.

T.3 Metrological characteristics

T.3.1 Weighing capacity

T.3.1.1 Maximum capacity (Max)

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

T.3.1.2 Minimum capacity (Min)

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

T.3.1.3 Weighing range

Range between the minimum and maximum capacities.

T.3.1.4 Maximum tare effect (T+, T–)

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

T.3.2 Actual scale interval (d)

Value expressed in units of mass of:

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

T.3.3 Verification scale interval (e)

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

T.3.4 Rate of operation

Number of loads weighed automatically per unit of time.

T.3.5 Load length

Length of load measured in the direction in which it is moving.

T.3.6 Warm-up time

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

T.3.7 Load transport system

The system used to transport the load over the load receptor.

T.3.8 Instrument that weighs statically

An instrument that operates such that the load is stationary during the time of the weight determining process.

T.4 Errors

T.4.1 Error (of indication)

The indication of an instrument minus the (conventional) true value of the mass. [Adapted from VIM 5.20]

T.4.2 Intrinsic error

The error of an instrument, determined under reference conditions. [VIM 5.24]

T.4.3 Initial intrinsic error

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

T.4.4 Mean (systematic) error ($\bar{x}$)

The mean value of the error (of indication) for a number of consecutive automatic weighings of a load, or similar loads, passed over the load receptor, expressed mathematically as

$$\bar{x} = \frac{\sum x}{n}$$

where:
x represents the error of a load indication,
$\bar{x}$ is the mean of the errors, and
n is the number of weighings.

T.4.5 Standard deviation of the error (s)

The standard deviation of the error (of indication) for a number of consecutive automatic weighings of a load, or similar loads, passed over the load receptor, expressed mathematically as

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

T.4.6 Fault

The difference between the error of indication of an instrument and the intrinsic error.

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

T.4.7 Significant fault

A fault greater than e.

A significant fault does not include:

- faults arising from simultaneous and mutually independent causes in the instrument or in its checking facility, or
- faults that imply it is impossible to perform a measurement, or
- faults that are so serious they will inevitably be noticed by all those interested in the measurement, or
- transitory faults that are momentary variations in the indications that cannot be interpreted, memorized or transmitted as a measurement result.

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 and or the indication of the instrument. [Adapted from VIM 2.7]

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 within the limits specified in this International Recommendation but 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 standard deviations and maximum permissible mean errors, as appropriate, specified in this Recommendation. [Adapted from VIM 5.5]

T.5.3 Reference conditions

A set of specified values of influence factors fixed to ensure valid intercomparison of the results of measurements. [Adapted from VIM 5.7]

T.6 Tests

T.6.1 Operational test

A test carried out on a complete instrument using a test load or loads of the type that it is intended to weigh, and using the load conveyor and load transport system to move it on to and off the load receptor.

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 whether the equipment under test (EUT) is able to accomplish its intended functions.

T.6.4 Span stability test

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

AUTOMATIC CATCHWEIGHING INSTRUMENTS

1 General

1.1 Scope

This International Recommendation specifies the metrological and technical requirements and test procedures for automatic catchweighing instruments (catchweighers), hereinafter called «instruments», that are subject to national metrological control.

It is intended to provide standardized requirements and testing procedures to evaluate the metrological and technical characteristics in a uniform and traceable way. A standardized test report format is given as part 2 of this Recommendation.

1.2 Application

This Recommendation applies to instruments that weigh pre-assembled discrete loads automatically.

1.3 Terminology

The terminology given in pages 4 to 9 shall be considered as a part of this Recommendation.

2 Metrological requirements

2.1 Accuracy classes

Instruments are divided into accuracy classes designated by:

X(x) or Y(y)

Class X(x) applies to instruments used to produce packages that are subject to the requirements of OIML R 87 «Net contents in packages».

Class Y(y) applies to all other automatic catch-weighing instruments such as weigh-price labellers, postal and shipping scales, and may also be used for instruments that weigh single loads of loose material.

Class X is a basic accuracy class that includes sub-classes designated by the factor x. It is an open class for which the value of x is specified by the manufacturer. The value of x shall be 1×10^k, 2×10^k, or 5×10^k, k being a positive or negative whole number or zero.

Class Y has two sub-classes specified by a or b.

The use of a class for a particular application may be determined by national requirements.

2.2 Maximum permissible errors for class X(x) instruments

The maximum permissible mean (systematic) error for any net load greater than or equal to the minimum capacity (Min) and less than or equal to the maximum capacity (Max), in automatic operation shall be as specified in Table 1.

Table 1

Load (m) expressed in verification scale intervals (e)		Maximum permissible mean error for class X(x) instruments	
Where x ≤ 1	Where x > 1	Initial verification	In-service
0 < m ≤ 500	0 < m ≤ 50	± 0.5 e	± 1 e
500 < m ≤ 2 000	50 < m ≤ 200	± 1 e	± 2 e
2 000 < m ≤ 10 000	200 < m ≤ 1 000	± 1.5 e	± 3 e

The maximum permissible standard deviation of the error (random error) shall be as specified in Table 2.

Table 2

Value of the mass of the net load m (g)	Maximum permissible standard deviation (as percentage of m or in grams) for class X(1) instruments	
	Initial verification	In-service
m ≤ 50	0.48 %	0.6 %
50 < m ≤ 100	0.24 g	0.3 g
100 < m ≤ 200	0.24 %	0.3 %
200 < m ≤ 300	0.48 g	0.6 g
300 < m ≤ 500	0.16 %	0.2 %
500 < m ≤ 1 000	0.8 g	1.0 g
1 000 < m ≤ 10 000	0.08 %	0.1 %
10 000 < m ≤ 15 000	8 g	10 g
15 000 < m	0.053 %	0.067 %

2.3 Maximum permissible errors for class Y(y) instruments

The maximum permissible error for any load equal to or greater than the minimum capacity (Min) and equal to or less than the maximum capacity (Max) in automatic operation shall be as specified in Table 3. (Note that the mpe-value includes the digital rounding error of the indicating device).

Table 3

Load (m) expressed in verification scales intervals (e)		Maximum permissible error for class Y(y) instruments	
Class Y(a)	Class Y(b)	Initial verification	In-service
0 < m ≤ 500	0 < m ≤ 50	± 1.5 e	± 2 e
500 < m ≤ 2 000	50 < m ≤ 200	± 2 e	± 3 e
2 000 < m ≤ 10 000	200 < m ≤ 1 000	± 2.5 e	± 4 e

2.4 Maximum and minimum capacities

Maximum capacity (Max) and minimum capacity (Min) shall be specified by the manufacturer.

The minimum capacity shall not be less than:

for class Y(a): 20 e
for class Y(b) : 10 e
for postal scales: 5 e

2.5 Maximum permissible errors for influence factor tests

2.5.1 Class X(x) instruments

For automatic operation the maximum permissible errors for class X(x) instruments shall be as specified in Table 1 and Table 2, as appropriate, for initial verification.

For static weighing in nonautomatic operation the maximum permissible errors for class X(x) instruments shall be as specified in Table 1 for initial verification.

2.5.2 Class Y(y) instruments

For automatic operation the maximum permissible errors for each load for class Y(y) instruments shall be as specified in Table 3, for initial verification.

For static weighing in nonautomatic operation the maximum permissible errors for class Y(y) instruments shall be as specified in Table 1 for initial verification, applying the limits for $x \leq 1$ for class Y(a), and for $x > 1$ for class Y(b).

2.6 Indication or printout of weight for test purposes

For class X(x) instruments indications and/or print-outs of the weight (or the difference between the weight and a nominal set point) shall be provided for determining the average and standard deviation of the measurement error, for which purpose the scale interval e shall be not greater than the appropriate limit for Table 2 or alternatively other practical means for demonstrating compliance with Table 1 and Table 2 shall be provided by agreement with the metrological authority.

