ORGANISATION INTERNATIONALE

DE MÉTROLOGIE LÉGALE

INTERNATIONAL RECOMMENDATION

Automatic gravimetric filling instruments
Part 1: Metrological and technical requirements - Tests

Doseuses pondérales à fonctionnement automatique
Partie 1: Exigences métrologiques et techniques - Essais

OIML R 61-1

Edition 1996 (E)

CONTENTS

FOREWORD

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This publication - reference OIML R 61-1, edition 1996 (E) - was developed by the OIML subcommittee TC 9/SC 2 *Automatic Weighing Instruments*. It was approved for final publication by the International Committee of Legal Metrology in 1995 and will be submitted to the International Conference of Legal Metrology in 1996 for formal sanction. It supersedes the previous edition dated 1985.

TERMINOLOGY

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 load by using the action of gravity on that load.

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

T.1.2 Automatic weighing instrument

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

T.1.3 Automatic gravimetric filling instrument

Instrument which fills containers with predetermined and virtually constant mass of product from bulk by automatic weighing, and which comprises essentially an automatic feeding device or devices associated with one or more weighing units and the appropriate control and discharge devices.

T.1.3.1 Associative (selective combination) weigher

Automatic gravimetric filling instrument comprising one or more weighing units and which computes an appropriate combination of the loads and combines them for subsequent discharge as a fill.

T.1.3.2 Cumulative weigher

Automatic gravimetric filling instrument with one weighing unit with the facility to effect the fill by more than one weighing cycle.

T.1.3.3 Subtractive weigher

Automatic gravimetric filling instrument for which the fill is determined by controlling the output feed from the weigh hopper.

T.1.4 Fill

One or more loads discharged into a single container to make up the predetermined mass.

T.1.5 Electronic instrument

An instrument equipped with electronic devices.

T.1.6 Control instrument

A weighing instrument used to determine the mass of the test fills delivered by the filling instrument.

T.2 Construction

Note: In this Recommendation the term “device” is applied to any part which uses any means to perform one or more specific functions.

T.2.1 Principal parts

T.2.1.1 Weighing unit

Device which provides information on the mass of the load to be measured. This device may consist of all or part of a non-automatic weighing instrument.

T.2.1.2 Load receptor

Part of the instrument intended to receive the load.

T.2.1.3 Feeding device

Device which provides a supply of product from bulk to the weighing unit. It may operate in one or more stages.

T.2.1.4 Control devices

T.2.1.4.1 Feed control device

Device which regulates the rate of feed of the feeding device.

T.2.1.4.2 Fill setting device

Device which allows the setting of the preset value.

T.2.1.4.3 Final feed cut-off device

Device which controls the cut-off of the final feed so that the average mass of the fills corresponds to the preset value. This device may include an adjustable compensation for the material in flight.

T.2.1.4.4 Correction device

Device which automatically corrects the setting of the filling instrument.

T.2.2 Electronic parts

T.2.2.1 Electronic device

A device comprising electronic sub-assemblies and performing a specific function. Electronic devices are usually manufactured as separate units and are capable of being independently tested.

T.2.2.2 Electronic sub-assembly

A part of an electronic device, employing electronic components and having a recognisable function of its own.

T.2.2.3 Electronic component

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

T.2.3 Indicating device

The part of a measuring instrument that displays an indication.

Notes:

(1) For a weighing instrument, the indicating device is the set of components which display the value, in units of mass, of the result of a weighing operation.

(2) For filling instruments, the indicating device may indicate either the mass of the load or the difference between this mass and the preset value provided the intention is made clear.

T.2.4 Ancillary devices

T.2.4.1 Zero-setting device

Device for setting the indicating device to zero when the load receptor is empty.

T.2.4.1.1 Non-automatic zero-setting device

Device for setting the indicating device to zero by an operator.

T.2.4.1.2 Semi-automatic zero-setting device

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

T.2.4.1.3 Automatic zero-setting device

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

T.2.4.2 Tare device

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

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

T.3 Metrological characteristics

T.3.1 Scale interval (d)

Value, expressed in units of mass, of the difference between:

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

T.3.2 Reference particle mass of a product

Mass equal to the mean of ten of the largest elementary particles or pieces of the product taken from one or more loads.

T.3.3 Preset value

Value, expressed in units of mass, preset by the operator by means of the fill setting device, in order to define the nominal value of the fills.

T.3.4 Static set point

Value of the test weights or masses which, in static tests, balance the value selected on the indication of the fill setting device.

T.3.5 Weighing cycle

The sequence of operations which include:

- delivery of material to the load receptor,
- a weighing operation, and
- the discharge of a single discrete load.

T.3.6 Final feed time

Time taken to complete the last stage of delivery of the product to a load receptor.

T.3.7 Minimum capacity (Min)

The smallest discrete load that can be weighed automatically on a load receptor.

T.3.8 Maximum capacity (Max)

The largest discrete load that can be weighed automatically on a load receptor.

T.3.9 Warm-up time

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

T.3.10 Average number of loads per fill

Half the sum of the maximum and minimum number of loads per fill that can be set by the operator or, in cases where the number of loads per fill is not directly determined by the operator, either the mean of the actual number of loads per fill (if known) in a period of normal operation, or the optimum number of loads per fill as may be specified by the manufacturer for the type of product which is to be weighed.

T.3.11 Rated minimum fill

The rated value of the fill below which the weighing results may be subject to errors outside the limits specified in this Recommendation.

T.3.12 Minimum discharge

The smallest load that can be discharged from a subtractive weigher.

T.4 Indications and errors

T.4.1 Methods of indication

T.4.1.1 Analogue indication

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

T.4.1.2 Digital indication

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

T.4.2 Errors

T.4.2.1 Error of indication

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

T.4.2.2 Intrinsic error

The error of an instrument under reference conditions.

T.4.2.3 Initial intrinsic error

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

T.4.2.4 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.4.2.5 Significant fault

A fault greater than 0.25 of the maximum permissible deviation of each fill (as specified in 2.2), for in-service verification, for a fill equal to the rated minimum fill.

The following are not considered to be significant faults, even when they exceed the value defined above:

- faults arising from simultaneous and mutually independent causes in the instrument,
- faults implying the impossibility to perform any stage of operation,
- faults being so serious that they are bound to be noticed by an operator,
- transitory faults being momentary variations in the indication or operation which cannot affect the final result of the automatic cycle.

