ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE

INTERNATIONAL RECOMMENDATION

Automatic rail-weighbridges
Part 1: Metrological and technical requirements - Tests

Ponts-bascules ferroviaires à fonctionnement automatique
Partie 1: Exigences métrologiques et techniques - Essais

OIML R 106-1

Edition 1997 (E)

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FOREWORD

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Bureau International de Métrologie Légale
11, rue Turgot - 75009 Paris - France
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This publication - reference OIML R 106-1, edition 1997 (E) - was developed by the OIML subcommittee TC 9/SC 2 *Automatic weighing instruments*. It was sanctioned by the International Conference of Legal Metrology in 1996 and supersedes the previous edition dated 1993.

TERMINOLOGY
(terms and definitions)

The terminology used in this Recommendation conforms to the *International Vocabulary of Basic and General Terms in Metrology* (VIM, 1993 edition) and the *Vocabulary of Legal Metrology* (VML, 1978 edition). In addition, for the purposes of this Recommendation, the following definitions apply:

T.1 General definitions

T.1.1 Weighing instrument

Measuring instrument that serves to determine the mass of a load by using the action of gravity.

T.1.2 Automatic weighing instrument

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

T.1.3 Rail-weighbridge

A weighing instrument having a load receptor, inclusive of rails for conveying railway vehicles.

T.1.4 Electronic instrument

An instrument equipped with electronic devices.

T.1.5 Control instrument

A nonautomatic weighing instrument used to determine the mass of a reference wagon.

T.1.6 Weigh zone

Zone in which a wagon must be located when it is weighed.

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 Load receptor

The part of the weigh zone that is intended to receive the load and which realizes a change in the balance of the instrument when a load is placed upon it.

T.2.1.1 Multiple load receptors

Two or more load receptors placed in series that are used as a single load receptor for full draught weighing.

T.2.1.2 Aprons

The parts of the weigh zone that are not the load receptor nor part of the load receptor.

T.2.2 Electronic device

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

T.2.2.1 Electronic subassembly

A part of an electronic device comprised of electronic components and having a recognizable function of its own.

T.2.2.2 Electronic component

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

T.2.3 Indicating device

The part of the instrument that displays the value of a weighing result in units of mass.

T.2.4 Ancillary devices

T.2.4.1 Zero-setting device

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

T.2.4.1.1 Nonautomatic zero-setting device

A zero-setting device that must be operated manually.

T.2.4.1.2 Semi-automatic zero-setting device

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

T.2.4.1.3 Automatic zero-setting device

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

T.2.4.2 Printing device

The means to print the weight values of wagons weighed on the instrument and/or a summation of those wagon weights.

T.3 Metrological characteristics

T.3.1 Weighing

T.3.1.1 Full draught weighing

Weighing a wagon that is entirely supported on the load receptor(s).

T.3.1.2 Partial weighing

Weighing a wagon in two or more parts on the same load receptor. The results are automatically added to indicate or print the wagon weight.

T.3.1.3 Weighing-in-motion (wim)

Weighing objects that are in motion.

T.3.1.3.1 Uncoupled wagon weighing

Weighing-in-motion of wagons that travel independently across a load receptor. (This is usually achieved by means of an incline of the approach to the load receptor).

T.3.1.3.2 Coupled wagon weighing

Weighing-in-motion of a train of coupled wagons to obtain a weight indication or printout of the individual wagons.

T.3.1.3.3 Train weighing

Weighing-in-motion of a number of coupled wagons to obtain a totalized weight of all the wagon weights.

T.3.1.4 Static weighing

Weighing a wagon while stationary and uncoupled to obtain a weight for the purposes of testing.

T.3.2 Capacity

T.3.2.1 Maximum capacity (Max)

The largest load that an instrument is designed to weigh-in-motion without totalizing.

T.3.2.2 Minimum capacity (Min)

The load below which a weighing-in-motion result before totalizing may be subject to an excessive relative error.

T.3.3 Wagon weight

T.3.3.1 Maximum wagon weight

The largest in-motion load that the installation is approved to weigh for a particular site.

T.3.3.2 Minimum wagon weight

The wagon weight below which a weighing-in-motion result may be subject to an excessive relative error.

T.3.4 Scale interval (d)

A value expressed in units of mass for weighing-in-motion that is the difference between:

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

T.3.4.1 Scale interval for stationary load

The scale interval used for static tests.

T.3.5 Speed

T.3.5.1 Maximum operating speed

The greatest velocity of a wagon that the instrument is designed to weigh-in-motion and above which the weighing results may be subject to an excessive relative error.

T.3.5.2 Minimum operating speed

The lowest velocity of a wagon that the instrument is designed to weigh-in-motion and below which the weighing results may be subject to an excessive relative error.

T.3.5.3 Range of operating speeds

The difference between the minimum and maximum operating speeds at which a wagon may be weighed-in-motion.

T.3.5.4 Maximum transit speed

The maximum speed that a railway vehicle can travel on the weigh zone without producing a permanent shift in the performance characteristics of a weighing instrument beyond those specified.

T.3.6 Warm-up time

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

T.3.7 Durability

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

T.4 Indications and errors

T.4.1 Methods of indication

T.4.1.1 Analogue indication

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

T.4.1.2 Digital indication

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

T.4.2 Errors

T.4.2.1 Error (of indication)

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

T.4.2.2 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 tests and durability evaluations.

T.4.2.4 Fault

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

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

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

T.4.2.5 Significant fault

A fault greater than d.

The following are not considered to be significant faults:

- faults that result from simultaneous and mutually independent causes in the instrument or in its checking facility;
- faults that imply the impossibility of performing any measurement;
- transitory faults that are momentary variations in the indications which cannot be interpreted, memorized or transmitted as a measurement result;
- faults that are so serious that they will inevitably be noticed by those interested in the measurement.

T.4.2.6 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.4.2.7 Maximum span stability error

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

T.4.2.8 Rounding error

The difference between a digital measurement result (indicated or printed) and the value of that measurement result with an analogue indication.

T.5 Influences and reference conditions

T.5.1 Influence quantity

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

T.5.1.1 Influence factor

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

T.5.1.2 Disturbance

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

T.5.2 Rated operating conditions

Conditions of use which give the ranges of the influence quantities for which the metrological characteristics are intended to lie within the specified maximum permissible errors.

T.5.3 Reference conditions

A set of specified values of influence factors fixed to ensure valid intercomparison of the results of measurements.

T.6 Tests

T.6.1 Static test

A test with standard weights or a load that remains stationary on the load receptor to determine an error.

T.6.2 In-motion (dynamic) test

A test with reference wagons that are in motion on the load receptor to determine an error.

T.6.3 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.6.4 Performance test

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

T.6.5 Span stability test

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

T.7 Rail vehicles

T.7.1 Wagon

A loaded or unloaded railway goods vehicle that is recognized by the instrument as a vehicle to be weighed.

T.7.2 Reference wagon

A wagon of known weight that is typical of those to be used for weighing on the instrument and which has been selected for the purposes of in-motion testing.

T.7.3 Total train

A number of coupled wagons whose totalized weight is to be obtained.

AUTOMATIC RAIL-WEIGHBRIDGES

1 General

1.1 Scope

This International Recommendation specifies the requirements and test methods for automatic rail-weighbridges, hereinafter referred to as “instruments”, that are used to determine the mass of railway wagons when they are weighed in motion.

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

1.2 Terminology

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

2 Metrological requirements

2.1 Accuracy classes

Instruments are divided into four accuracy classes as follows:

0.2 0.5 1 2

An instrument may be in a different accuracy class for wagon weighing than that for train weighing.

2.2 Maximum permissible errors

2.2.1 Weighing-in-motion (wim)

The maximum permissible errors for weighing-in-motion shall be as specified in Table 1.

Table 1

Accuracy class	Percentage of mass of single wagon or total train, as appropriate	
	Initial verification	In-service
0.2	±0.10 %	±0.2 %
0.5	±0.25 %	±0.5 %
1	±0.50 %	±1.0 %
2	±1.00 %	±2.0 %

Note: For the application of maximum permissible errors refer to 2.8.2.1 and 2.8.2.2.