For class Y(y) instruments practical means for demonstrating compliance with Table 1 and Table 3 shall be provided.

2.7 Units of measurement

The units of mass to be used on an instrument are the milligram (mg), the gram (g), the kilogram (kg) and the tonne (t).

2.8 Effect of eccentric loading

If it is possible to pass loads eccentrically, the maximum permissible errors given in 2.5 shall not be exceeded at any eccentric setting (see 6.2).

2.9 Influence factors

Refer to Annex A for test conditions.

2.9.1 Temperature

Instruments shall comply with the appropriate metrological and technical requirements at temperatures from – 10 °C to + 40 °C. However, for special applications the limits of the temperature range may differ from those given above but such a range shall not be less than 30 °C and shall be specified in the descriptive markings.

2.9.2 Power supply (AC)

Instruments that are powered by an AC electricity supply shall comply with the appropriate metrological and technical requirements when operated at voltages from – 15 % to + 10 % of the value marked on the instrument.

2.9.3 Tilting

Instruments which are not intended for installation in a fixed position and which do not have a level indicator shall comply with the appropriate metrological and technical requirements when tilted by 5 %.

Where a level indicator is present it shall enable the instrument to be set to a tilt of 1 % or less.

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 Accidental maladjustments

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

3.2.2 Static adjustment

An instrument may be fitted with a span adjustment device. External influence upon this device shall be practically impossible after securing.

3.2.3 Dynamic setting

An instrument may be fitted with a dynamic setting facility, available to the user, to compensate for the dynamic effects of the load in motion. This facility may operate over a weight range relative to a setting weight (or weights) provided that when the facility is used for that weight range and in accordance with the manufacturer's instructions, the maximum permissible errors are not exceeded.

Once dynamic setting has taken place to give a weight range over which the permissible errors are not exceeded, the instrument shall automatically take appropriate action for loads falling outside that range; for these loads printout of weight shall also be inhibited.

Instruments with dynamic setting shall have a facility for any access to dynamic setting to be automatically and non-erasably recorded. For class X(x) instruments a static span adjustment device which is capable of being sealed may be provided as an alternative. Use of either of these facilities may be determined by national prescription.

3.2.4 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 indication is made impossible. Keys shall be marked unambiguously.

3.3 Zeroing and tare devices

3.3.1 Zero-setting

An instrument shall be provided with a zero-setting device which may be automatic, semi-automatic or manual.

A zero-setting device shall be capable of setting zero to within 0.25 e and shall have a range of adjustment not exceeding 4 % of maximum capacity.

Note: Random errors in dynamic operation may prevent indication of zero to within 0.25 e. However, the maximum permissible mean value of the setting error shall be not greater than ± 0.25 e.

An automatic zero-setting device shall operate:

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

A nonautomatic zero-setting device shall not be operable during automatic operation.

A semi-automatic zero-setting device shall function only when the stability criteria are fulfilled.

3.3.2 Zero-tracking device

A zero-tracking device shall operate only when:

- the indication is at zero, or at a negative net value equivalent to gross zero, and
- the stability criteria are fulfilled, and
- the corrections are not more than 0.5 e/second.

When zero is indicated after a tare operation, the zero-tracking device may operate within a range of 4 % of Max around the actual zero value.

Note: Zero-tracking is functionally similar to automatic zero-setting. The differences are important in applying the requirements of 3.3.1 and 3.3.2. Refer to T.2.10.3 and T.2.10.4. For many types of catchweigher, which have automatic zero-setting, zero-tracking will not be appropriate. The maximum rate of correction applicable to zero-tracking does not apply to zero-setting.

- Automatic zero-setting is activated by an event, such as switch-on or as part of the automatic weighing cycle or after a programmed interval.
- Zero-tracking may operate continuously (when the conditions of 3.3.2 are fulfilled) and must therefore be subject to a maximum rate of correction (0.5 e/second) to prevent interaction with the normal weighing process.

3.3.3 Tare device

A tare device shall permit setting the indication to zero with an accuracy better than ± 0.25 e, and its operation shall be clearly visible.

Note: Random errors in dynamic operation may prevent indication of zero to within 0.25 e. However, the maximum permissible mean value of the setting error shall be not greater than ± 0.25 e.

Provision for entry of tare shall be independent of the zero-setting function.

The indication of the tare shall be to the same scale interval as the instrument.

A semi-automatic or automatic tare device shall operate only when the stability criteria are fulfilled.

A nonautomatic or semi-automatic tare device shall not be operable during automatic operation.

3.3.4 Preset tare device

A preset tare value:

- may be introduced into the instrument with a resolution smaller than e provided that the instrument shall be inhibited from automatically modifying the entered value to correspond with the verification scale interval;
- may be operated together with one or more tare devices provided that the tare weight values are clearly designated when indicated or printed;
- shall be clearly indicated and identified at least temporarily.

3.4 Indication of weighing results

3.4.1 Quality of reading

Reading of the results shall be reliable, easy and unambiguous under conditions of normal use:

- the overall inaccuracy of reading of an analogue indicating device shall not exceed 0.2 e,
- 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.

3.4.2 Form of the indication

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

The scale interval shall be in the form 1×10^k, 2×10^k or 5×10^k units in which the result is expressed, k being a positive or negative whole number or zero.

A digital indication shall display at least one figure beginning at the extreme right.

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.

Zero may be indicated by one zero to the extreme right, without a decimal sign.

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.

3.4.3 Limits of indication

There shall be no indication above Max + 9 e or, for class X(x) instruments, Max + three times the maximum permissible standard deviation value as specified in Table 2, whichever is the greater.

3.4.4 Indication or printout of weight for normal operation

For normal operation the scale interval of indications or printouts of individual article weights shall not be less than the verification scale interval e.

3.5 Printing device

Printing shall be clear and permanent for the intended use. Printed figures shall be at least 2 mm high.

If printing takes place, the name or the symbol of the unit of measurement shall be either to the right of the value or above a column of values.

Printing a weighing result below minimum capacity shall not be possible.

The data may be stored in a memory of the instrument before printing. The same data shall not be printed twice on the ticket or label.

3.6 Price computing instrument

The price to pay shall be calculated and rounded to the nearest interval of price to pay by multiplication of weight and unit price, both as indicated or printed by the instrument. The device which performs the calculation is considered a part of the instrument.

The interval of price to pay, and the monetary symbols and location shall comply with national regulations applicable to trade.

The unit price is restricted to Price/100 g or Price/kg.

3.7 Weigh or weigh-price labelling instrument

A weigh or weigh-price labelling instrument shall have at least one display for the weight. It may be used temporarily for set-up purposes such as supervision of weight setting limits, unit prices, preset tare values and commodity names.

It shall be possible to verify the actual values of unit price and preset tare during automatic operation.

An instrument may totalize weight and price data on one or more tickets or labels provided that the total values are identified by a special word or symbol. All totals shall be the algebraic sums of all the values printed.

3.8 Descriptive markings

Instruments shall bear the following markings.

3.8.1 Markings shown in full

- name or identification mark of the manufacturer
- name or identification mark of the importer (if applicable)
- serial number and type designation of the instrument
- maximum rate of operation (if applicable) in the form: ...loads per minute
- maximum speed of load transport system (if applicable) in the form: ...m/s
- electrical supply voltage in the form: ...V
- electrical supply frequency in the form: ...Hz
- working fluid pressure (if applicable) in the form: ...kPa
- adjustment range referred to set point (if applicable) in the form: ± ...g or % (of set point value)

3.8.2 Markings shown in code

- pattern approval sign
- indication of the class of accuracy X(x) or Y(y)
- verification scale interval in the form: e = ...
- actual scale interval in the form: d = ...
- maximum capacity in the form: Max = ...
- minimum capacity in the form: Min = ...
- maximum tare additive in the form: T = + ...
- maximum tare subtractive in the form: T = – ...