Note: For instruments where the fill may be greater than one load, the value of the significant fault applicable for a test on one static load shall be calculated in accordance with the test procedures

T.4.2.6 Span stability

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

T.4.3 Reference value for accuracy class

The value for accuracy class determined by static testing of the weighing unit during influence quantity testing at pattern approval stage. The reference value for accuracy class is equal to the best accuracy class for which the instrument may be verified for operational use.

T.5 Influences and reference conditions

T.5.1 Influence quantity

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

T.5.1.1 Influence factor

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

T.5.1.2 Disturbance

An influence quantity having a value within the limits specified in this 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 permissible deviations specified in this Recommendation.

T.5.3 Reference conditions

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

T.6 Tests

T.6.1 Material test

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

T.6.2 Simulation test

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

T.6.3 Performance test

A test to verify 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 characteristics over a period of use.

AUTOMATIC GRAVIMETRIC FILLING INSTRUMENTS

1 General

1.1 Scope

This International Recommendation specifies the metrological and technical requirements for automatic gravimetric filling instruments, hereafter called “filling instruments”, which sub-divide a bulk product into fills of predetermined and virtually constant mass by automatic weighing, the fills being kept separate.

Notes: (1) This Recommendation places no constraint on the maximum or minimum capacities of the instruments for which this Recommendation is applicable. OIML International Recommendation R 87 *Net content in packages* applies to fills less than or equal to 25 kg.

(2) Filling instruments may also be required to comply with certain requirements of other OIML Recommendations, e.g. an instrument which could operate as a nonautomatic instrument will need to comply with OIML R 76.

1.2 Terminology

The terminology given in pages 4 to 10 shall be considered as a part of this Recommendation.

2 Metrological requirements

2.1 Accuracy classes

The accuracy class and reference value for accuracy class shall be specified in accordance with 2.2 and marked on the instrument in accordance with 3.10.

Accuracy classes shall be specified for intended usage, i.e. nature of the product to be weighed, type of installation, value of the fill, and operating rate.

Note: The limitation of accuracy classes to certain applications may be determined by national prescription.

2.2 Limits of error

2.2.1 Maximum permissible error for static tests

The instrument shall have a reference value for accuracy class, Ref(x), applicable for static testing only, for which the maximum permissible error for influence factor tests shall be as specified in 2.4, multiplied by the class designation factor (x).

2.2.2 Maximum permissible deviation of each fill

The instrument shall have a specified accuracy class X(x) for which the maximum permissible deviation of each fill from the average shall be equal to the limits specified in Table 1, multiplied by the class designation factor (x).

(x) shall be 1×10^k, 2×10^k, 5×10^k, k being a positive or negative whole number or zero.

Table 1

Value of the mass of the fills M (g)	Maximum permissible deviation of each fill from the average for class X(1)	
	Initial verification	In-service
M ≤ 50	6.3 %	9 %
50 < M ≤ 100	3.15 g	4,5 g
100 < M ≤ 200	3.15 %	4,5 %
200 < M ≤ 300	6.3 g	9 g
300 < M ≤ 500	2.1 %	3 %
500 < M ≤ 1 000	10.5 g	15 g
1 000 < M ≤ 10 000	1.05 %	1,5 %
10 000 < M ≤ 15 000	105 g	150 g
15 000 < M	0.7 %	1 %

(See 6.3 for the number of fills required to find the average value).

For in-service testing, when the reference particle mass exceeds 0.1 of the maximum permissible in-service deviation, the values derived from Table 1 shall be increased by 1.5 times the value of the reference particle mass. However, the maximum value of the maximum permissible deviation shall not exceed (x) × 9 %.

Note: Particle mass correction is not applicable to limits which are derived from Table 1, e.g. influence quantity tests, zero setting etc.

2.3 Maximum permissible preset value error (setting error)

For instruments where it is possible to preset a fill weight the maximum difference between the preset value and the average mass of the fills shall not exceed 0.25 of the maximum permissible deviation of each fill from the average, as specified for in-service verification in 2.2.2. This limit will apply for initial verification and for in-service testing.

2.4 Maximum permissible error for influence factor tests

The maximum permissible error for any static test load during influence factor tests shall be 0.25 of the maximum permissible deviation (as specified in 2.2.2) for in-service verification, corresponding to the value of a fill equal to that load.

Note: For instruments where the fill may not be equal to one load, the maximum permissible error applicable for a test on one static load shall be calculated in accordance with the test procedures (see Annex A.6).

2.5 Influence factors

Refer to Annex A for test conditions.

2.5.1 Static temperatures

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.

2.5.2 Power supply (AC)

Instruments which 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 reference voltage (defined in IEC 1000-4-11 section 5).

2.5.3 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.

2.6 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).

3 Technical requirements

3.1 Suitability for use

A filling instrument shall be designed to suit the method of operation and the products for which it is intended. It shall be of adequately robust construction so that it maintains its metrological characteristics.

3.2 Security of operation

3.2.1 Accidental maladjustment

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 Use of a printer

Any print-out is for information purposes only and not for use in a commercial transaction, except preset values and number of weighings.

3.2.3 Ancillary devices

Any ancillary device provided for use with a filling instrument shall not affect the correct functioning of the instrument.

3.2.4 Scale interval (d)

Scale intervals of all indicating devices associated with a weighing unit shall be the same.

3.3 Fill setting device

If fill setting is by means of a scale, it shall be graduated in units of mass.

If fill setting is by means of weights, they shall be either weights in accordance with OIML requirements or purpose-designed of any nominal value, distinguishable by shape and identified with the filling instrument.

3.4 Final feed cut-off device

The final feed cut-off device shall be clearly differentiated from any other device.

The direction of movement corresponding to the sense of the desired result shall be shown, where applicable.

3.5 Feeding device

The feeding device shall be designed to provide sufficient and regular flowrate(s).

An adjustable feeding device shall be fitted with an indication of the direction of movement corresponding to the sense of the adjustment of the feed where applicable.

3.6 Load receptor

The load receptor, and feed and discharge devices as appropriate, shall be designed to ensure that residual material retained after each discharge is negligible.

Instruments using the subtractive weighing principle shall be designed to ensure that residual material retained at feed from the discharge gate is negligible.

The load receptor shall provide access and facilities so that where necessary test weights or masses up to the maximum capacity can be placed in position, in a safe and secure manner. If these facilities are not a permanent fixture of the instrument, they must be kept in the vicinity of the instrument.

Manual discharge of the load receptor shall not be possible during automatic operation.