On initial verification of an instrument weighing coupled wagons, the errors of not more than 10 % of the weighing results taken from one or more passes of the test train may exceed the appropriate maximum permissible error given in Table 1 but shall not exceed two times that value.

2.2.2 Static weighing

The maximum permissible errors on static weighing for increasing or decreasing loads shall be the appropriate values in Table 2.

Table 2

Maximum permissible errors	Load (m) expressed in numbers of scale intervals
±0.5 d	$0 \leq m \leq 500$
±1.0 d	$500 < m \leq 2\,000$
±1.5 d	$2\,000 < m \leq 10\,000$

2.3 Scale interval (d)

For a particular method of weighing-in-motion and combination of load receptors, all weight indicating and printing devices on an instrument shall have the same scale interval.

The relationship between the accuracy class, the scale interval and the maximum wagon weight divided by the scale interval shall be as specified in Table 3.

Table 3

Accuracy class	d (kg)	(maximum wagon weight)/d	
		minimum	maximum
0.2	≤ 50	1 000	5 000
0.5	≤ 100	500	2 500
1	≤ 200	250	1 250
2	≤ 500	100	600

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

2.4 Minimum capacity

The minimum capacity shall not be less than 1 t, and not greater than the value of the result of the minimum wagon weight divided by the number of partial weighings.

2.5 Minimum wagon weight

The minimum wagon weight shall not be less than 50 d.

2.6 Single axle or bogie weights

Single axle or bogie weights shall not be indicated or printed without an associated warning that these weighing results cannot be verified.

2.7 Agreement between indicating and printing devices

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

- zero for digital devices;
- not greater than the absolute value of the maximum permissible error for weighing-in-motion for analogue devices.

2.8 Weighing test methods

The appropriate provisions of this subclause are specified in 5.1 (pattern evaluation), 5.2 (initial verification) and 5.3 (in-service inspection).

2.8.1 Static weighing

An instrument to be used as a control instrument shall meet the requirements of 2.8.3.2, and 2.8.1.1 to 2.8.1.6 inclusive. The maximum permissible errors shall comply with Table 2.

2.8.1.1 Multiple load receptors

Each load receptor shall be tested by the static-weighing method both independently and in combination.

2.8.1.2 Zero-setting

The instrument shall be capable of setting zero to within ±0.25 of the scale interval for a stationary load.

2.8.1.3 Eccentric loading

The indications for different positions of the load shall comply with the maximum permissible errors for the given load.

2.8.1.4 Verification standards

The error of the standard weights or masses used shall not be greater than one-third of the maximum permissible error for the load, as specified in Table 2.

2.8.1.5 Test loads

2.8.1.5.1 Load at which errors are to be determined

Errors shall be determined for test loads of:

- zero;
- minimum capacity;
- maximum capacity;
- at or near a load where the maximum permissible error changes.

2.8.1.5.2 Distribution of test load

Except for eccentricity tests, standard weights or masses shall be evenly distributed on the load receptor.

2.8.1.5.3 Eccentricity tests

Tests shall be carried out without excessive stacking or overlapping of the load on the load receptor provided that the conditions are practical and safe. The test load shall be equal to one half of the maximum capacity rounded up to the next 1 tonne increment. The test load shall be on the rails covering the least area as is practicable and stacked across each pair of supports of the load receptor.

2.8.1.6 Discrimination tests

An additional load that is equal to 1.4 times the scale interval for a stationary load, when gently placed on or withdrawn from each load receptor in turn when at equilibrium at any load shall change the initial indication.

2.8.2 Weighing-in-motion

2.8.2.1 Wagon weighing

The maximum permissible error for coupled or uncoupled wagon weighing, shall be one of the following values, whichever is greater:

- the value calculated according to Table 1, rounded to the nearest scale interval;
- the value calculated according to Table 1, rounded to the nearest scale interval for the weight of a single wagon equal to 35 % of the maximum wagon weight (as inscribed on the descriptive markings), or
- 1 d.

2.8.2.2 Train weighing

The maximum permissible error for train weighing shall be one of the following values, whichever is greater:

- the value calculated according to Table 1, rounded to the nearest scale interval;
- the value calculated according to Table 1, for the weight of a single wagon equal to 35 % of the maximum wagon weight (as inscribed on the descriptive markings) multiplied by the number of reference wagons in the train (not exceeding 10 wagons) and rounded to the nearest scale interval, or
- 1 d for each wagon in the train but not exceeding 10 d.

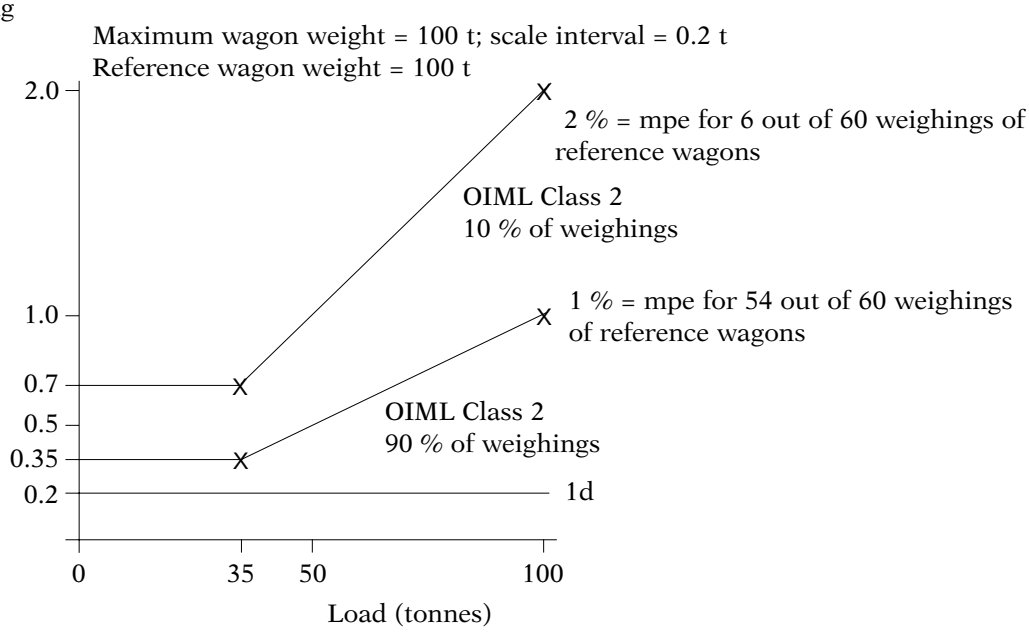
See Figure 1 for an illustration of this requirement.

Figure 1

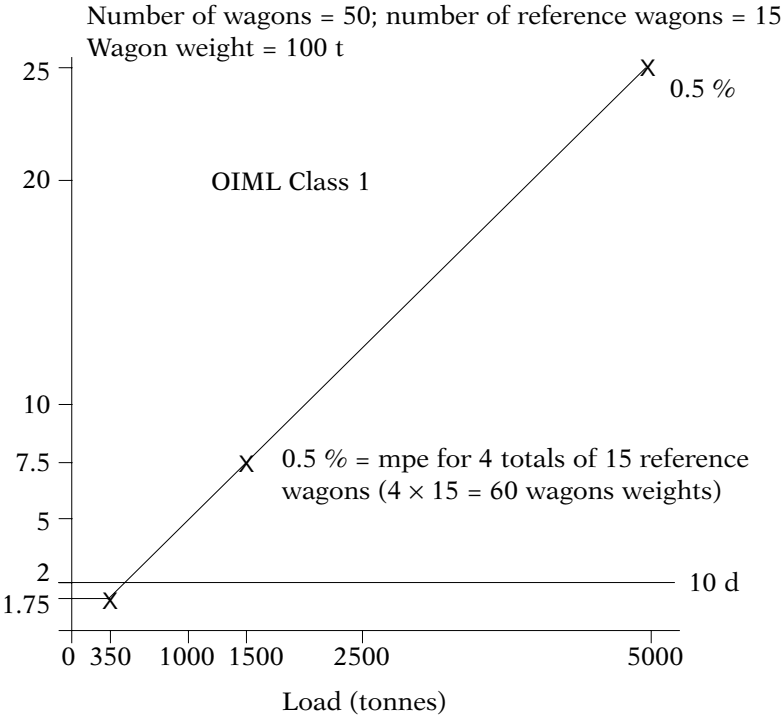
AUTOMATIC RAIL-WEIGHBRIDGES

Illustration of maximum permissible errors and in-motion test requirements for a sample train