3.8.3 Supplementary markings

Depending upon the particular use of the instrument, supplementary markings may be required on pattern approval by the metrological authority issuing the pattern approval certificate (for example: temperature range).

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

3.8.4 Presentation of descriptive markings

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

They shall be grouped together in a clearly visible place on the instrument, either on a descriptive plate fixed near the indicating device or on the indicating device itself. It shall be possible to seal the plate bearing the markings, unless it cannot be removed without being destroyed.

The descriptive markings may be shown on a programmable display which is controlled by software. In this case, means shall be provided for any access to reprogramming of the markings to be automatically and non-erasably recorded, e.g. by traceable access software. When a programmable display is used, the plate of the instrument shall bear at least the following markings:

- type and designation of the instrument,
- name or identification mark of the manufacturer,
- pattern approval number,
- electrical supply voltage,
- electrical supply frequency,
- pneumatic pressure.

3.9 Verification marks

3.9.1 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.

3.9.2 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.

When the mark is made with a stamp the support may consist of a strip of lead or any other material with similar qualities, inserted into a plate fixed to the instrument, or in a cavity bored in the instrument.

When the mark consists of an adhesive transfer a space must be prepared for this purpose.

4 Requirements for electronic instruments

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

4.1 General requirements

4.1.1 Rated operated conditions

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

4.1.2 Influence factors

An instrument shall comply with the requirements of 2.9 and shall also comply with appropriate metrological and technical requirements at a relative humidity of 85 % at the upper limit of the temperature range.

4.1.3 Disturbances

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

(a) significant faults do not occur, i.e. the difference between the weight indication due to the disturbance and the indication without the disturbance (intrinsic error) does not exceed the value specified in T.4.7, or

(b) significant faults are detected and acted upon.

Note: A fault equal to or less than the value specified in T.4.7 is allowed irrespective of the value of the error of indication.

4.1.4 Evaluation for compliance

A pattern of an electronic instrument is presumed to comply with the requirements of 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

The requirements in 4.1.3 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 4.1.3 (a) or (b) is applied is left to the manufacturer.

4.2 Functional requirements

4.2.1 Indicator display test

If the failure of an indicator display element can cause a false weight indication then the instrument shall have a display test facility which is automatically initiated at switch-on of indication, e.g. indication of all the relevant signs of the indicator in their active and non-active states for a sufficient time to be easily observed by the operator.

4.2.2 Acting upon a significant fault

When a significant fault has been detected, the instrument shall either be made inoperative automatically, or a visual or audible indication shall be provided automatically and shall continue until such time as the user takes action or the fault disappears.

4.2.3 Warm-up time

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

4.2.4 Interface

An instrument may be equipped with an interface permitting the coupling of the instrument to external equipment. When an interface is used, the instrument shall continue to function correctly and its metrological functions shall not be influenced.

4.2.5 Battery power supply

An instrument that operates from a battery power supply shall, whenever the voltage drops below the manufacturer's specified minimum value, either continue to function correctly or automatically be put out of service.

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 of 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 test

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

Tests are to be carried out 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 electronic devices shall be tested, where possible as a simulated instrument including all electronic elements of a system which can affect the weighing result. In addition, an examination shall be carried out on the fully operational weighing instrument.

Susceptibility that would result from the use of electronic interfaces to other equipment shall be simulated in the tests.

4.3.3 Span stability test

When the instrument is subjected to the span stability test specified in A.9, the absolute value of the difference between the errors obtained for any two measurements shall not exceed half the maximum permissible error for influence factor tests for a near maximum capacity load.

4.3.4 Continually updated weight indication

Where it is not possible for instruments to be fully operational during the influence factor tests then the instrument shall be provided with a continually updated weight indication.

5 Metrological controls

5.1 General

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

- pattern approval,
- initial 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 pattern approval and initial verification is provided in OIML International Documents D 19 and D 20 respectively.

5.2 Pattern approval

5.2.1 Documentation

The application for pattern approval shall include documentation comprising:

- metrological characteristics of the instrument,
- a 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, and
- any document or other evidence that the design and construction of the instrument complies with the requirements of this Recommendation.

5.2.2 General requirements

Pattern evaluation shall be carried out on one or more and not normally more than three instruments that represent the definitive pattern. If the performance of an instrument could be affected by a particular manner of operation or a particular manner of use for which conditions cannot be duplicated other than in an in-situ operation then at least one of the instruments shall be completely installed at a typical site. At least one of the instruments shall be submitted in a form suitable for laboratory simulation tests. The evaluation shall consist of tests specified in 5.2.3.

5.2.3 Pattern 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 on initial verification referred to in 2.2 or 2.3 using standard test loads described in 6.1.3 or test loads specified by the manufacturer,
- the technical requirements in clause 3,
- the requirements in clause 4 for electronic instruments, where applicable.

The appropriate metrological authority shall:

- conduct the tests in a manner that prevents an unnecessary commitment of resources,
- permit the results of these tests to be assessed for initial verification.

Note: The appropriate metrological authority is advised to accept, with the consent of the applicant, test data obtained from other metrological authorities without repeating the tests.

5.2.3.1 Operational tests

Tests shall be done as follows:

- in accordance with the descriptive markings (3.8),
- under the normal conditions of use for which the instrument is intended, and
- in accordance with the test methods in clause 6.

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

5.2.3.2 Tests and checks for compliance with technical requirements

Tests and checks shall be done to assess compliance with the requirements for security of operation in 3.2.

5.2.3.3 Influence factor tests

Influence factors shall be applied to the complete instrument or simulator as specified in 6.5.3 and in Annex A, in accordance with:

- subclause 2.8 for all instruments,
- clause 4 for electronic instruments.

5.2.3.4 Apportioning of errors

Where it is necessary to separately test parts of an instrument or system the following requirements apply.

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

The fractions P_i shall satisfy the following equation:

$$P_1^2 + P_2^2 + P_3^2 + ... \leq 1$$

The fraction P_i shall be chosen by the manufacturer of the module and shall be verified by an appropriate test. However, the fraction shall not exceed 0.8 and shall not be less than 0.3, when more than one part contributes to the effect in question.

If the metrological characteristics of the load cell have been evaluated in accordance with the requirements of OIML International Recommendation R 60, that evaluation shall be used to aid pattern evaluation if so requested by the applicant.

Note: As the requirements of this subclause only apply to the instrument submitted for pattern 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 an indicating device or printer to give the appropriate increment or scale interval, or
- use of change point weights, or
- any other means mutually agreed.

5.2.4 Provision of means of testing

For the purposes of testing, the metrological authority may require from the applicant an appropriate quantity of articles, a control instrument and personnel to perform the tests.

5.2.5 Place of testing

Instruments submitted for pattern 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.

5.3 Initial verification and in-service inspection

5.3.1 Tests

Instruments shall be tested to verify that they comply with the requirements in clause 2, excluding 2.8, and clause 3 for the type of article(s) for which they are intended and when operated under the normal conditions of use.

Instruments that weigh statically may be tested in nonautomatic mode.

Tests shall be carried out by the appropriate 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 an automatic weighing operation will be the same whether for the purposes of testing or for use for a transaction.