3.7 Zero-setting and tare devices

The filling instrument shall be provided with a zero-setting device, which may also be used for the setting of tare. The device may be:

- manual, or
- semi-automatic, or
- automatic.

Zero-setting and tare devices shall be capable of setting to less than or equal to 0.25 of the maximum permissible deviation for in-service verification for a fill equal to the minimum capacity for instruments with one weighing unit, and for a fill equal to the rated minimum fill for selective combination weighers.

Non-automatic or semi-automatic zero-setting and tare devices must be locked during automatic operation.

The weighing unit shall be in stable equilibrium when the zero-setting and tare devices are being set.

3.8 Equilibrium mechanism

The equilibrium mechanism may be provided with detachable masses which shall be either weights in accordance with OIML requirements or purpose designed masses of any nominal value, distinguishable by shape and identified with the filling instrument.

3.9 Security

A security means shall be provided for components and pre-set controls to which access is prohibited. National legislation may specify the sealing that is required.

3.10 Descriptive markings

Filling instruments shall bear the following markings.

3.10.1 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
- product(s) designation (i.e. materials that may be weighed)
- temperature range (if applicable, see 2.5.1) in the form: ....°C / ....°C
- electrical supply voltage in the form: V
- electrical supply frequency in the form: .... Hz
- working fluid pressure (if applicable) in the form: .... kPa
- average number of loads/fill (if applicable) ....
- maximum fill (if applicable) ....
- rated minimum fill ....
- maximum rate of operation (if applicable) in the form: .... loads per minute

3.10.2 Markings shown in code

- pattern approval sign
- indication of the accuracy class X(x)

- reference value for accuracy class Ref(x)
- scale interval (if applicable) in the form: d = ...
- maximum capacity in the form: Max = ...
- minimum capacity (or minimum discharge where applicable) in the form: Min = ...
- maximum additive tare in the form: T = + ...
- maximum subtractive tare in the form: T = − ....

An instrument may be verified for different materials for which different classes apply or which require different operating parameters to maintain limits of error. Marking shall be such that the alternative class or operating parameters are clearly associated with the appropriate material designation.

In the case of subtractive weighers the minimum load to be discharged shall be specified.

3.10.3 Presentation of descriptive markings

The descriptive markings shall be indelible and of a size, shape and clarity to enable legibility under normal conditions of use of the filling instrument. They shall be grouped together in a clearly visible place on the filling instrument, either on a data plate fixed to the instrument or on the filling instrument itself.

Where the markings are placed on a data plate, it shall be possible to seal the plate bearing the markings. Where they are marked on the filling instrument itself, it shall not be possible to remove them without destroying them.

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 on 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.

3.11 Verification marks

3.11.1 Position

The filling instrument 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 filling instrument without damaging the marks,
- allow easy application of the mark without changing the metrological qualities of the filling instrument,
- be visible without the filling instrument having to be moved when it is in service.

3.11.2 Mounting

Filling 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, this support may consist of a strip of lead or any other material with similar qualities, inserted into a plate fixed to the filling instrument or a cavity bored in the filling instrument itself.

When the marks consist of an adhesive transfer, a space shall be prepared for this purpose.

3.12 Control instrument

The control instrument may be separate from or an integral part of the filling instrument.

4 Requirements for electronic instruments

Electronic filling 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 operating conditions

Electronic 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 electronic instrument shall comply with the requirements of 2.5 and shall also comply with appropriate metrological and technical requirements at a relative humidity of 85 % at the upper limit of the temperature range of the instrument.

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) shall not exceed the value specified in T.4.2.5, or

(b) significant faults are detected and acted upon.

Note: A fault equal to or less than the value in T.4.2.5 is allowed irrespective of the value of the error of indication.

4.1.4 Evaluation for compliance

The 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 automatically made inoperative 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 which allows it to be coupled 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 instrument is intended to verify compliance with the applicable requirements of this Recommendation and especially with the requirements of clause 4.

4.3.1 Examinations

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

4.3.2 Performance tests

An electronic 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 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

When an electronic instrument is subjected to the span stability test specified in A.7, 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.

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 verification.

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 *Pattern evaluation and pattern approval* and D 20 *Initial and subsequent verification of measuring instruments and processes* respectively.

5.1.1 Provision of means of testing

For the purposes of testing, the metrological authority may require from the applicant the product (i.e. the material to be weighed), the handling equipment, the appropriately qualified personnel and a control instrument.

5.1.2 Material tests

5.1.2.1 For pattern evaluation

The material used as the test load for pattern evaluation shall be representative of a product for which the instrument is designed. The test shall be conducted in accordance with the test procedure in A.8.1.

5.1.2.2 For initial verification and in-service verification

The in-situ material tests shall be done in accordance with the descriptive markings, under the normal conditions for which the instrument is intended. The test shall be conducted in accordance with the test procedure in A.8.2.

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, including interlocks,
- 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 normally not more than three) units that represent the definitive pattern. One or more of the units shall be complete and fully operational for the purposes of 5.2.3.1. One or more of the units shall be submitted in a form suitable for simulation testing in a laboratory and shall include the whole of the electronics which affect the weighing result except in the case of an associative weigher where only one representative weighing unit may be included.

The instrument or simulated instrument shall have a load indicator, or an interface allowing access to a quantity that can be calibrated to provide an indication of load, so that the requirements of 2.2.1 (maximum permissible errors for static tests) may be tested and so that the instrument may be tested for influence quantities. The scale interval of the load indicator shall not exceed 0.125 of the maximum permissible deviation for in-service verification for a fill equal to the minimum capacity.

The evaluation shall consist of the tests specified in 5.1.2.1 and 5.2.3.

5.2.3 Pattern evaluation

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

- the requirements specified for static tests in clause 2,
- 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 which prevents an unnecessary commitment of resources.

Note: The appropriate metrological authority is advised to accept, with the consent of the applicant, equivalent test data obtained from other metrological authorities.

5.2.3.1 Tests for compliance with technical requirements

Operational tests with material shall be done in accordance with the procedure in A.8.1 on a complete instrument to assess compliance with the technical requirements of clause 3.

5.2.3.2 Influence factor tests

Influence factors shall be applied during simulation tests in a manner that will reveal a corruption of the weighing result of any weighing process to which the instrument could be applied, in accordance with:

- subclause 2.5 for all instruments,
- clause 4 for electronic instruments.