Wagon weighing



Train weighing



2.8.3 Verification standards

2.8.3.1 Separate control instrument

A control instrument capable of being used to determine the mass of each reference wagon when stationary and uncoupled shall be available for in-motion tests. The error of that instrument shall not be greater than either of the following values:

a) one-third of the appropriate maximum permissible error for in-motion weighing in 2.8.2 and Table 1 if the control instrument is verified immediately prior to the in-motion tests;

b) one-fifth of the maximum permissible error if the control instrument is verified at any other time.

An instrument constructed only for partial weighing of two-axle wagons may be used as the control instrument provided that the alignment calibration in Annex B has been successfully applied.

2.8.3.2 Integral control instrument

An instrument under test may be used as the control instrument provided that it meets the following requirements:

- it shall have an appropriate scale interval or scale interval for stationary load;
- it shall comply with the requirements in 2.8.1 and 2.8.3.1.

An instrument constructed only for partial weighing of two-axle wagons may be used as the control instrument provided that the alignment calibration in Annex B has been successfully applied.

2.9 Influence quantities

2.9.1 Static temperature

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

For special applications, however, the limits of the temperature range may differ provided that this range shall not be less than 30 °C and shall be specified in the descriptive markings.

Instruments shall be tested in accordance with the static temperatures test in A.8.1.

2.9.2 Mains power supply (AC)

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

Instruments shall be tested in accordance with the mains power supply (AC) test in A.8.3.

2.9.3 Battery power supply (DC)

Instruments that are powered by a DC supply shall comply with the appropriate metrological and technical requirements in accordance with 4.3.8.

Instruments shall be tested in accordance with the battery power supply (DC) test in A.8.4.

2.10 Conditions of use

2.10.1 Use as a nonautomatic weighing instrument

An instrument that can be used as a nonautomatic weighing instrument shall meet the requirements of the OIML International Recommendation R 76-1 for class III or class IIII nonautomatic weighing instruments.

2.10.2 Scale interval for stationary load

If the scale interval for stationary load is not equal to the scale interval (d), it shall be automatically out of service when the instrument is in use for weighing-in-motion. In addition, if the instrument is not verified for use as a nonautomatic weighing instrument, the scale interval for stationary load shall not be readily accessible and shall only be used for static testing.

3 Technical requirements

3.1 Composition

Instruments shall include the following:
- one or more load receptors;
- aprons;
- vehicle-type identification devices (e.g. track switches, load cells, transponder, etc);
- indicating device;
- printer;
- control unit.

3.2 Suitability for use

Instruments shall be designed to suit the vehicles, site and method of operation for which they are intended.

Instruments constructed only for partial weighing shall not be used to weigh liquid loads or any other load that may be subjected to fluctuations in its gravity center, unless there is a possibility to anticipate and compensate for such fluctuations.

3.3 Security of operation

3.3.1 Accidental maladjustment

Instruments shall be constructed so that maladjustments likely to disturb their metrological performance cannot normally take place without the effect being easily detected.

3.3.2 Interlocks

Interlocks shall prevent the use of any control device that may alter a weighing operation.

3.3.3 Uncoupled wagon weighing

Instruments used for uncoupled wagon weighing shall recognize and indicate the following situations:

a) the passage of two or more coupled wagons;

b) the passage of two or more uncoupled wagons that is sufficiently close to cause either a malfunction of the instrument or errors exceeding the appropriate maximum permissible errors.

3.3.4 Use as a nonautomatic weighing instrument

An instrument to be used as a nonautomatic weighing instrument shall:

- comply with the requirements of OIML R 76-1 for class III or class IIII nonautomatic weighing instruments;
- be equipped with an enabling device for nonautomatic operation that prevents both automatic operation and in-motion weighing.

3.3.5 Zero-setting device

An instrument shall be equipped with a semi-automatic or automatic zero-setting device for each load receptor. Its operation shall be possible only when the instrument is in stable equilibrium and when the rate of correction is no more than 0.5 d/s.

The range of the zero-setting device shall not exceed 4 % of the maximum capacity.

3.4 Indicating and printing devices

3.4.1 Quality of indication

The weight indication shall be the self-indicating type. Indicating and printing devices shall allow reliable, simple and unambiguous reading of the results by simple juxtaposition and shall bear the name or symbol of the appropriate unit of mass.

3.4.2 Printing

The minimum printout resulting from each normal weighing operation shall be each wagon weight in the case of wagon weighing and total train weight in the case of train weighing.

3.4.3 Weighing range

Instruments shall not indicate or print:

- the weight of any wagon, or
- a totalized weight inclusive of any wagon,

that will cause a weighing result less than Min or greater than Max + 9 d.

3.4.4 Operating speed

The printer shall not print the weight of any wagon that has travelled over the load receptor at a speed outside the range of operating speeds. An appropriate indication

shall be included on the printout for any wagon weight not printed and a subtotal may be printed exclusive of unweighed wagons provided that an indication clearly specifies that it is not the total train weight.

3.4.5 Roll back

The weight indication and printout shall not be altered due to any part of any wagon travelling over the load receptor more than once.

3.5 Installation

3.5.1 Ease of static testing

The instrument shall be accessible to vehicles for moving test weights if it is to be used as the control instrument.

3.5.2 Drainage

If the weighing mechanism is contained in a pit, there shall be a provision for drainage to ensure that no portion of the instrument becomes submerged or partially submerged in water or any other liquid.

3.6 Descriptive markings

Instruments shall bear the following basic markings at each location having a weight indicating or printing device.

3.6.1 Markings shown in full

- identification mark of the manufacturer
- identification mark of the importer (if applicable)
- designation of the instrument
- serial number of the instrument (on each load receptor, if applicable)
- weighing method (see T.3.1)
- maximum wagon weight ..... kg or t
- minimum wagon weight ..... kg or t
- not to be used to weigh liquid products (if applicable)
- full draught or number of partial weighings per wagon
- maximum transit speed ..... km/h
- direction of weighing (if applicable)
- wagons pushed/pulled (whichever is applicable)
- scale interval for stationary load (if applicable) ..... kg or t
- electric power supply voltage V
- electric power supply frequency ..... Hz

3.6.2 Markings shown in code

3.6.2.1 For all instruments

- pattern approval sign in accordance with national requirements
- accuracy class (for each weighing method, if applicable) 0.2, 0.5, 1 or 2
- maximum capacity Max = ... kg or t
- minimum capacity Min = ... kg or t
- scale interval d = ... kg or t
- maximum operating speed v_{max} = ... km/h
- minimum operating speed v_{min} = ... km/h

3.6.2.2 For coupled wagon and train weighing

Markings required for each weighing method applicable:

- maximum number of wagons per train n_{max} = ...
- minimum number of wagons per train n_{min} = ...

3.6.3 Supplementary markings

Depending upon the particular use of the instrument, one or more supplementary markings may be required on pattern approval by the metrological authority issuing the pattern approval certificate.

3.6.4 Other markings

The designation of the liquid(s) which the instrument is designed to weigh (if applicable).

3.6.5 Presentation of descriptive markings

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

Markings shall be grouped together in a clearly visible place on the instrument, either on a descriptive plate fixed near the indicating device or on the indicating device itself.