The appropriate metrological authority:

- shall conduct the tests in a manner that prevents an unnecessary commitment of resources,
- may, where appropriate and to avoid duplicating tests previously done on the instrument for pattern evaluation under 5.2.3.1, use the results of observed tests for initial verification.

Dynamic tests shall be done:

- in accordance with the descriptive markings (3.8),
- under the rated conditions for which the instrument is intended,
- in accordance with the test methods in clause 6 using test loads described in 6.1.3.

Accuracy requirements shall be applied in accordance with the appropriate part or parts in 2.2 or 2.3.

Note: The accuracy class that was achieved at approval stage may not be achieved at initial verification if the loads to be used are significantly less stable or of different dimensions. In this case a lower accuracy class shall be marked in accordance with 2.2 or 2.3 and 3.8.4. Marking of a higher accuracy class than was achieved at approval stage is not permitted.

5.3.2 Provision of means of testing

For the purposes of testing, the metrological authority may require from the applicant an appropriate quantity of articles, a control instrument and personnel to perform the tests.

6 Test methods

6.1 Determination of errors for automatic weighing

Notes: (1) Other methods which achieve a similar level of confidence in limits of error may be used.

(2) For some approval testing nonautomatic operation of the instrument may be specified or may be more appropriate - see 6.5.

6.1.1 Values of the mass of test loads

Test loads shall be applied as follows:

a) test load values close to Min and Max,
b) test loads at two critical points in between Min and Max.

It is only necessary to use one test load at each of the above nominal values.

6.1.2 Number of test weighings

The number of consecutive test weighings taken and used to determine the mean value and the standard deviation shall be as specified in Table 4.

Table 4

Class	Mass of load	Number of test weighings
X(x)	$m \leq 10$ kg	60
	10 kg $< m \leq$ 25 kg	32
	25 kg $< m \leq$ 100 kg	20
	100 kg $< m$	10
Y(y)	Minimum 10 for any load	

Note: For class Y(y) the number of test weighings shall be at least 10 unless impractical.

6.1.3 Types of test load

a) For pattern evaluation, a test load shall be used which complies with the following conditions:

- appropriate dimensions,
- constant mass,
- solid, non-hygroscopic, non-electrostatic, non-magnetic material,
- metal-to-metal contact to be avoided.

b) For initial verification and in-service inspection, test loads shall be the type of article(s) which are intended to be used.

6.1.4 Conditions of tests

The load transport system shall be set to a speed corresponding to the maximum rate of operation and, if adjustable by the operator, also at a speed approximately midway in the adjustment range.

Zero shall be set at the start of each test sequence at a given load value.

6.1.5 Individual errors of weighings

The individual errors of weighings shall be the difference between the conventional true value of the mass of the test load as described in 6.1.6 and the indicated weight observed and recorded (see 6.1.7).

6.1.6 Conventional true value of the mass of the test load

The mass of a test load shall be determined on a control instrument to an accuracy at least five times higher (three times higher if the control instrument is verified immediately prior to the automatic test) than whichever is the smaller of the appropriate error allowances of Tables 1 and 2, or than the appropriate error allowance of Table 3, and the result shall be considered as the conventional true value of the mass of the test load.

6.1.7 Indicated weight for class X(x) instruments

Either the individually displayed or printed weights shall be noted for each load and the mean and standard deviation shall be calculated and recorded for each test or, where suitable facilities, for directly performing these calculations, exist within the instrument under test these may be used provided that they are checked for accuracy before use. In this situation it is not mandatory that the individual weights are recorded. No specific method of verifying that the instrument meets the calculation requirements is given as the method used will depend on the particular design being tested. However, any methods used shall demonstrate that the correct errors are being calculated as specified in 6.1.5, the correct formulae as specified in T.4.4 and T.4.5 are being used for the calculations in the instrument, and shall include at least some checks with loads. Details of the method used shall be recorded in the appropriate place in the pattern evaluation report.

6.2 Eccentric test for instruments that weigh in motion

To determine the effect of eccentric loading (see 2.8) an automatic weighing test, as described in 6.1, shall be carried out with a test load of 1/3 Max (plus the additive tare capacity, if applicable) using the portion of the load transport system that is halfway between the center and the back, and repeated with the same test load using the portion of the load transport system that is halfway between the center and the front.

6.3 Eccentric test for instruments that weigh statically

To determine the effect of eccentric loading a static weighing test shall be carried out with a test load of 1/3 Max (plus the additive tare capacity, if applicable) located in each of the four quarter segments of the stationary load transport system.

On an instrument with a load transport system having n points of support, with $n > 4$, the fraction $1/(n-1)$ of Max (plus the additive tare capacity, if applicable) shall be applied to each point of support.

6.4 Status of automatic correction facilities

Status of dynamic adjustment and automatic zeroing facilities shall be as specified for each test.

6.5 Static test loads for approval testing

6.5.1 Span stability testing

For span stability testing a single static test load near maximum capacity shall be used.

6.5.2 Disturbance testing

For disturbance testing a single static test load between Min and Max shall be used.

6.5.3 Influence factor tests

6.5.3.1 Requirement for static or dynamic operation

The mode of operation required for influence factor tests shall be decided as follows.

All instruments designed to weigh loose material shall be tested in static, nonautomatic mode.

All tests with loads greater than or equal to 50 kg may be done statically in nonautomatic mode.

For instruments designed to weigh discrete objects dynamically (i.e. with the load in motion) the mode of operation for influence factor tests shall be as specified for each individual test in Annex A.

For instruments designed to weigh discrete objects statically the mode of operation for influence factor tests may be as specified for each individual test in Annex A or may be decided on by the procedure of 6.5.3.2.

6.5.3.2 Option for nonautomatic testing

As an alternative to automatic operation during influence factor testing, static test loads may be applied in a nonautomatic mode provided that:

- the instrument weighs statically in normal operation and,
- the test of 6.5.3.3 has demonstrated that random errors are not significant in normal operation and,
- where a decision is made to test in nonautomatic mode this shall be applied to all the influence factor tests and recorded in the test report.

Influence factor tests for loads of 50 kg or greater may always be done in a nonautomatic mode.

6.5.3.3 Determination of random errors for instruments that weigh statically

To determine whether static loads may be used for influence factor testing, the following test shall be applied before approval testing takes place: automatic test weighings, as specified in 6.1, shall be applied to the instrument under normal conditions of use for Min and Max load values and for the load transport system set to the maximum rate of operation and also at a rate midway in the adjustment range.

Static loads may be used for influence factor testing where the results of these tests demonstrate that, for the test loads, the differences between the results of several weighings of the same load are not greater than the maximum permissible error of the instrument for that load given in Table 1 for initial verification.

ANNEX A

TESTING PROCEDURES FOR AUTOMATIC CATCHWEIGHING INSTRUMENTS
(Mandatory)

Meaning of symbols:

I = Indication
I_n = n^{th} indication
L = Load
ΔL = Additional load to next changeover point
P = I + 1/2 e – ΔL = Indication prior to rounding (digital indication)
E = I – L or P – L = Error
E_0 = Error at zero load
mpe = Maximum permissible error
mpme = Maximum permissible mean (systematic) error for automatic operation
mps = Maximum permissible standard deviation of the error for automatic operation
EUT = Equipment under test

A.1 Administrative examination (5.2)

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

A.2 Compare construction with documentation (5.2)

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

A.3 Initial examination

A.3.1 Metrological characteristics

Note metrological characteristics according to the test report format (see OIML R 51-2).

A.3.2 Descriptive markings (3.8)

Check the descriptive markings according to the checklist given in the test report format.

A.3.3 Suitability for use (3.1)

Check the suitability for use according to the checklist given in the test report format.