5.2.3.3 Apportioning of errors

Where parts of an instrument are examined separately in the process of pattern approval, 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:

$$(P_1^2 + P_2^2 + P_3^2 + \dots) \leq 1$$

The fraction P_i shall be chosen by the manufacturer of the part 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 or other major component has been evaluated in accordance with the requirements of any OIML International Recommendation (e.g. OIML R 60 for load cells), that evaluation shall be used to aid in the 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 maximum permissible error or maximum allowable variation has been exceeded will be decided mutually between the metrological authority and the applicant. The means may be for example:

- the provision or adaptation of the indicating device to give the required resolution,
- the use of change point weights, or
- any other means mutually agreed.

5.2.4 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.

5.2.5 Certificate of approval and determination of classes (2.2.1 and A.5)

The pattern approval certificate shall state the reference value for the accuracy class as determined by the static tests in A.5, and shall state that the actual class (equal to or greater than the reference value) shall be determined by compliance with the metrological requirements at initial verification.

5.3 Initial verification

5.3.1 General requirements

Instruments shall be examined for conformity with the approved pattern where applicable and shall be tested for compliance with clause 2 (excluding 2.2.1 and 2.5) for the intended products and corresponding accuracy classes under normal conditions of use.

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.

5.3.2 Material tests

Material tests shall be carried out in compliance with 5.1.2 using the test methods in 6.

5.3.3 Conduct of the tests

The appropriate metrological authority:

- shall conduct the tests in a manner which 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 to assess for initial verification.

5.3.4 Determination of accuracy class

The appropriate metrological authority shall:

- determine the accuracy class for the materials used in the tests in accordance with 5.2.5 by reference to the material test results and the limits of error specified in 2.2.2 and 2.3 for initial verification,
- verify that accuracy classes marked in accordance with 3.10 are equal to or greater than the accuracy classes determined as above.

5.4 In-service verification

In-service verification shall be as specified in 5.3.1 and 5.3.2. The maximum permissible errors shall be as specified in 2.2.2 for in-service verification.

The appropriate metrological authority shall conduct the tests in a manner which prevents an unnecessary commitment of resources.

6 Test methods

6.1 Determination of the mass of individual fills

The mass of individual fills is determined using one of the methods in 6.5.1 or 6.5.2.

6.2 Conduct of material tests

(a) The tests shall be carried out on fills using loads at, or near to, the maximum capacity and also at, or near to, the minimum capacity. Material tests should only be carried out with the products the instrument is intended to be used for.

(b) Cumulative weighers shall be tested as above with the maximum practical number of loads per fill and also with the minimum number of loads per fill, and associative weighers as above with the average (or optimum) number of loads per fill.

(c) If the minimum capacity is less than one third of the maximum capacity then tests shall also be carried out near the centre of the load weighing range preferably at a value close to, but not above, 100 g, 300 g, 1 000 g or 15 000 g, as appropriate.

(d) All tests shall be conducted with any adjustable parameter critical to metrological integrity, e.g. final feed time or rate, set to the most onerous condition allowed by the manufacturer's printed instructions and incorporated in the descriptive markings.

6.2.1 Testing the effect of a correction device

6.2.1.1 Any correction device, e.g. in-flight correction and/or automatic zero-setting fitted to an instrument shall be operated during the tests according to the manufacturer's printed instructions.

6.2.1.2 If the correction device is not activated during each filling operation, then tests at minimum capacity shall be arranged to include the effect of one or more regular operations of the correction device, e.g. by including in the test at least three fills immediately before and after the activation of the device.

6.2.1.3 The initial fills after the change between maximum capacity and minimum capacity shall be included in the test unless the instrument bears a clear warning to discard the stated number of fills after a change to the instrument settings.

6.3 Number of fills

The number of individual test fills depends upon the preset value (m) as specified in Table 2.

Table 2

$m \leq 10$ kg	60 fills
10 kg $< m \leq 25$ kg	32 fills
25 kg $< m \leq 100$ kg	20 fills
100 kg $< m$	10 fills

6.4 Accuracy of standards

The control instrument and standard weights used in testing shall ensure the checking of the test fills to an error not greater than either:

(a) one third of the maximum permissible deviation and maximum permissible preset value error (as appropriate) for automatic weighing (subclauses 2.2 and 2.3 respectively) if the control instrument or the device used for control purposes is verified immediately prior to the material test, or,

(b) one fifth of the maximum permissible deviation and maximum permissible preset value error (as appropriate) for automatic weighing (subclauses 2.2 and 2.3 respectively) in all other cases.

6.5 Material test methods

6.5.1 Separate verification method

The separate verification method requires the use of a (separate) control instrument to find the conventional true value of the mass of the test fill.

6.5.2 Integral verification method

With this method the instrument being tested is used to determine the conventional true value of the mass of the test fill. The integral verification method shall be conducted using either:

(a) an appropriately designed indicating device, or
(b) an indicating device with standard weights to assess the rounding error.

The total uncertainty of the test method (separate or integral verification) shall be not greater than one third of the maximum permissible error for the instrument.

Notes: (1) The integral verification method depends on determining the masses of the loads. Limits of error as specified in 2.2 are for the mass of the fill. If it is not possible to ensure that in normal operation all of the load is discharged at each cycle of operation, i.e. that the sum of the loads is equal to the fill, then the separate verification method (6.5.1) must be used.

(2) When using the integral verification method for a cumulative weighing instrument a sub-division of the test fill is unavoidable. When calculating the conventional true value of the mass of the test fill, it is necessary to consider the increased uncertainty due to the division of the test fill.

6.5.2.1 Interruption of automatic operation

An automatic filling operation of a test fill shall be initiated as for normal operation. However the automatic operation shall be interrupted twice during each filling cycle, i.e. after the load is assembled and after the load is discharged.

An automatic operation shall not be interrupted during consecutive weighing cycles if the speed of operation is so high that the interruption would significantly affect the mass of the fill.

(a) Pre-discharge (full) interrupt

The automatic operation shall be interrupted after the load receptor(s) has (have) been loaded and the feed of material has ceased. When the load receptor(s) has (have) stabilized, the net weight of the fill indicated or determined by balancing with standard weights shall be recorded and the instrument switched back to automatic operation.

(b) Post-discharge (empty) interrupt

The automatic operation shall be interrupted after the load(s) has (have) been discharged and the load receptor(s) is (are) ready to receive a further load. When the load receptor(s) has (have) stabilized, the empty load receptor weight indicated or determined by balancing with standard weights shall be recorded and the instrument switched back to automatic operation.