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

3.7 Verification marks

3.7.1 Position

Instruments shall have a place for the application of verification marks. The following applies for this place:

- the part on which the marks are located cannot be removed from the instrument without damaging the marks;

- the place shall permit the easy application of the marks without changing the metrological qualities of the instrument;
- the marks shall be visible when the instrument is in service.

3.7.2 Mounting

Instruments required to bear verification marks shall have a verification mark support located as specified above, which shall ensure the conservation of the marks as follows:

- when the mark is made with a stamp, the support may consist of a strip of lead or any other material with similar qualities inserted into a plate fixed to the instrument or a cavity bored into the instrument;
- when the mark consists of an adhesive transfer, a space shall be provided for this purpose.

4 Requirements for electronic instruments

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

4.1 General requirements

4.1.1 Rated operating conditions

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

4.1.2 Disturbances

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

a) significant faults do not occur, or

b) significant faults are detected and acted upon.

Note: A fault equal to or less than the value specified in T.4.2.5 (1 d) is allowed irrespective of the value of the error of indication.

4.1.3 Durability

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

4.1.4 Evaluation for compliance

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

4.2 Application

4.2.1 The requirements in 4.1.2 may be applied separately to the following:

a) each individual cause of significant fault, and/or

b) each part of the electronic instrument.

4.2.2 The choice as to whether to apply 4.1.2 (a) or (b) is left to the manufacturer.

4.3 Functional requirements

4.3.1 Acting upon a significant fault

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

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

4.3.2 Switch-on procedure

Upon switch-on (in the case of electronic instruments permanently connected to the mains at switch-on of indication), a special procedure shall be performed that indicates all the relevant signs of the indicator in their active and nonactive states for a sufficient time to be easily observed by the operator.

4.3.3 Influence factors

An electronic instrument shall comply with the requirements of 2.9, and in addition it shall maintain its metrological and technical characteristics at a relative humidity of 85 % at the upper limit of the temperature range of the instrument.

4.3.4 Disturbances

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

a) The difference between the weight indication due to the disturbance and the indication without the disturbance (intrinsic error) shall not exceed the value specified in T.4.2.5 (1 d).

b) The instrument shall detect and act upon a significant fault.

4.3.5 Warm-up time

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

4.3.6 Interface

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

4.3.7 Mains power supply (AC)

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

4.3.8 Battery power supply (DC)

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

4.4 Examination and tests

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

4.4.1 Examinations

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

4.4.2 Performance tests

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

Tests are to be conducted on the whole instrument except when the size and/or configuration of the instrument does not lend itself to testing as a unit. In such cases, the separate electronic devices shall be subjected to testing. It is not intended that electronic devices be further dismantled for separate testing of components. In addition, an examination shall be carried out on the fully operational weighing instrument or, if necessary, on the electronic devices in a simulated set-up that sufficiently represents the weighing instrument. The equipment shall continue to function correctly as specified in Annex A.

4.4.3 Span stability tests

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

When the instrument is subjected to the span stability test specified in A.10:

- the maximum allowable variation in the errors of indication shall not exceed half the absolute value of the maximum permissible error in 2.2.2 Table 2 for the test load applied on any of the n measurements;

- where the differences of the results indicate a trend more than half the allowable variation specified above, the test shall be continued until the trend comes to rest or reverses itself, or until the error exceeds the maximum allowable variation.

5 Metrological controls

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

- pattern evaluation;
- initial verification;
- in-service inspection.

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

5.1 Pattern evaluation

5.1.1 Documentation

The application for pattern evaluation shall include documentation which provides the following information:

- metrological characteristics of the instrument;
- a standard set of specifications for the instrument;
- a functional description of the components and devices;
- drawings, diagrams and general software information (if applicable), explaining the construction and operation;
- any document or other evidence demonstrating that the design and construction of the instrument complies with the requirements of this Recommendation.

5.1.2 General requirements

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

5.1.3 Pattern evaluation tests

Instruments shall comply with the following:

a) the metrological requirements in clause 2, particularly with reference to maximum permissible errors and, if appropriate, when the instrument is operated in accordance with the manufacturer's specifications for products;

Note: Evaluation for static weighing (2.8.1) shall be excluded unless the instrument is constructed for use as a control instrument (2.8.3.2).

b) the technical requirements in clause 3.

Additionally, electronic instruments shall comply with the requirements in clause 4.

The appropriate metrological authority shall be responsible for the following:

- conducting the tests in a manner which prevents an unnecessary commitment of resources, and
- permitting the results of these tests to be assessed for initial verification when the same instrument is involved.

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

The metrological authority may, at its discretion and under its own responsibility, accept test data provided by the applicant for the submitted pattern and reduce its own testing program accordingly.

5.1.3.1 In-motion tests

The instrument shall be tested in accordance with the provisions in 2.8.2 by reference to "initial verification" as appropriate and shall comply with the requirements in 2.7. Errors shall be determined by comparing the test results with the reference wagon mass derived as in 2.8.3. The range of speeds used during these tests shall be in accordance with the pattern specification.

5.1.3.1.1 Uncoupled wagons

Instruments for weighing individual uncoupled wagons shall be tested using not less than five reference wagons having a range of loads from zero load (wagon tare weight) to that of a fully loaded wagon. A minimum of five weight indications or printouts of each wagon shall be used for assessing compliance with the requirements in 2.8.2.1.

5.1.3.1.2 Coupled wagons

Instruments designed to weigh either individual coupled wagons or a total train of coupled wagons shall be tested in either of the following manners:

a) by using a test train of empty reference wagons and a test train of both full and partially filled reference wagons. Each test train shall be comprised of not less than 5 (and normally not more than 15) reference wagons and shall be weighed repeatedly and in each direction (if applicable) to yield not less than 60 wagon weights or the equivalent in total train weight;

b) according to the requirements in 5.2.2.

Each weight indication and printout obtained in the test shall be used for assessing compliance with the requirements in either 2.8.2.1 or 2.8.2.2, as appropriate.

5.1.3.2 Simulation tests

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

- 2.9 for all instruments;
- 4 for electronic instruments.

When conducting such tests on a load cell or on an electronic device equipped with an analogue component, the maximum permissible error for the device under test shall be 0.7 times the appropriate value specified in Table 2.

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

Note: Since the requirements of this clause apply only to the instrument submitted for pattern evaluation and not to those subsequently submitted for verification, the means used to determine if the appropriate maximum permissible error or maximum allowable variation has been exceeded will be decided and mutually agreed upon between the metrological authority and the applicant. Following are examples of these means:

- an adaptation of the indicating device to give greater resolution than that of the scale interval;
- the use of the scale interval for stationary load;
- the use of change points;
- any other means mutually agreed upon.

5.1.3.3 Tests for compliance with technical requirements

Tests shall be conducted to determine compliance with the requirements in 3.3 and 3.4.

5.1.4 Provision of means for testing

For the purposes of testing, the applicant may be required to furnish the metrological authority with the test vehicles, material, qualified personnel and a control instrument. The instrument under test may be used as a control instrument provided it complies with the requirements in 2.8.3.2.

5.1.5 Place of testing

Instruments submitted for pattern approval may be tested at the following places:

- a site at which all necessary tests can be conducted and agreed upon between the metrological authority and the applicant;
- a laboratory considered appropriate by the metrological authority;
- any other suitable place mutually agreed upon by the metrological authority and the applicant.

5.2 Initial verification

5.2.1 Tests

Instruments shall comply with the requirements in clauses 2 (except 2.9) and 3 for any product(s) for which they are intended and when operated under normal conditions of use.

Tests shall be carried out by the appropriate metrological authority, in-situ, in a normal installation. The instrument shall be installed so that an automatic weighing operation will be virtually the same for testing as it is for a transaction.

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

5.2.2 In-motion tests

In-motion tests shall be conducted in accordance with 5.1.3.1, with the exception that the types of vehicles and, for tests with coupled wagons, the number of vehicles in the test train shall be in accordance with the normal operation of the instrument and used in accordance with clause 6.