A.3.4 Security of operation (3.2)

Check the instrument for security against accidental maladjustments and static adjustment according to the checklist given in the test report format.

A.3.5 Controls (3.2.4)

Check the controls according to the checklist given in the test report format.

A.3.6 Indication of weighing results (3.4)

Check the indication of the weighing results according to the checklist given in the test report format.

A.3.7 Price computing instrument (3.6)

Check the price computing instrument according to the checklist given in the test report format.

A.3.8 Weigh or weigh-price labelling instrument (3.7)

Check according to the checklist given in the test report format.

A.4 General test requirements

A.4.1 Power supply

Energize 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.4.2 Zero-setting

Adjust the EUT as closely as practicable to zero prior to each test, and do not re-adjust it at any time during the test, except to reset if a significant fault has been indicated.

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

A.4.3 Dynamic setting

Dynamic setting shall be done in accordance with manufacturers instructions prior to commencing the tests.

Before commencing influence factor tests, dynamic setting may be repeated for each load value and thereafter may not be repeated.

Dynamic setting should not be repeated during disturbance tests except after a significant fault.

If the dynamic setting process is part of a calibration procedure for the whole weight range then the dynamic setting should not be repeated before testing with different load values.

A.4.4 Static test loads

Static test loads may be optionally used for the influence factor testing in A.7 for machines designed to weigh loose material and for machines that weigh statically where the conditions in 6.5.3 are met (including a test applied before the testing in A.7 commences).

A.4.5 Temperature

The tests 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.4.6 Use of standard weights to assess rounding error

A.4.6.1 General method to assess error prior to rounding

For instruments with digital indication having scale interval e, 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 say 0.1 e are successively added until the indication of the instrument is increased unambiguously by one scale interval (I + e). The additional load ΔL added to the load receptor gives the indication, P, prior to rounding by using the following formula:

$$P = I + 0.5\ e - \Delta L$$

The error prior to rounding is:

$$E = P - L = I + 0.5\ e - \Delta L - L$$

Example: an instrument with a scale interval e of 5 g is loaded with 1 kg and thereby indicates 1 000 g. After adding successive weights of 0.5 g, the indication changes from 1 000 g to 1 005 g at an additional load of 1.5 g. Inserted in the above formula these observations give:

$$P = (1\ 000 + 2.5 - 1.5)\ g = 1\ 001\ g$$

Thus the true indication prior to rounding is 1 001 g, and the error is:

$$E = (1\ 001 - 1\ 000)\ g = +\ 1\ g$$

A.4.6.2 Correction for error at zero

Evaluate the error at zero load, (E_0), by the method of A.4.6.1. Evaluate the error at load L, (E), by the method of A.4.6.1.

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

$$E_c = E - E_0$$

Example: if, for the example in A.4.6.1, the error calculated at zero load was:

$$E_0 = +\ 0.5\ g,$$

the corrected error is:

$$E_c = +\ 1 - (+\ 0.5) = +\ 0.5\ g$$

A.5 Test program

A.5.1 Pattern evaluation (5.2.3)

All tests of A.1 through A.9 shall normally be applied for pattern evaluation.

Either the individually displayed or printed weights shall be recorded for each load and, for class X(x) instruments, the mean and standard deviation subsequently calculated for each test or, where suitable facilities for directly performing these calculations exist within the instrument under test, these may be used provided that they are checked for accuracy before use. In this situation it is not mandatory that the individual weights are recorded. No specific method of verifying that the instrument meets the calculation requirements is given as the method used will depend on the particular design being tested. However, any methods used shall demonstrate that the correct errors are calculated as in 6.1.5, that the correct formulae as specified in T.4.4 and T.4.5 are being used for the calculations in the instrument, and shall include at least some checks with loads. Details of the method used shall be recorded in the appropriate place in the pattern evaluation report.

Types of test loads to be used must comply with 6.1.3.

A.5.2 Initial verification (5.3)

All of A.6 (Metrological performance tests) except for A.6.2 (Warm-up) is normally required for initial verification tests.

Either, the individually displayed or printed weight values shall be recorded for each load and, for class X(x) instruments, the standard deviation and mean calculated for each test or, where suitable facilities for performing these calculations exist in the instrument under test, these may be used as detailed in the approval documents.

Types of test loads to be used must comply with 6.1.3.

A.6 Metrological performance tests

A.6.1 General

A.6.1.1 Standard operational test (5.2.3.1)

The test procedure shall be as follows.

Start the automatic weighing system, including (if the EUT is installed in the place of use) the surrounding equipment which is normally operational when the instrument is in use.

Set the load transport system to a speed corresponding to the maximum rate of operation (as defined in the terminology).

Except where stated, select four test loads, which must include values close to Min and Max and two critical points in between Min and Max (6.1.1). Only one test load is required for each of the above load values.

The number of test weighings for each load depends on mass of the test load as specified in 6.1.2.

Enable the test loads to be automatically weighed for the specified number of times and record each weight indication.

Calculate errors for class X(x) with the definitions in T 4.4 and T 4.5.

The standard operational test is used for a number of different tests:

- dynamic setting,
- eccentricity for dynamic weighing instruments,
- static temperatures,
- temperature effect on no load indication,
- damp heat, steady state,
- power voltage variation,
- operational tests.

A.6.1.2 Optional static tests for machines that weigh statically (6.5)

As an alternative to automatic operation during influence factor testing (A.7) static test loads may be applied in a nonautomatic mode provided the conditions of 6.5.3 are met.

Static loads: If static test loads are chosen to replace consecutive test weighings they shall be selected in accordance with A.6.1.1 and the load transport system shall be set to the rate specified in A.6.1.1, although the actual transport system under the load may be stationary if this is the condition that occurs during the normal weight determining cycle of the instrument. Where a decision is taken to replace dynamic test loads with static test loads this shall be applied to all the relevant influence factor tests and shall be recorded in the test report.

A.6.2 Warm-up

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. If the zero is set as part of the normal automatic weighing cycle then this function shall be enabled or simulated as part of the test.

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 (4.2.3).

(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 A.4.6.1

(6) Apply a static load close to Max. Determine the error by the method of A.4.6.1 and A.4.6.2.

(7) Verify that:
   - zero indication error is not greater than 0.25 e (3.3.1),
   - span error is not greater than the maximum permissible error specified in Table 1 for initial verification.

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

(9) After each time interval verify that:

- zero indication error is not greater than 0.5 e (3.3.1),
- span error is not greater than the maximum permissible error specified in Table 1 for initial verification.

A.6.3 Range of dynamic setting (3.2.3)

A.6.3.1 Range

If the dynamic setting facility is specified for a limited weight range (or ranges) then the standard weighing test shall be done at load values close to the limits of the range for at least one of the nominal load values specified in A.6.1.1.

A.6.3.2 Out of range interlock

If the dynamic setting facility is specified for a limited weight range (or ranges) then it shall be verified that operation and print out outside of the specified range is inhibited, by attempting to weigh loads that are close to but outside the range.

A.6.4 Zero-setting (3.3)

A.6.4.1 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 or disable the automatic zero-setting before testing.

The range and accuracy of zero-setting shall be tested by applying loads as specified below either dynamically or to a static part of the load receptor or after the instrument is halted.

A.6.4.2 Range of zero-setting

(a) Positive range

With the load receptor empty, set the instrument to zero. Place a test load on the load receptor and set the instrument to zero again. Continue incrementing the test load until zero-setting fails.

The maximum load that can be re-zeroed is the positive portion of the zero-setting range.