6.6 Preset value

The indicated preset value of the fill shall be noted where applicable.

6.7 Mass and average value of the test fill

The test fill shall be weighed on a control instrument and the result shall be considered as being the conventional true value of the test fill. The average value of all the fills in the test shall be calculated and noted.

6.8 Deviation for automatic weighing

The deviation for automatic weighing used to determine compliance of each fill with the maximum permissible deviation for automatic weighing (2.2) shall be the difference between the conventional true value of the mass of the test fill (as defined in 6.7) and the average value of all the fills in the test.

6.9 Preset value error for automatic weighing

The preset value error for automatic weighing used to determine compliance with 2.3 shall be the difference between the average value of the conventional true value of the mass of the test fills (as defined in 6.7) and the preset value for the fills.

ANNEX A

TESTING PROCEDURES FOR AUTOMATIC GRAVIMETRIC FILLING 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 d – ΔL = Indication prior to rounding (digital indication)
E	=	I – L or P – L = Error
mpd	=	Maximum permissible deviation of each fill from the average
EUT	=	Equipment under test
se	=	Setting error
mpse	=	Maximum permissible setting error
md	=	Maximum deviation of each fill from the average

A.1 Examination for pattern approval

A.1.1 Administrative examination (5.2)

Review the documentation that is submitted to determine if it is adequate and correct. For pattern approval the documentation shall include:

- 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, including interlocks.

Consider any document or other evidence that the design and construction of the instrument complies with the requirements of this Recommendation.

A.1.2 Compare construction with documentation (4.3 and 5.2)

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

A.1.3 Technical requirements (3)

Examine the instrument for conformity with technical requirements according to the checklist given in the test report format (see OIML R 61-2).

A.1.4 Functional requirements (4.2 and 4.3)

Examine the instrument for conformity with functional requirements according to the checklist given in the test report format.

A.2 Examination for initial verification

A.2.1 Compare construction with documentation (5.3.1)

Examine the instrument for conformity with the approved pattern.

A.2.2 Descriptive markings (3.10)

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

A.3 General test requirements

A.3.1 Power supply

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

A.3.2 Zero-setting

Using the manual or semi-automatic zero-setting facility, adjust the EUT as closely as practicable to zero prior to each test, and do not readjust 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.3.3 Temperature

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

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

A.3.4 Control instruments

A.3.4.1 Accuracy of test system (6.4)

The control instrument and standard weights used in testing shall ensure the determination of the weight of test loads and fills to an error not greater than either:

(a) one third of the maximum permissible error of the instrument i.e., in the case of material tests, one third of the maximum permissible deviation and maximum permissible preset value error (as appropriate) for automatic weighing, if the control instrument or the device used for control purposes is verified immediately prior to the material test, or

(b) one fifth of the maximum permissible error of the instrument i.e., in the case of material tests, one fifth of the maximum permissible deviation and maximum permissible preset value error (as appropriate) for automatic weighing, in all other cases.

Note: Accuracy requirements for the test system depend on the limits of error which depend on the accuracy class. However the class is determined from the results of the tests. It is therefore necessary that the metrological authority responsible for testing should be informed of the best accuracy class that may be achieved, prior to commencement of testing.

A.3.4.2 Use of standard weights to assess rounding error

A.3.4.2.1 General method to assess error prior to rounding

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

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

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

The error prior to rounding is:

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

Example: An instrument with a scale interval, d, 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 prior to rounding is:

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

A.3.4.2.2 Correction for error at zero

Evaluate the error at zero load, (E_0) by the method of A.3.4.2.1.

Evaluate the error at load L, (E) by the method of A.3.4.2.1

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

$$E_c = E - E_0$$

Example: if, for the example in A.3.4.2.1, 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.4 Test program

A.4.1 Pattern evaluation (5.2.3)

A.4.1.1 Clauses A.1, A.5, A.6, A.7 and subclause A.8.1 shall normally be applied for pattern evaluation.

A.4.1.2 For instruments in which the weighing function is provided by a nonautomatic weighing instrument that has been approved in respect of conformity with OIML R 76, the tests specified in A.4.1.1 may be omitted where equivalent test results specified in R 76 prove conformity with the relevant parts of this Recommendation. Use of OIML R 76 test results shall be recorded in the test report checklist and summary.

A.4.2 Initial verification (5.3)

Clause A.2 and subclause A.8.2 shall be applied for initial verification tests.

Static weighing test method (A.5.4) may also be used if necessary to verify the indicator for the integral verification method of material tests.

A.5 Static tests (pattern approval stage)

A.5.1 General (5.2.2)

Electronic instruments or instrument simulators are required to have a load indicator, or an interface allowing access to a quantity that can be calibrated to provide an indication of load so that the effect of influence quantities may be tested and the reference accuracy class determined. This facility also enables testing of warm-up time and zero- and tare-setting where applicable. The static weighing tests are normally done as part of influence quantity testing.

Limits for warm-up time tests and for accuracy of zero- and tare-setting tests are derived from 2.2, and are therefore dependent on the reference accuracy class. Therefore the results of these tests must be evaluated after the reference accuracy class has been determined.

A.5.2 Warm-up time (4.2.3)

This test is to verify that in the period immediately after switch-on, operation is inhibited until the warm-up time is finished, i.e. until the metrological performance can be maintained. 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 specified 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 power 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) 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.3.4.2.1.

(6) Apply a static load close to Max. Determine the error by the method of A.3.4.2.1 and A.3.4.2.2.

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

(8) From (5) verify that the zero-setting error is not greater than the limit specified in 3.7.

(9) From (6) and (7) verify that:

- the error (corrected for zero error) for a static load close to Max is not greater than the limit specified in 2.4,
- after each time interval the error at zero is not greater than twice the limit specified in 3.7.

Note: Zero-setting accuracy is specified as 0.25 mpd so the additional allowance of 0.25 mpd is added for variation of zero after the initial zero-setting. This is consistent with 2.4 (mpe for a static test load) and A.6.2.2 (temperature effect on no load indication).

A.5.3 Zero- and tare-setting (3.7)

A.5.3.1 General

Unless it is clear that zero and tare functions are performed by the same process then both functions shall be tested separately.

Zero- and tare-setting may be by more than one mode, for example :

- nonautomatic or semi-automatic,
- automatic at switch-on,
- automatic at start of automatic operation,
- automatic as part of weighing cycle.