5.2.3 Provision of means for testing

For the purposes of testing, the applicant may be required to furnish the metrological authority with the test vehicles, material, qualified personnel and a control instrument. The instrument under test may be used as a control instrument provided it complies with the requirements in 2.8.3.2.

5.2.4 Place of testing

Initial verification tests shall be conducted entirely at the place of installation and during testing, the instrument shall include all parts which form the assembly as intended for normal use.

5.3 In-service inspection

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

6 On site test methods

6.1 Proportion of reference wagons in a test train

The proportion of reference wagons to the remaining wagons in a test train shall be in accordance with Table 4.

Table 4

Total number of wagons in test train (n)	Minimum number of reference wagons
$< n \leq 10$	n
$10 < n \leq 30$	10
$30 < n$	15

6.2 In-motion tests with coupled wagons

If the number of reference wagons is less than the total number of wagons in a test train, the reference wagons shall be distributed throughout the train.

6.3 In-motion tests with liquid load

When using liquid loads, tests shall be consistent with the intended use of the instrument.

ANNEX A
TEST PROCEDURES FOR AUTOMATIC RAIL-WEIGHBRIDGES
(Mandatory)

Meaning of symbols:

I	=	Indication
L	=	Load
ΔL	=	Additional load to next changeover point
P	=	I + 0.5 d – ΔL = Indication prior to rounding
P_n	=	n^{th} indication prior to rounding
d	=	Scale interval
E	=	P – L = error
E_0	=	Error calculated at zero
E_c	=	Corrected error
mpe	=	Maximum permissible error
EUT	=	Equipment under test
Max	=	Maximum capacity
Min	=	Minimum capacity

A.1 Documentation (5.1.1)

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

A.2 Comparing construction with documentation (5.1.1)

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

Examine the simulator to ensure that it is adequate for train movement simulation. It shall provide the signals from track switches, or other vehicle type identification devices, normally transmitted when a vehicle passes over the weighing system. It is not expected to simulate effects such as dynamic loading.

A.3 Initial examination

A.3.1 Metrological characteristics

Note metrological characteristics according to the test report format (see OIML R 106-2).

A.3.2 Descriptive markings (3.6)

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

A.3.3 Verification marks (3.7)

Check the arrangements for verification marks according to the checklist given in the test report format.

A.4 General

A.4.1 General requirements for electronic instruments under test (EUT) (4)

Energize the EUT for a time period equal to or greater than the warm-up time specified by the manufacturer and maintain it energized for the duration of the test.

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 it if a significant fault has been indicated.

The deviation of the no-load indication due to any test condition shall be recorded, and any load indication shall be corrected accordingly to obtain the weighing results.

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

A.4.1.1 Indication with a scale interval smaller than d

If an instrument with digital indication has a device for displaying the indication with a smaller scale interval, this device may be used to calculate the error. If a device is used it should be noted in the test report.

A.4.2 Calculation of error

For instruments with digital indication with a test scale interval (see note in 5.1.3.2) less or equal to 0.1 d, the device may be used directly to read the error.

For instruments with digital indication and with a test scale interval greater than 0.1 d, changeover points are used to determine the indication of the instrument, prior to rounding, as follows:

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

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

The error prior to rounding is:

$$E = P - L$$

thus $$E = (I + 0.5\ d - \Delta L) - L$$

Example: an instrument with a scale interval, d, of 10 kg is loaded with 1000 kg and thereby indicates 1000 kg. After adding successive weights of 1 kg, the indication changes from 1000 kg to 1010 kg at an additional load of 3 kg. Inserted in the above formula these observations give:

$$P = (1000 + 5 - 3)\ kg = 1002\ kg$$

Thus the true indication prior to rounding is 1002 kg, and the error is:

$$E = (1002 - 1000)\ kg = 2\ kg$$

A.5 Test program

A.5.1 Pattern evaluation (5.1)

All tests of clauses A.6 to A.10 shall normally be applied for pattern evaluation.

The tests for clauses A.6 to A.10 shall be performed with static load, a wheel movement simulator (switches) may be used if necessary for the calculation of the weighing results.

A.5.2 Initial verification (5.2)

Initial verification tests normally only includes the tests in clause A.11.

The test shall include all dynamic in-motion effects corresponding to normal operation of the instrument.

A.6 Performance tests during pattern evaluation

The equipment under test should have the following items associated with it, for the purpose of testing:

- weight simulator;
- train wheel simulator.

For practical reasons, the weight simulator may take various forms. For example, it may be a weigh pan or platform scale of approximately 1/1000th of the weight range of a site installation.

Whichever method is adopted, it must be independently calibrated and readable to at least 0.1 d.

A.6.1 General conditions

A.6.1.1 Temperature

The tests shall be performed at a steady ambient temperature, usually normal room temperature unless otherwise specified.

The temperature is deemed to be steady when the difference between the extreme temperatures noted during the test does not exceed one-fifth of the temperature range of the given instrument without being greater than 5 °C and the rate of change does not exceed 5 °C per hour.

A.6.1.2 Power supply

Instruments using electric power shall normally be connected to the power supply and “on” throughout the tests.

A.6.1.3 Automatic zero-setting

During the tests, the automatic zero-setting device may be switched off. When this is done it should be mentioned in the test report.

For certain tests the test description specifies whether the automatic zero-setting shall be operative or inoperative.

A.6.1.4 Recovery

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

A.6.2 Checking of zero

A.6.2.1 Range of zero-setting (3.3.5)

A.6.2.1.1 Semi-automatic zero-setting

This test shall not be carried out during the span stability test.

With the load receptor empty, set the instrument to zero. Place a test load on the load receptor and use the zero-setting device. Continue incrementing the test load until the zero-setting device fails to re-zero when activated. The maximum load that can be re-zeroed is the positive portion of the zero-setting range.

To test the negative portion of the zero-setting range, recalibrate the instrument with an additional weight on the load receptor at the zero and span points. This additional weight should be greater than the negative zero-setting range. Then remove weights and after each weight is removed, use the zero-setting device. The maximum load that can be removed while the instrument can still be re-zeroed by the zero-setting device, is the negative portion of the zero-setting range.

Recalibrate the instrument without this additional weight.

A.6.2.1.2 Automatic zero-setting

This test shall not be carried out during the span stability test.

With the load receptor empty, add weights in small quantities and after each weight is added allow time for the automatic zero-setting device to function to see if the instrument is re-zeroed automatically. Repeat this procedure until the instrument will not be re-zeroed automatically. The maximum load that can be re-zeroed is the positive portion of the automatic zero-setting range.

To test the negative portion of the zero-setting range recalibrate the instrument with an additional weight on the load receptor at the zero and span points. This additional weight should be greater than the negative zero-setting range. Then remove weights and after each weight is removed, allow time for the automatic zero-setting device to function to see if the instrument is re-zeroed automatically. The maximum load that can be removed while the instrument can still be re-zeroed by the zero-setting device, is the negative portion of the zero-setting range.

Re-zero the instrument without this additional weight.

A.6.3 Setting to zero before loading

For instruments with digital indication, the adjustment to zero, or the determination of the zero point is carried out as described in A.6.5.1.

A.6.4 Association of indicating and printing devices (2.7)

If the instrument has more than one indicating device, the indications of the various devices (both indicating and printing) are compared during the test.

A.6.5 Nonautomatic tests of the control instrument

Note: This subclause is only applicable to instruments which are to be used as control instruments.

A.6.5.1 Accuracy of zero-setting (2.8.1.2)

A.6.5.1.1 Semi-automatic zero-setting

The accuracy of the zero-setting device is tested by setting the instrument to zero and then determining the additional load at which the indication changes from zero to one scale interval above zero. The error at zero is calculated according to the description in A.4.2.

A.6.5.1.2 Automatic zero-setting

The indication is either brought outside the zero range, or the automatic zero-setting is disabled. Then the additional load at which the indication changes from one scale interval to the next above is determined and the error is calculated according to the description in A.4.2. It is assumed that the error at zero load would be equal to the error at the load in question.