(b) Negative range

(1) Remove any load from the load receptor and set the instrument to zero. Then if possible remove non essential components of the load receptor, such that the instrument cannot be re-zeroed by use of the zero-setting device. (If this is not possible then any mass that can be removed without disabling the zero function may be considered as the negative portion of the zero-setting range.)

(2) Add weights to the load receptor until the instrument indicates zero again.

(3) Then remove weights and, after each weight is removed, use the zero-setting device. The maximum load that can be removed while the instrument can still be rezeroed by the zero-setting device, is the negative portion of the zero-setting range.

(4) Alternatively, and if it is not possible to test the negative range of zero setting by removing parts of the instrument, then the instrument may be temporarily recalibrated with a test load applied before proceeding to step (3) above. (The test load applied for the temporary recalibration should be greater than the permissible negative zero setting range which can be calculated from the result of the positive range test).

(5) If it is not possible to test the negative zero-setting range by these methods then only the positive part of the zero-setting range need be considered.

(6) 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.6.4.3 Accuracy of zero-setting

Accuracy of zero-setting may be tested in nonautomatic (i.e. static) mode, by incrementing load weights by a small amount; or in a dynamic mode using an indicator of appropriate resolution.

A.6.4.3.1 To determine accuracy of zero by incrementing of load weights:

(1) Set the instrument to zero and then disable the zero-setting functions as specified in A.6.4.1. If the instrument has a zero-tracking facility then the indication must be brought out of the zero-tracking range (e.g. by loading with 10 e).

(2) Apply loads to the load receptor. Increment each successive load by a small amount (less than e) to determine the additional load at which the indication changes from zero to one scale interval above zero (or from one scale interval to the next above if a load of 10 e was added to disable zero-tracking).

(3) Calculate the error at zero by the method of A.4.6.1.

A.6.4.3.2 To determine accuracy of zero in automatic mode:

(1) Set the instrument to zero as specified in A.6.4.1.

(2) Simulate passing of a load while the load transport system is running with no load and record the no-load indication for 60 automatic weighings. (Alternatively carry out 60 test weighings in automatic mode of a load close to zero and subtract the load value from the mean of the indications.)

(3) Calculate the mean of the indications $\bar{x}$ and the standard deviation s.

(4) Verify that:

$$| \bar{x} | \leq 0.25\,e - 0.167\,s$$

(5) If $| \bar{x} |$ is greater than $(0.25\,e - 0.167\,s)$ but less than $0.25\,e$, then the zero error shall be acceptable if it can be shown with 90 % confidence by other methods that the true mean μ is less than or equal to $0.25\,e$. This may be necessary when s is significantly large relative to e.

Note: It is assumed that the true mean μ is equal to the zero error. The uncertainty associated with $\bar{x}$, the estimator of the true mean, is related to the standard deviation of the indications and to the number of weighings as follows:

$$|\bar{x}| \leq 0.25\,e - 1.296\,\frac{s}{\sqrt{n}}$$

(where n is the number of weighings, close to, or greater than 60). This equation gives a probability of 0.9 that the zero error is not greater than 0.25 e.
However, the probability of

$$|\bar{x}| > 0.25\,e - 1.296\,\frac{s}{\sqrt{n}}$$

when the true mean μ is not greater than 0.25 e, is the probability of rejecting a good instrument. (If μ = 0.25 e there is a 0.9 probability of rejecting the instrument).
Therefore, if s is significantly large in relation to e, it may be necessary to increase the number of weighings or to use an alternative method.

A.6.5 Stability of zero and frequency of automatic zero-setting (3.3.1)

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

(1) Examine the instrument to establish the approximate maximum interval between automatic zero settings when in normal use.

(2) Allow the instrument to be reset automatically.

(3) After an interval close to the maximum zero-setting interval established in (1) but before a further automatic zero-setting, carry out the test of A.6.4.3.1 or A.6.4.3.2.

(4) Stages (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.6.6 Tare setting (3.3.3)

Accuracy of tare setting may be tested in nonautomatic (i.e. static) mode, by incrementing load weights by a small amount, or in a dynamic mode using an indicator of appropriate resolution. The normal mode of tare setting shall be tested.

Errors of tare setting shall be calculated in accordance with the method for zero setting as specified in A.6.4.3.1 and A.6.4.3.2.

Other methods which verify the requirements of 3.3.3 may be used where appropriate.

A.6.6.1 Automatic and semi-automatic tare

A.6.6.1.1 Static tare

Place the tare load on the load receptor and allow the tare function to operate (refer to the manufacturers instructions for the exact method).

Increment the tare load by using change point weights until the indication has definitely changed by one scale interval. Verify by the method of A.6.4.3.1 that the tare setting accuracy is better than ± 0.25 e.

A.6.6.1.2 Dynamic tare

Pass the load to be tared over the load receptor to allow the tare function to operate (refer to manufacturers instructions).

Then when the tare has been set up carry out 60 test weighings in automatic mode of the tare load. Calculate mean and standard deviation. Verify by the method of A.6.4.3.2 that the tare setting accuracy is better than ± 0.25 e.

A.6.6.2 Preset tare

Set the tare by following the manufacturers instructions. Weigh the tare load statically or dynamically, as appropriate to normal operation, and calculate the tare setting error as in A.6.6.1.1 or A.6.6.1.2.

A.6.7 Eccentricity (2.8 and 6.2)

A.6.7.1 Eccentric test for instruments that weigh in motion

The instrument shall be under conditions of normal operation. The test shall be carried out during automatic operation. Zero-setting functions shall be in operation. Dynamic setting may be performed before each new value of test load is used. Automatic zero setting shall be in operation (if available).

Apply a load equal to 1/3 Max (plus the additive tare capacity, if applicable) across the load receptor with the load at the center of each of the following bands where:

Band 1 - is from the center of the load receptor to one edge of the transport system,

Band 2 - is from the center of the load receptor to the opposite edge of the transport system.

The load is passed across the load receptor the specified number of times (6.1.2). The errors shall not exceed the appropriate maximum permissible errors for influence factor tests.

A.6.7.2 Eccentric test for instruments that weigh statically

Apply a load equal to 1/3 Max (plus the additive tare capacity, if applicable) in each of the four quarter segments of the stationary load transport system. On an instrument with a load transport system having n points of support with $n > 4$ the fraction $1/(n - 1)$ of Max (plus the additive tare capacity, if applicable) shall be applied to each point of support.

The errors shall not exceed the appropriate maximum permissible errors for influence factor tests.

A.6.8 Alternative operating speeds (6.1.4)

The test procedure shall be as follows.

Start the automatic weighing system, including the surrounding equipment which is normally used when the instrument is in use. The test shall be carried out during automatic operation. Zero-setting functions shall be in operation. Dynamic setting may be performed before each new value of test load is used.

Two test load values are selected, one value close to Min and one value close to Max. One test load is used at each of the above load values.

The number of test weighings depends on mass of the test load (6.1.2).

The load transport system shall be set to speed corresponding to the maximum speed of operation and also at a speed approximately midway through the adjustment range (6.1.4).

If the instrument is specified for alternative maximum capacities corresponding to alternative operating speeds then each speed must be tested with the correct load. In this case it is not necessary to retest minimum and critical load values for each speed.

The test load is passed across the load receptor the specified number of times and the results are noted. Maximum permissible errors shall be as specified in 2.2 or 2.3 as appropriate.

A.7 Influence factor tests

Where possible tests shall be carried out on fully operational equipment in their normal operational state unless otherwise specified. When tested in other than a normal configuration, the procedure shall be mutually agreed by the approving authority and the applicant.

When the effect of one factor is being evaluated, all other factors are to be held relatively constant, at a value close to normal.