It is normally only necessary to test the accuracy of zero- and tare-setting in one mode if it is clear that the same process is used for each mode. If zero or tare is set as part of the automatic weighing cycle then this mode shall be tested. To test automatic zero- or tare-setting it is necessary to allow the instrument to operate through the appropriate part of the automatic cycle and then to halt the instrument before testing.

A.5.3.2 Accuracy of zero-setting (3.7)

(1) Set the instrument to zero in a mode as determined by A.5.3.1.

(2) Add weights to the load receptor to determine the additional load at which the indication changes from zero to one scale interval above zero.

(3) Calculate the error at zero according to the description in A.3.4.2.1.

A.5.3.3 Accuracy of tare-setting (3.7)

Accuracy of tare shall be tested at the maximum tare as specified by the manufacturer.

(1) Place the tare load on the load receptor and allow the tare function to operate in a mode as determined by A.5.3.1 and in accordance with the manufacturers' instructions.

(2) Add weights to the load receptor to determine the additional load at which the indication changes from zero to one scale interval above zero.

(3) Calculate the error according to the description in A.3.4.2.1.

A.5.4 Static weighing test method (5.2.3)

Apply test loads from zero up to and including Max, and similarly remove the test loads back to zero. The test loads selected shall include values close to Max and Min and other critical loads as specified in 6.2(a), subject to requirements of this Annex.

Determine the error at each test load, using the procedure of A.3.4.2, if necessary, to obtain the accuracy requirements of A.3.4.1.

It should be noted that when loading or unloading weights, the load shall be progressively increased or progressively decreased.

A.5.5 Determination of reference accuracy class (5.2.5)

The static weighing tests during application of influence factors (as appropriate) shall be used at pattern approval stage to establish the reference value for accuracy class, i.e. Ref(x), as follows:

(1) Perform static weighing tests for influence factors and loads as specified in this Annex.

(2) For each load determine the maximum permissible error for influence factor tests for class X(1), $mpe_{(1)}$.

(Refer to 2.4 and to this Annex where appropriate).

(3) Calculate [Error / $mpe_{(1)}$] for each load.

(4) From (3) determine the maximum value of [Error / $mpe_{(1)}$] for all the influence factor tests, $[Error / mpe_{(1)}]_{max}$

(5) Determine Ref(x) from $[Error / mpe_{(1)}]_{max}$ such that:

$$Ref(x) \geq [Error / mpe_{(1)}]_{max} \quad \text{and}$$

$$Ref(x) = 1 \times 10^k, 2 \times 10^k, \text{or } 5 \times 10^k,$$

the index k being a positive or negative whole number or zero. Values for significant fault shall then be calculated from the mpd for the reference class.

A.6 Influence factor and disturbance tests

A.6.1 Test conditions

A.6.1.1 General requirements

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

It is generally not possible to apply the influence factors or disturbances to an instrument which is processing material automatically. The instrument shall therefore be subjected to the influence factors or disturbances under static conditions or simulated operation as defined herein. The permissible effects of the influence factors or disturbances, under these conditions, are specified for each case.

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

Where parts of the instrument are examined separately, errors shall be apportioned in accordance with 5.2.3.3.

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

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

A.6.1.2 Simulator requirements

A.6.1.2.1 General

The simulator for influence factor and disturbance tests should include all electronic elements of the weighing system.

A.6.1.2.2 Load cell

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

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

A.6.1.2.3 Interfaces

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

A.6.1.2.4 Documentation

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

A.6.1.3 Test limits for multi-load instruments

For instruments where the fill may consist of more than one load, the value of a significant fault and the limit of error for influence factor tests must be determined by the metrological authority after considering the design of the instrument and the method of test, such that the effect on the fill is equivalent to the values specified in T.4.2.5 and 2.4.

A.6.1.3.1 Significant fault for multi-load instruments

The following examples show how to determine the value of a significant fault on selective combination weighers and cumulative weighers when testing.

- Significant fault for selective combination weighers:

A fault greater than 0.25 of the maximum permissible deviation of each fill (as specified in Table 1) for in-service verification divided by the square root of the average (or optimum) number of loads in a fill, for a fill equal to the minimum capacity multiplied by the average (or optimum) number of loads in a fill.

Example: For a class X(1) instrument with Min = 200 g designed for an average of 8 loads per fill, fill = 1 600 g, the maximum permissible deviation of each fill from the average fill (as specified in Table 1) for in-service verification is 1.5 % = 24 g. Hence the value of significant fault is:

$$0.25 \times (24 / \sqrt{8}) = 2.12 \text{ g}$$

- Significant fault for cumulative weighers:

A fault greater than 0.25 of the maximum permissible deviation of each fill (as specified in Table 1) for in-service verification, for a fill equal to the rated minimum fill, divided by the square root of the minimum number of loads per fill.

Example: For a class X(1) instrument with Max = 1 200 g and rated minimum fill of 8 kg: 8 kg/1.2 kg = 6.67; therefore the minimum number of loads per fill is 7. The maximum permissible deviation (as specified in Table 1) for the minimum fill of 8 kg is 1.5 % or 120 g. Hence the value of significant fault is:

$$0.25 \times (120 / \sqrt{7}) = 11.34 \text{ g}$$

Note: This definition of significant fault for cumulative weighers does not include Min. A cumulative weigher would normally be used at or near to Max.

A.6.1.3.2 Limits of error for influence factor tests

The following examples show how to determine the limit of error for influence factor testing for selective combination weighers and cumulative weighers when testing.

- For selective combination weighers the maximum permissible error for any static test load during influence factor tests shall be 0.25 of the maximum permissible deviation for in-service verification for the appropriate mass of the fill divided by the square root of the average (or optimum) number of loads per fill.

Example: Class X(1) selective combination weigher, where the average number of loads per fill = 4. For a static test load = 100 g the appropriate mass of the fill will be 400 g for which the maximum permissible deviation for in-service verification is 3 %, i.e. 12 g. Hence the maximum permissible error for influence factor tests is:

$$0.25 \times (12 \text{ g} / \sqrt{4}) = 1.5 \text{ g}$$

- For cumulative weighers the maximum permissible error for any static test load during influence factor tests shall be 0.25 of the maximum permissible deviation for in-service verification for the rated minimum fill divided by the square root of the minimum number of loads per fill.