A.6.5.2 Determination of weighing performance

A.6.5.2.1 Preloading

Before the first weighing test the instrument shall be preloaded once to Max.

A.6.5.2.2 Weighing test (2.8.1.5.1)

Apply substitution material from zero up to and including Max, and then remove the material back to zero. When determining the initial intrinsic error, at least ten different load values are selected, and for other weighing tests at least five are selected. The values of the loads selected shall include Max and Min, and values at or near those at which the maximum permissible error (mpe) changes.

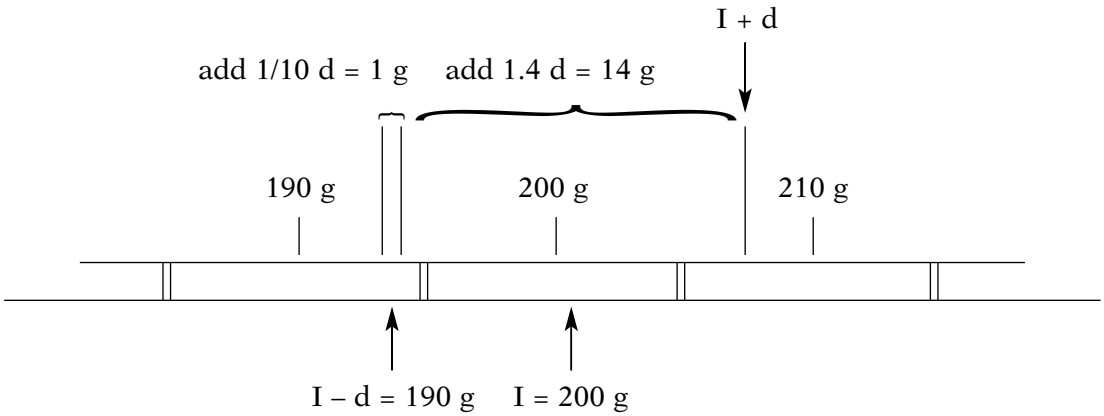
It should be noted that when loading or unloading weights the load must be respectively increased or decreased in a uniform progression.

A.6.5.3 Discrimination test (2.8.1.6)

The following tests are performed with three different loads, e.g. Min, 0.5 Max and Max.

A load plus sufficient substitution material (e.g. 10 times 0.1 d) is placed on the load receptor. The additional material is then successively removed until the indication, I, is decreased unambiguously by one actual scale interval, I – d. Replace substitution material equivalent to 0.1 d and then a load equal to 1.4 d shall be gently placed on the load receptor and the result will be increased by one actual scale interval above the initial indication, I + d.

Example: instrument with d = 10 g



The indication at start is I = 200 g. Remove additional weights until the indication changes to I – d = 190 g. Add 0.1 d – 1 g and thereafter 1.4 d = 14 g. The indications must then be I + d = 210 g.

A.7 Additional functionality

A.7.1 Warm-up time test (4.3.5)

(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 indicating device. Verify that it is not possible to initiate automatic weighing or printout until the indication has stabilized or until completion of the warm-up time if this is specified by the manufacturer.
(3) As soon as the indication of the indicating device has stabilized, set the instrument to zero and determine the error of zero-setting.
(4) Apply a load close to Max. Determine the error by the method in A.4.2.
(5) Repeat stages (3) and (4) after 5, 15 and 30 minutes.

A.7.2 Agreement between indicating and printing devices (2.7)

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

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

A.8 Influence factor tests

Summary of tests

	Test	Characteristic under test	Conditions applied
A.8.1	Static temperature	Influence factor	mpe(*)
A.8.2	Damp heat, steady state	Influence factor	mpe
A.8.3	Mains power supply voltage variation (AC)	Influence factor	mpe
A.8.4	Battery power supply voltage variation (DC)	Influence factor	mpe

(*) mpe: maximum permissible error

A.8.1 Static temperature tests (2.9.1)

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

Table 5

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

Supplementary information to the IEC test procedures

Object of the test:	To verify compliance with the provisions in 2.9.1 under conditions of dry heat (non condensing) and cold.
Test procedures in brief:	
Precondition:	16 hours.
Condition of the EUT:	Normal power supplied and “on” for a time period equal to or greater than the warm-up time specified by the manufacturer. Power is to be “on” for the duration of the test.
Stabilization:	2 hours at each temperature under “free air” conditions.
Temperature:	As specified in 2.9.1.
Temperature sequence:	Reference temperature of 20 °C; Specified high temperature; Specified low temperature; A temperature of 5 °C; Reference temperature of 20 °C.
Number of test cycles:	At least one cycle.
Weighing test:	Adjust the EUT as close to zero indication as practicable prior to the test (if an automatic zero-tracking device is connected, adjust it to a value near zero). The EUT shall not be readjusted at any time during the test.

After stabilization at the reference temperature and again at each specified temperature, apply at least five different test loads or simulated loads and record:

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

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

A.8.2 Damp heat, steady state (4.3.3)

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

Table 6

Environmental phenomena	Test specification	Test set-up
Damp heat, steady state	Upper limit temperature and relative humidity of 85 % for 2 days (48 hours)	IEC 68-2-56
Use IEC 68-2-28 for guidance on damp heat tests and refer to Bibliography [2] for specific parts of the IEC test.		

Supplementary information to the IEC test procedures

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

Precondition: None required.

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

Adjust the EUT as close to zero indication as practicable prior to the test (if an automatic zero-tracking device is connected, adjust it to a value near zero). The EUT shall not be readjusted at any time during the test.

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

Stabilization:	3 hours at reference temperature and 50 % humidity; 2 days (48 hours) at the upper limit temperature as specified in 2.9.1.
Temperature:	Reference temperature of 20 °C and at the upper limit as specified in 2.9.1.
Relative humidity:	50 % at reference temperature; 85 % at upper limit temperature.
Temperature-humidity sequence:	Reference temperature of 20 °C at 50 % humidity; The upper limit temperature at 85 % humidity; Reference temperature of 20 °C at 50 % humidity.
Number of test cycles:	At least one cycle.
Weighing test and test sequence:	After stabilization of the EUT at reference temperature and 50 % humidity, apply at least five different test loads or simulated loads and record: a) date and time; b) temperature; c) relative humidity; d) test load; e) indications (as applicable); f) errors; g) functional performance. Increase the temperature in the chamber to the upper limit and increase the relative humidity to 85 %. Maintain the EUT at no load for a period of 2 days (48 hours). Following the 2 days, apply at least five test loads and record the data as indicated above. Allow full recovery of the EUT before any other tests are performed.
Maximum allowable variations:	All errors shall be within the maximum permissible errors specified in Table 2.

A.8.3 Mains power supply voltage variation (AC) (2.9.2)

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

Table 7

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

Supplementary information to the IEC test procedures

Object of the test:	To verify compliance with the provisions in 2.9.2 under conditions of voltage variations.
Test procedures in brief:	
Precondition:	None required.
Condition of the EUT:	Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Power is to be "on" for the duration of the test. Adjust the EUT as close to zero indication as practicable prior to the test. If it has an automatic zero-setting function then the instrument should be set to zero after applying each level of voltage.
Number of test cycles:	At least one cycle.
Weighing test:	The EUT shall be tested at no load and with one test load or simulated load between 50 % and maximum capacity of the EUT.
Test sequence:	Stabilize the power supply at the reference voltage within the defined limits and record: a) date and time; b) temperature; c) relative humidity; d) power supply voltage; e) test loads; f) indications (as applicable); g) errors; h) functional performance. Repeat the test weighing for each of the voltages defined in IEC 1000-4-11 section 5 (noting the need in certain cases to repeat the test weighing at both ends of the voltage range) and record the indications.
Maximum allowable variations:	All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in Table 2.