Summary of tests

Test	Conditions applied	§
Static temperatures	mpe(*)	A.7.1
Temperature effect on no load indication	mpe	A.7.2
Damp heat, steady state	mpe	A.7.3
Power voltage variation	mpe	A.7.4
Tilting	mpe	A.7.5

(*) mpe: maximum permissible error (see 2.5)

A.7.1 Static temperatures (2.9.1)

Static temperature tests are carried out according to basic standard IEC Publication 68-2-1 (1990) and IEC Publication 68-2-2 (1974) as detailed in the Bibliography [1] and according to Table 5.

Table 5

Environmental phenomena	Test specification	Test set-up
Temperature	Reference of 20 °C	
	Specified high for 2 hours	IEC 68-2-2
	Specified low for 2 hours	IEC 68-2-1
	5 °C	IEC 68-2-1
	Reference of 20 °C	
Use IEC 68-3-1 (1974) for background information and refer to Bibliography [1] for specific parts of the IEC test.		

Supplementary information to the IEC test procedures

Object of the test:	To verify compliance with the provisions in 2.9.1 under conditions of dry heat (non condensing) and cold. The test A.7.2 may be conducted during this test.
Test procedures in brief:	
Preconditioning:	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. The zero-setting and zero-tracking facilities shall be enabled as for normal operation.
Stabilization:	2 hours at each temperature under «free air» conditions.
Temperature:	As specified in 2.9.1.
Temperature sequence:	The reference temperature of 20 °C The specified high temperature The specified low temperature A temperature of 5 °C The reference temperature of 20 °C
Number of test cycles:	At least one cycle.
Weighing test:	After stabilization at the reference temperature and again at each specified temperature, conduct weighing tests in automatic mode except where specified in 6.5.3.1, using test loads of mass according to 6.1.1 and number of test weighing's according to 6.1.2. (For optional static tests see A.6.1.2). Record: a) date and time b) temperature c) test load d) indications (as applicable) e) errors f) functional performance
Maximum allowable variations:	All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 2.5.

A.7.2 Temperature effect on the no-load indication

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

Note: This test should not be performed for instruments that have automatic zero setting as part of the automatic weighing process.

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

This test may be performed during the temperature test A.7.1.

Maximum allowable variations: The change in zero indication shall not vary by more than the value of the significant fault for a temperature difference of 5 °C.

Condition of 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.

A.7.3 Damp heat, steady state (4.1.2)

Damp heat, steady state test are carried out according to basic standard IEC Publication 68-2-56 (1988) and IEC Publication 68-2-28 (1980) as detailed in Bibliography [2] and according to Table 6.

Table 6

Environmental phenomena	Test specification	Test set-up
Damp heat, steady state	Upper limit temperature and relative humidity of 85 % for 2 days	IEC 68-2-56
Use IEC 68-2-28 for guidance for damp heat tests and refer to Bibliography [2] for specific parts of the IEC test.		

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.

Preconditioning: None required.

Test load: One static test load close to minimum capacity.

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.

The zero-setting and zero-tracking facilities shall be enabled as for normal operation. Adjust the EUT as close to zero indication as is practicable, prior to the test.

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 at the upper limit temperature as specified in 2.9.1.
Temperature:	Reference temperature of 20 °C and at the upper limit as specified in 2.9.1.
Relative humidity:	50 % at reference temperature. 85 % at upper limit temperature.
Temperature/humidity sequence:	The reference temperature of 20 °C at 50 % humidity The upper limit temperature at 85 % humidity The 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 the test load. Record: a) date and time b) temperature c) relative humidity d) test load e) indications (as applicable) f) errors 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. Following the 2 days, apply the static test load and record the data as indicated above. Allow full recovery of the EUT before any other tests are performed.
Maximum allowable variations:	All errors shall be within the maximum permissible errors specified in 2.5.

A.7.4 Power voltage variation (2.9.2)

Power voltage variation tests are carried out according to basic standard IEC Publication 1000-4-11 (1994) as detailed in Bibliography [6] and according to Table 7.

Table 7

Environmental phenomena	Test specification	Test set-up
Voltage variation	Reference voltage	IEC 1000-4-11
	Reference voltage + 10 %	
	Reference voltage – 15 %	
	Reference voltage	
Reference voltage (rated voltage) shall be as defined in IEC 1000-4-11 section 5; refer to Bibliography [6] for specific parts of the IEC test.		

Supplementary information to the IEC test procedures

Object of the test:	To verify compliance with the provisions in 2.9.2 under conditions of voltage variations.
Test procedures in brief:	
Preconditioning:	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. If it has an automatic zero-setting function then the instrument should be set to zero after applying each level of voltage.
Number of test cycles:	At least one cycle.
Weighing test:	The EUT shall be tested with one test load selected from 6.1 at a critical value. The test shall be carried out during automatic operation except where specified in 6.5.3.1. Zero setting function shall be in operation.
Test sequence:	Stabilize the power supply at the reference voltage within the defined limits and pass the test loads as specified in A.6.1.1. Record: a) date and time b) temperature c) power supply voltage d) test load e) indications (as applicable) f) errors g) functional performance Repeat the test weighing for each of the voltages defined in IEC 1000-4-11 in section 5 (noting the need in certain cases that the test weighing will be repeated 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 2.5.

A.7.5 Tilting (2.9.3)

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

Note: This test only applies to instruments that will not be permanently installed. This test is not required for mobile instruments with a level indicator if it can be established that the tilt can be adjusted to 1 % or less.

An instrument not intended for installation in a fixed position that does not have a level indicator shall be tested as follows:

Zero-setting and zero-tracking shall be in operation.

Object of the test:	To verify compliance with the provisions in 2.9.3.
Preconditioning:	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. The zero-setting and zero-tracking facilities shall be enabled as for normal operation.
Number of test cycles:	At least one cycle.
Test severity:	Operational tests with a load close to Min and Max at 5 % tilt.
Test procedure:	
Weighing test and test sequence:	The test consists of conducting the operational tests as described in 5.2.3.1 (but only using loads close to Min and Max) at each of the following positions. The test shall be carried out during automatic operation except where specified in 6.5.3.1. Re-zero at each new position prior to conducting the operational test: a) reference position b) 5 % longitudinally forward c) 5 % longitudinally backwards d) 5 % transversely forward e) 5 % transversely backwards f) reference position Record: a) date and time b) test load c) indications (as applicable) d) errors e) functional performance
Maximum allowable variations:	All errors shall be within the maximum permissible errors specified in 2.5.

A.8 Disturbance tests

A.8.1 Short time power reduction (4.1.3)

Short time power reduction (voltage dips and short interruptions) tests are carried out according to basic standard IEC Publication 1000-4-11(1994) as detailed in Bibliography [6] and according to Table 8.

Table 8

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 50 % 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 1000-4-11
The reference voltage (rated voltage) shall be as defined in IEC 1000-4-11 section 5; refer to Bibliography [6] for specific parts of the IEC test.		

Supplementary information to the IEC test procedures

Object of the test: To verify compliance with the provisions in 4.1.3 under conditions of short time mains voltage interruptions and reductions while observing the weight indication of a single static load.

Test procedures in brief:

Preconditioning: 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. Not to be adjusted or readjusted at any time during the test except the reset if a significant fault has been indicated.

Number of test cycles: At least one cycle.

Weighing test and test sequence: The EUT shall be tested with a single static test load between Min and Max.

Stabilize all factors at nominal reference conditions. Apply the test load.

Record:

a) date and time
b) temperature
c) power supply voltage
d) test load
e) indications
f) errors
g) 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 1000-4-11 section 8.2.1. During interruption observe the effect on the EUT and record as appropriate.