Example: For a class X(1) instrument with Max = 1 200 g and rated minimum fill of 8 kg: 8 kg/1.2 kg = 6.67; therefore the minimum number of loads per fill = 7. The maximum permissible deviation (as specified in Table 1) for the minimum fill of 8 kg is 1.5 %, i.e. 120 g. Hence the maximum permissible error for influence factor tests is:

$$0.25 \times (120 / \sqrt{7}) = 11.35 \text{ g}$$

Note: For cumulative weighers the average number of loads per fill is not known. Therefore it is not possible to define the limit of error for influence factors in terms of average loads per fill and appropriate mass of the fill. The above definition is based on maximum load and rated minimum fill.

A.6.2 Influence factor tests

Summary of tests

Test	Characteristic under test	Conditions applied
A.6.2.1 Static temperatures	Influence factor	mpe (*)
A.6.2.2 Temperature effect on no-load indication	Influence factor	mpe
A.6.2.3 Damp heat, steady state	Influence factor	mpe
A.6.2.4 Power voltage variation	Influence factor	mpe
A.6.2.5 Tilting	Influence factor	mpe

(*) mpe: maximum permissible error

A.6.2.1 Static temperatures (2.5.1)

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 Bibliography [1] and according to Table 3.

Table 3

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 2.5.1 under conditions of dry heat (non condensing) and cold. The test A.6.2.2 may be conducted during this test.
Test procedures in brief.	
Precondition:	16 hours
Condition of the EUT:	Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Power is to be "on" for the duration of the test. The automatic zero-setting should be disabled.
Stabilization:	2 hours at each temperature under "free air" conditions.
Temperature:	As specified in 2.5.1.
Temperature sequence:	Reference temperature of 20 °C Specified high temperature Specified low temperature Temperature of 5 °C 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 the following: Adjust the EUT as close to zero indication as practicable. It is important to ensure that the test result is unaffected by the automatic zero-setting function which should therefore be disabled. The EUT shall be tested with at least five different static test loads (or simulated loads) including Maximum and Minimum capacities. When loading or unloading weights the load must be respectively increased or decreased monotonically. Record: a) date and time b) temperature c) relative humidity d) test load e) indications f) errors g) functional performance
Maximum allowable variations:	All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 2.4.

A.6.2.2 Temperature effect on no-load indication

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 temperatures as well as at 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.6.2.1).

Maximum permissible variations:	The change in zero indication shall not vary by more than the maximum permissible error for influence factor tests for a load equal to the rated minimum fill, 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.6.2.3 Damp heat, steady state (4.3.2)

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 4.

Table 4

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 4.3.1 under conditions of high humidity and constant temperature.
Precondition:	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 2.5.1.
Temperature:	Reference temperature of 20 °C and at the upper limit as specified in 2.5.1.
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 stabilisation 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 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 2.4.

A.6.2.4 Power voltage variation (2.5.2)

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 5.

Table 5

Environmental phenomena	Test specification	Test set-up
Voltage variation	Reference voltage	IEC 1000-4-11
	Reference voltage + 10 %	
	Reference voltage – 15 %	
	Reference voltage	
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 2.5.2 under conditions of voltage variations.
Test procedures in brief.	
Precondition:	None required.
Condition of the EUT:	Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. 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 a test load approximately equal to the minimum capacity. Zero-setting function shall be in operation.
Test sequence:	Stabilize the power supply at the reference voltage within the defined limits and apply the test load. Record the following data: 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 to repeat the test weighing at both ends of the voltage range) and record the indications.
Maximum allowable variations:	All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 2.4.

A.6.2.5 Tilting (2.5.3)

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.

Test method:	Static tests whilst the EUT is tilted.
Object of the test:	To verify compliance with the provisions in 2.5.3 under conditions of tilt.

Test procedure in brief:	The test consist of tilting the EUT both forwards and backwards, longitudinally and from side to side (transversely), while observing the weight indications for a static test load.
Test severities:	Instruments without level indicators shall be tested at a tilt of 5 %.
Maximum allowable variations:	All indications shall be within maximum permissible errors specified in 2.4.
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. Adjust the EUT in its reference position (not tilted) as close to zero indication as practicable. If the instrument is provided with automatic zero-setting it shall not be in operation. The test shall be performed with a test load approximately equal to the maximum capacity.
Test sequence:	Record the zero indication. Apply the test load and record the indication. Remove the test load. Tilt the EUT longitudinally to the appropriate extent and record the zero indication. Apply the test load and record the indication. Remove the test load. Without further adjustment to any control affecting metrological performance tilt the EUT to the appropriate extent in the opposite direction and repeat the static weighing tests as above. Tilt the EUT in the transverse direction to the appropriate extent and repeat the tests. Tilt the EUT in the opposite direction and repeat the tests. In order to determine the influence of tilting on the loaded instrument, the indication obtained at each tilt shall be corrected for the deviation from zero which the instrument had prior to loading.

A.6.3 Disturbance tests (4.1.3)

A.6.3.1 Short time power reduction

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 [7] and according to Table 6.

Table 6

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 section 5. Refer to Bibliography [7] 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 mains voltage interruptions and reductions while observing the weight indication for a static load approximately equal to the minimum capacity.

Test procedures in brief:

Precondition: None required.

Condition of the EUT: Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer.

Adjust the EUT as close to zero indication as practicable, prior to the test. Zero-setting functions shall not be in operation. 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 test load approximately equal to the minimum capacity.

Stabilize all factors at nominal reference conditions. Apply the test load and record the following data:

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 values given in T.4.2.5, or the EUT shall detect and act upon a significant fault.

A.6.3.2 Electrical bursts (fast transient tests)

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 the Bibliography [5] and according to Tables 7.1, 7.2 and 7.3.

Table 7.1: 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 may exceed 3 m according to the manufactures functional specification.		

Table 7.2: Input and output DC 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 appliances that cannot be connected to the mains while in use.		

Table 7.3: Input and output AC 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 AC 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 static test load approximately equal to the minimum capacity.
Test procedures in brief:	
Precondition:	None required.
Condition of the EUT:	Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. 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.4.2.5, or the instrument shall detect and act upon a significant fault.

A.6.3.3 Electrostatic discharge

Electrostatic discharge tests are carried out according to basic standard IEC 1000-4-2 (1995), with test signals and conditions as given in Table 8. As detailed in Bibliography [3].

Table 8

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 s. In the case of a non conductive enclosure, discharges shall be applied on the horizontal or 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 8 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 static test load approximately equal to the minimum capacity.
Test procedures in brief:	
Precondition:	None required.
Condition of the EUT:	Normal power supplied and “on” for a time period equal to or greater than the warm-up time specified by the manufacturer. 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.4.2.5, or the instrument shall detect and act upon a significant fault.