A.8.4 Battery power supply voltage variation (DC) (2.9.3 and 4.3.8)

Test method:	Variation in DC power supply. Where the EUT continues to operate below the stated battery voltage, the following test shall be conducted using an equivalent variable DC power source.
Object of the test:	To verify compliance with the provisions in 2.9.3 and 4.3.8 under conditions of varying DC power supply. The requirements shall be met either by use of an equivalent variable DC power source or by allowing the battery voltage to fall by use.

Reference to standard:	No reference to international standards can be given at the present time.
Test procedures in brief:	The test consists of subjecting the EUT to DC power variations when the former is operating under normal atmospheric conditions with one test load or simulated load between 50 % and maximum capacity of the EUT.
Test severity:	Supply voltage: lower limit, the voltage at which the EUT clearly ceases to function (or is automatically put out of service) + 2 % of this voltage.
Number of test cycles:	At least one cycle.
Conduct of the test:	
Precondition:	None required.
Test equipment:	Variable DC power source; Calibrated voltmeter; Load cell simulator, if applicable.
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 as part of the automatic weighing process, then the instrument should be set to zero after applying each level of voltage.
Test sequence:	Stabilize the power supply at nominal battery voltage ±2 % and record the following data at no load and with one load or simulated load between 50 % and maximum capacity of the EUT: a) date and time; b) temperature; c) relative humidity; d) power supply voltage; e) test load; f) indications (as applicable); g) errors; h) functional performance. Reduce the power supply to the EUT until the equipment clearly ceases to function and note the voltage. Switch the EUT "off" and increase the power supply voltage to nominal battery voltage ±2 %. Switch the EUT "on" and reduce the power supply voltage to the above noted voltage (out of service voltage) + 2 % of the noted voltage. Record the data indicated above.

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

A.9 Disturbance tests (4.1.2 and 4.3.4)

Summary of tests

	Test	Characteristic under test	Conditions applied
A.9.1	Voltage dips and short interruptions	Disturbance	sf(*)
A.9.2	Electrical fast transients/ burst immunity	Disturbance	sf
A.9.3	Electrostatic discharge	Disturbance	sf
A.9.4	Electromagnetic susceptibility	Disturbance	sf

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

A.9.1 Voltage dips and short interruptions

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

Table 8

Environmental phenomena	Test specification	Test set-up
Voltage dips and short interruptions	Interruption from reference voltage to zero voltage for one half cycle Interruption from reference voltage to 50 % of reference voltage for two half cycles These mains voltage interruptions shall be repeated ten times with a time interval of at least 10 seconds	IEC 1000-4-11
The reference voltage (rated voltage) shall be as defined in IEC 1000-4-11 section 5. Refer to Bibliography [6] for specific parts of the IEC test.		

Supplementary information to the IEC test procedures

Object of the test: To verify compliance with the provisions in 4.1.2 under conditions of short time mains voltage interruptions and reductions.

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. The EUT shall not be re-adjusted at any time during the test except to reset if a significant fault has been indicated.
Number of test cycles:	At least one cycle.
Weighing test and test sequence:	Stabilize all factors at nominal reference conditions. Apply one load or simulated load between 50 % and maximum capacity of the EUT and record: a) date and time; b) temperature; c) relative humidity; d) power supply voltage; e) test load; f) indications (as applicable); g) errors; h) functional performance. Interrupt the power supply to zero voltage for a period equal to one half cycle and conduct the test as detailed in IEC 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.9.2 Electrical fast transients/burst immunity

Electrical fast transients/burst immunity tests are carried out according to basic standard IEC 1000-4-4 (1995), for 2 minutes with a positive polarity and for 2 minutes with a negative polarity. As detailed in Bibliography [5] and according to Tables 9.1, 9.2 and 9.3.

Table 9.1: Ports for signal lines and control lines

Environmental phenomena	Test specification	Test set-up
Fast transient common mode	0.5 kV (peak) 5/50 ns T_l/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 manufacturer’s functional specification.		

Table 9.2: 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 9.3: 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 4.1.2 under conditions where fast transients are superimposed on the mains voltage.

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. The EUT shall not be readjusted at any time during the test except to reset if a significant fault has been indicated.

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

Weighing test: Stabilize all factors at nominal reference conditions. Apply one load or simulated load between 50 % and maximum capacity of the EUT and record the following with and without the transients:

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

Maximum allowable variations: The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed the value given in T.4.2.5 or the instrument shall detect and act upon a significant fault.

A.9.3 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 10 and as detailed in Bibliography [3].

Table 10

Environmental phenomena	Test specification	Test set-up
Electrostatic discharge	8 kV air discharge 6 kV contact discharge	IEC 1000-4-2
Note: The 6 kV contact discharge shall be applied to accessible conductive parts. Metallic contacts e.g. in battery compartments or in socket outlets are excluded from this requirement.		

Contact discharge is the preferred test method. 20 discharges (10 with positive and 10 with negative polarity) shall be applied on each accessible metal part of the enclosure. The time interval between successive discharges shall be at least 10 seconds. In the case of a non-conductive enclosure, discharges shall be applied on the horizontal 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 10 are not required.

Supplementary information to the IEC test procedures

Object of the test: To verify compliance with the provisions in 4.1.2 under conditions where electrostatic discharges are applied.

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. The EUT shall not be re-adjusted at any time during the test except to reset if a significant fault has been indicated.

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

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

50 % and maximum capacity of the EUT and record the following with and without electrostatic discharge:

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

Maximum allowable variations: The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed the value given in T.4.2.5 or the instrument shall detect and act upon a significant fault.

A.9.4 Electromagnetic susceptibility

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

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

Table 11: Enclosure port

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

Supplementary information to the IEC test procedures

Object of the test: To verify compliance with the provisions in 4.1.2 under conditions of specified electromagnetic fields applied.

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. The EUT shall not be re-adjusted at any time during the test except to reset if a significant fault has been indicated.

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

Weighing test:

Stabilize all factors at nominal reference conditions. Apply one load or simulated load between 50 % and maximum capacity of the EUT and record the following with and without electromagnetic fields:

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

Maximum allowable variations:

The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed the value given in T.4.2.5 or the instrument shall detect and act upon a significant fault.

A.10 Span stability test (4.4.3)

Summary of test

	Test	Characteristic under test	Condition applied
A.10	Span stability	Stability	1/2 absolute mpe(*)

(*) mpe: maximum permissible error on initial verification in 2.2.2 Table 2. Note: the maximum permissible error for the zero point shall also be taken into consideration.

Test method:

Span stability.

Object of the test:

To verify compliance with the provisions in 4.4.3 after the EUT has been subjected to the performance tests.

Reference to standard:

No reference to international standards can be given at the present time.

Test procedures in brief:

The test consists of observing the variations of the error of the EUT or simulator under sufficiently constant ambient conditions (reasonable constant conditions in a normal laboratory environment) at various intervals: before, during, and after the EUT has been subjected to performance tests.

The performance tests shall include the temperature test and, if applicable, the damp heat test; an endurance test shall not be included. Other performance tests listed in this Annex may be performed.

The EUT shall be disconnected twice from the mains power supply (or battery supply where fitted)

for at least 8 hours during the period of the test. The number of disconnections may be increased if so specified by the manufacturer or at the discretion of the approval authority in the absence of any specification.

In the conduct of this test, the operating instructions for the instrument as supplied by the manufacturer shall be considered.

The EUT shall be stabilized at sufficiently constant ambient conditions after switch-on for at least five hours, and at least 16 hours after the temperature and damp heat tests have been performed.

Test severities:

Test duration: 28 days or the time period necessary to conduct the performance tests, whichever is less.

Time (t) between tests (days): $0.5 \leq t \leq 10$.

Test load: near maximum capacity (Max); the same test weights shall be used throughout the test.

Maximum allowable variations:

The variation in the errors of indication shall not exceed half the absolute value of the maximum permissible error in clause 2.2.2 Table 2 for the test load applied on any of the n measurements.

Number of tests (n):

At least 8 except where the differences of the results indicate a trend more than half the allowable variation specified, the measurements shall be continued until the trend comes to rest or reverses itself, or until the error exceeds the maximum allowable variation.