Reduce the power supply to 50 % of nominal voltage for a period equal to two half cycles and conduct the test as detailed in IEC 1000-4-11 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 the value given in T.4.7 (1 e), or the EUT shall detect and act upon a significant fault.

A.8.2 Electrical bursts (Fast transient tests) (4.1.3)

Electrical bursts tests (Fast transient tests) are carried out according to basic standard IEC 1000-4-4 (1995), for 2 minutes with a positive polarity and for 2 minutes with a negative polarity as detailed in Bibliography [5] and according to Tables 9.1, 9.2 and 9.3.

Table 9.1: 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 1000-4-4
Note: Applicable only to ports or interfacing with cables whose total length exceed 3 m according to the manufacturer's functional specification.		

Table 9.2: Input and output d.c. power ports

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 1000-4-4
Note: Not applicable to battery operated appliance that cannot be connected to the mains while in use.		

Table 9.3: Input and output a.c. power ports

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 1000-4-4

A coupling/decoupling network shall be applied for testing a.c. power ports.

Supplementary information to the IEC test procedures

Object of the test:	To verify compliance with the provisions in 4.1.3 under conditions where electrical bursts (Fast transients) are superimposed on the mains voltage while observing the weight indication for a single static test load between Min and Max capacity.
Test procedures in brief:	
Preconditioning:	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. Reset the EUT if a significant fault has been indicated.
Stabilization:	Before any test stabilize the EUT under constant environmental conditions.
Weighing test:	With the single static load in place record the following with and without the transients: a) date and time b) temperature c) test load d) indications (as applicable)
Maximum allowable variations:	The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed the value given in T.4.7 (1 e) or the instrument shall detect and act upon a significant fault.

A.8.3 Electrostatic discharge (4.1.3)

Electrostatic discharge tests are carried out according to basic standard IEC 1000-4-2 (1995) as detailed in Bibliography [3], with test signals and conditions as given in Table 10.

Table 10

Environmental phenomena	Test specification	Test set-up
Electrostatic discharge	8 kV air discharge 6 kV contact discharge	IEC 1000-4-2
Note: 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.		

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 and vertical coupling planes as specified in IEC 1000-4-2 (1995). Air discharges shall be used where contact discharges cannot be applied. Tests with other (lower) voltages than those given in Table 10 are not required.

Supplementary information to the IEC test procedures

Object of the test:	To verify compliance with the provisions in 4.1.3 under conditions where electrostatic discharges are applied while observing the weight indication for a single static load close to but not less than the minimum capacity.
Test procedures in brief:	
Preconditioning:	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. Reset the EUT if a significant fault has been indicated.
Stabilization:	Before any test stabilize the EUT under constant environmental conditions.
Weighing test:	With the single static load in place record the following with and without electrostatic discharge: a) date and time b) temperature c) test load d) indications (as applicable)
Maximum allowable variations:	The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed the value given in T.4.7 (1 e) or the instrument shall detect and act upon a significant fault.

A.8.4 Electromagnetic susceptibility (4.1.3)

Electromagnetic susceptibility tests (radio-frequency electromagnetic fields 26 MHz to 1 000 MHz tests) are carried out in accordance to IEC 1000-4-3 (1995) as detailed in Bibliography [4] and according to Table 11.

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 11: Enclosure port

Environmental phenomena	Test specification	Test set-up
Radio-frequency electromagnetic field, 1 kHz, 80 % AM	26 MHz to 1 000 MHz 3 V/m (rms) (unmodulated)	IEC 1000-4-3

Supplementary information to the IEC test procedures

Object of the test:	To verify compliance with the provisions in 4.1.3 under conditions of specified electromagnetic fields applied while observing the weight indication for a single static load close to but not less than the minimum capacity.

Test procedures in brief:

Preconditioning:	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. Reset the EUT if a significant fault has been indicated.
Stabilization:	Before any test stabilize 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) test load d) indications (as applicable)
Maximum allowable variations:	The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed the value given in T.4.7 (1 e) or the instrument shall detect and act upon a significant fault.

A.9 Span stability test (4.3.2)

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 procedure in brief:	The test consists of observing the variations of the error of the EUT under sufficiently constant ambient conditions (reasonably 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 from the mains power supply, or battery supply where fitted, two times 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 5 hours, and at least 16 hours after the temperature and damp heat tests have been performed.
Test severity:	Test duration: 28 days or the time period necessary to conduct the performance test, whichever is less. Time (t) between tests: $0.5 \leq t \leq 10$ (days) Test load: a static test load near maximum capacity (Max); the same test weights shall be used throughout the test.
Maximum allowable variations:	All functions shall operate correctly. The variation in the indication of the test load shall not exceed 1/2 the absolute value of the mpe specified in Table 2 for the test load applied on any of the (n) tests conducted.
Number of tests (n):	$n \leq 8$. If the test results indicate a trend, i.e. the errors continue to increase or decrease in the same direction, conduct additional tests until the trend comes to rest or reverses itself, or until the error exceeds the maximum allowable variation.
Preconditioning:	None required.
Test equipment:	Verified mass standards.
Condition of 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 a zero indication as practicable before each test. The automatic zero-tracking should be made inoperative during the test (if the EUT is so equipped).
Test sequence:	Stabilize all factors at nominal reference conditions. Apply the test load (or simulated load) and record the following data: a) date and time, b) temperature, c) barometric pressure, d) relative humidity, e) test load, f) indication, g) errors, h) functions performance, i) changes in test location. Repeat this test at periodic intervals during and after the conduct of the various performance tests. Allow full recovery of the EUT before any other tests are performed.

BIBLIOGRAPHY

Below are references to Publications of the International Electrotechnical Commission (IEC), where mention is made in some of the tests in Annex A.

[1] IEC Publication 68-2-1 (1990): Basic environmental testing procedures. Part 2: Tests, Test Ad: Cold, for heat dissipating equipment under test (EUT), with gradual change of temperature.

IEC Publication 68-2-2 (1974): Basic environmental testing procedures, Part 2: Tests, Test Bd: Dry heat, for heat dissipating equipment under test (EUT) with gradual change of temperature.

IEC Publication 68-3-1 (1974): Background information, Section 1: Cold and dry heat tests.

[2] IEC Publication 68-2-56 (1988): Environmental testing, Part 2: Tests, Test Cb: Damp heat, steady state. Primarily for equipment.

IEC Publication 68-2-28 (1980): Guidance for damp heat tests.

[3] IEC Publication 1000-4-2(1995): Electromagnetic Compatibility (EMC), Part 4: Testing and measurement techniques - Section 2: Electrostatic discharge immunity test. Basic EMC Publication.

[4] IEC Publication 1000-4-3(1995): Electromagnetic Compatibility (EMC), Part 4: Testing and measurement techniques - Section 3: Radiated, radio-frequency, electromagnetic field immunity test.

[5] IEC Publication 1000-4-4(1995): Electromagnetic Compatibility (EMC), Part 4: Testing and measurement techniques - Section 4: Electrical fast transient/burst immunity test. Basic EMC publication.

[6] IEC Publication 1000-4-11(1994): Electromagnetic compatibility (EMC), Part 4: Testing and measurement techniques - Section 11: Voltage dips, short interruptions and voltage variations immunity tests. Section 5.2 (Test levels - Voltage variation). Section 8.2.2 (Execution of the test-voltage variation).

[7] IEC Publication 1000-4-11(1994): Electromagnetic compatibility (EMC), Part 4: Testing and measurement techniques - Section 11: Voltage dips, short interruptions and voltage variations immunity tests. Section 5.1 (Test levels - Voltage dips and short interruptions). Section 8.2.1 (Execution of the test-voltage dips and short interruptions).

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