A.6.3.4 Electromagnetic susceptibility

Electromagnetic susceptibility tests (radio frequency electromagnetic fields 26 MHz to 1 000 Mhz tests) are carried out in accordance with IEC 1000-4-3 (1995). As detailed in Bibliography [4] and according to Table 9.

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 9: 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 test load approximately equal to the minimum capacity.

Test procedures in brief:

Precondition: None required.

Condition of the EUT: Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. 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.4.2.5, or the instrument shall detect and act upon a significant fault.

A.7 Span stability test (4.3.3)

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.

Test procedure in brief: The test consists of observing the variations of 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. 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 the manufacturer specifies so or at the discretion of the approval authority in the absence of any such 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 severities:	Test duration: 28 days or over the period necessary for the conduct of the performance tests, whichever is less. Time t (days) between tests: $0.5 \leq t \leq 10$. Test load: a static test load near maximum capacity (Max); the same test weights shall be used throughout the test.
Maximum allowable variations:	The variation in the indication of the test load shall not exceed 1/2 the absolute value of the mpe for influence factor tests (2.4) for the test load applied on any of the (n) tests conducted.
Number of tests (n):	$n \geq 8$. If the test results indicate a trend more than half the permissible variation specified above, conduct additional tests until the trend comes to rest or reverses itself, or until the error exceeds the maximum permissible variation.
Precondition:	None required.
Test equipment:	Verified mass standards.
Condition of the EUT:	Adjust the EUT as close to zero indication as practicable before each test.
Test sequence:	Stabilize all factors at nominal reference conditions. If the instrument is provided with automatic zero-setting it shall not be in operation. 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) changes in test location

and apply all necessary corrections resulting from variations of temperature, pressure, etc. between the various measurements.

At the first measurement immediately repeat zeroing and loading four times to determine the average value of error. For the next measurements perform only one, unless either the result is outside the specified tolerance or the range of the five readings of the initial measurement was more than 1/10 of the maximum permissible variation.

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.

A.8 Procedure for material tests

A.8.1 Material tests at pattern evaluation (5.1.2.1 and 5.2.)

Operational tests with material shall be done on a complete instrument to assess compliance with the technical requirements of clause 3 with material for the test load as specified in 5.1.2.1.

A.8.1.1 Feeding device (3.5)

Check that the feeding device provides sufficient and regular flow rate.

Check that any adjustable feed device has an indication of the direction of movement corresponding to the sense of the adjustment of the feed (where applicable).

For instruments using the subtractive weighing principle check that residual material retained at the feeding device after each load is delivered, is negligible relative to limits of error.

A.8.1.2 Load receptor (3.6)

For instruments that weigh material in a separate load receptor prior to discharge to a container, check that the residual material retained at the load receptor after each discharge is negligible relative to limits of error.

Check that manual discharge of the load receptor is not possible during automatic operation.

A.8.2 Material tests at initial verification (5.1.2.2 and 5.3)

Metrological tests with material shall be done on a complete instrument, fully assembled and fixed in the position in which it is intended to be used and as specified in 5.1.2.2.

The accuracy class (or classes) shall be determined from the results.

A.8.2.1 Requirements for metrological material tests

Types of loads (5.3.1 and 6.2 (a)):	The materials used as the test load shall be as specified in 6.2 (a).
Mass of test loads and fills (6.2):	The mass of the test loads and fills shall be as specified in 6.2 (a, b and c).
Adjustments (6.2 (d)):	The adjustments shall be set as specified in 6.2 (d).
Correction devices (6.2.1):	Any correction device shall be operated as specified in 6.2.1.
Number of fills (6.3):	The number of fills shall be as specified in 6.3.

A.8.2.2 Methods for metrological material tests (6.5)

One of the following verifications methods shall be used:

- Separate verification method: the separate verification method is as defined in 6.5.1.
- Integral verification method: the integral verification method is as defined in 6.5.2.

A.8.2.3 Procedure for metrological material tests

(1) Set up the instrument in accordance with 6.2 (d) and 6.2.1.

(2) Select a preset value for the fill and set the load value if different from the fill, in accordance with 6.2. Record the indicated preset value.

(3) Run the instrument to produce a number of fills as specified in 6.3.

(4) Weigh all the fills by one of the methods in 6.5.1 or 6.5.2.

(5) Calculate the average value of all the fills in the test and the preset value error (2.3).

(6) Calculate the deviation of each fill from the average (2.2).

(7) Repeat stages (2) to (6) for other loads as specified in 6.2.

Concerning 6.7: The result of weighing the test fill on the control instrument shall be considered as the conventional true value of the test fill.

Concerning 6.8: The deviation for automatic weighing used to determine compliance of each fill with the maximum permissible deviation for automatic weighing (2.2) shall be the difference between the conventional true value of the mass of the test fill as defined in 6.7 and the average value of all the fills in the test.

Concerning 6.9: The preset value error for automatic weighing used to determine compliance with 2.3 shall be the difference between the average value of the conventional true value of the mass of the test fills, as defined in 6.7 and the preset value for the fills.

A.8.2.4 Determination of accuracy class (5.2.5)

(1) For each preset value of the test fill, determine the preset value error (i.e. the setting error, se) and the maximum permissible preset value error for class X(1), $mpse_{(1)}$.

Then calculate [se / $mpse_{(1)}$] for each preset value of the test fill.

(2) For each preset value of the test fill determine the maximum actual deviation from the average (md) and the maximum permissible deviation from the average for class X(1), $mpd_{(1)}$.

Then calculate md / $mpd_{(1)}$ for each preset value of the test fill.

(3) From (1) determine the maximum value of [se / $mpse_{(1)}$],

$$[se / mpse_{(1)}]_{max}$$

(4) From (2) determine the maximum value of md / $mpd_{(1)}$,

$$[md / mpd_{(1)}]_{max}$$

(5) Determine the accuracy class (x) such that

$$(x) \geq [se / mpse_{(1)}]_{max}$$

$$\text{and } (x) \geq [md / mpd_{(1)}]_{max}$$

$$\text{and } (x) = 1 \times 10^k, 2 \times 10^k, \text{ or } 5 \times 10^k,$$

the index k being a positive or negative whole number or zero.

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).

GRANDE IMPRIMERIE DE TROYES
130, rue Général-de-Gaulle, 10000 Troyes
Printed in France