Precondition:

None required.

Test equipment:

Verified mass standards or simulated load.

Condition of the EUT:

Normal power supplied and “on” for a time period equal to or greater than the warm-up time specified by the manufacturer.

Adjust the EUT as close to zero indication as practicable before each test. The automatic zero-tracking should be made inoperative during the test (if the EUT is so equipped).

Test sequence:

Stabilize all factors at nominal reference conditions.

Adjust the EUT as close to zero as possible.

Automatic zero-tracking shall be made inoperative and the automatic built-in span adjustment device shall be made operative.

- Initial measurement

Determine the span error using the following method:

1. Determine the initial zero error (E_0)

If necessary disable any automatic zero-setting or zero-tracking devices, by placing a "zero weight" of for example 10 times the scale interval on the load receptor. Note the indication at zero (I_0).

Either by use of an indicator with a suitable higher resolution scale interval or using the change point weight method in A.4.2.2 (noting the total addition change point weight ΔL_0) determine and record the initial zero error (E_0).

2. Determine the error at near Max capacity (E_L)

Carefully remove the change point weights (if used) and apply the test load (or simulated load) and note the indication (I_L).

Either by use of an indicator with a suitable higher resolution scale interval or using the change point weight method in A.4.2.2 (noting the total addition change point weight ΔL) determine and record the error at near Max capacity (E_L).

Record:

a) date and time;
b) temperature;
c) barometric pressure;
d) relative humidity;
e) value of 0.1 d;
f) test load;
g) total of added change point weights at zero load ΔL_0;
h) total of added change point weights at test load ΔL;
i) the following indications:
   - indication at zero (I_0);
   - the indication of test load (I_L);
j) calculate:
   - initial zero error E_0;
   - error at test load (E_L);
k) change in location

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

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

- Subsequent measurements

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

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

The measurements shall continue until there are at least 8 measurements except where the differences of the results indicate a trend more than half the allowable variation specified, the measurements shall be continued until the trend comes to rest or reverses itself, or until the error exceeds the maximum allowable variation.

A.11 In-situ tests

A.11.1 General

Note the accuracy class required for wagon weighing and train weighing.

Ensure that the desired scale interval and the maximum wagon weight comply with Table 3. Check that the minimum capacity complies with 2.4.

Check that the minimum wagon weight complies with 2.5.

For pattern evaluation, testing may be carried out for coupled weighing, uncoupled weighing or train weighing depending on the approval required by the applicant.

For initial verification, tests shall be carried out corresponding to the normal site operation of the instrument.

A.11.2 Rail alignment

If exemption from the alignment calibration at Annex B is required, alignment of ±1 mm must be demonstrated to the satisfaction of the metrological authority by means of:

- survey by the authority;
- submission of independent survey results;
- other mutually acceptable procedure.

A.11.3 Control instrument

Establish whether or not the instrument is to be used as the control instrument. If it is to be used as the control instrument it shall comply with 2.8.3.2.

If not the static weighing (2.8.1) shall be omitted.

If wagons have to be moved over some distance from the control instrument to the EUT, the conditions must be closely controlled. Differences in weather conditions will cause errors which will not be determinable and so this should be avoided where possible.

A.11.4 Static weighing (2.8.1)

Apply test loads from zero up to and including Max, then remove the test loads back to zero. Ensure that the error is recorded at change in load (normally in steps of one tonne). Ensure that errors are recorded in line with A.4.2. Record the errors and compare them to the limits in Table 2.

A.11.5 Eccentricity tests (2.8.1.5.3)

Apply the eccentricity test only where it is practical and safe to do so. On installations where the weighed length is very short it may not be possible to apply this test fully. If so note the reduced load.

A.11.6 Coupled weighing (5.1.3.1.2)

A.11.6.1 Static weighing (empty)

Select the required number of reference wagons as in Table 4 and weigh them individually, statically and uncoupled on the control instrument.

Any errors shall not exceed the appropriate mpe as given in Table 1 and 2.2.1.

A.11.6.2 Coupled wagon weighing (empty)

Record the wagon weights of the coupled reference wagons, in-motion (6.2) as they are displayed or printed by the instrument under test at a variety of speeds up to the maximum. Record the errors.

The instrument under test must behave correctly for the condition of operating speed (3.4.4). The printer shall not print the weight of any wagon that has travelled over the load receptor at a speed outside the range of operating speeds. An appropriate indication shall be included on the printout for any wagon weight not printed. A sub-total may be printed exclusive of wagons which have not been weighed provided that it is indicated it is not the total train weight.

The instrument shall also operate in the following manner in the case of rollback (3.4.5). The roll-back condition shall be detected automatically and the weighing process shall be aborted, i.e. the instrument shall either:

a) not indicate or print any weighing result, or
b) give a clear indication that any indicated or printed weighing result may not be correct.

Repeat the in-motion tests to obtain not less than 60 wagon weights.

A.11.6.3 Static weighing (full)

Select the required number of reference wagons (see Table 4) and weigh them individually, statically and uncoupled on the control instrument.

Take note of the need to only partially fill some of the wagons (5.1.3.1.2).

Any errors shall not exceed the appropriate mpe as given in Table 1 and 2.2.1.

A.11.6.4 Coupled wagon weighing (full)

Record the wagon weights of the coupled reference wagons, in-motion as they are displayed or printed by the instrument under test at a variety of speeds up to the maximum. Record the errors.

The instrument under test must behave correctly for the condition of operating speed (3.4.4). The printer shall not print the weight of any wagon that has travelled over the load receptor at a speed outside the range of operating speeds. An appropriate indication shall be included on the printout for any wagon weight not printed. A sub-total may be printed exclusive of wagons which have not been weighed provided that it is indicated it is not the total train weight.

The instrument shall also operate in the following manner in the case of rollback (3.4.5). The roll-back condition shall be detected automatically and the weighing process shall be aborted, i.e. the instrument shall either:

a) not indicate or print any weighing result, or

b) give a clear indication that any indicated or printed weighing result may not be correct.

A.11.7 Uncoupled weighing (5.1.3.1.1)

A.11.7.1 Static weighing

Select not less than 5 wagons and fill them with a range of loads from zero load to that of a fully loaded wagon and weigh them statically on the control instrument.

A.11.7.2 Uncoupled wagon weighing

Record the wagon weights of the uncoupled reference wagons, in-motion, as they are displayed or printed by the instrument under test at a variety of (controlled) speeds including near Max, near Min and the typical site operating speed. Record the errors.

The instrument under test must behave correctly for the condition of operating speed (3.4.4). The printer shall not print the weight of any wagon that has travelled over the load receptor at a speed outside the range of operating speeds. An appropriate indication shall be included on the printout for any wagon weight not printed. A sub-total may be printed exclusive of wagons which have not been weighed provided that it is indicated it is not the total train weight.

A minimum of 5 weight printouts of each wagon shall be obtained.

A.11.8 Train weighing

Tests are the same as in A.11.6 and may be carried out in conjunction with A.11.6 without repeating the test, if both modes of operation are required.

The weights of the reference wagons shall be summed and any errors shall not exceed the appropriate mpe as given in Table 1 and applied to the summation.

ANNEX B

ALIGNMENT CALIBRATION OF SINGLE-AXLE WEIGHING INSTRUMENTS

The alignment calibration is NOT RECOMMENDED as an adequate substitute for verification of reference wagons by full draught weighing and shall only be applied under the conditions in 2.8.3.2.

B.1 The alignment calibration applies to instruments that operate by partial weighing of two-axle wagons and the same instrument is required for use as the control instrument for the purposes of determining the mass of reference wagons in 2.8.3.2.

B.2 Instruments that operate by partial weighing are exempt from the alignment calibration procedure provided the following:

- the top surface of both rails along the length of the weigh zone are vertically aligned to ±1 mm, and
- the alignment has been checked along both rails at not less than two positions on the load receptor and not less than two positions within a wagon length from the load receptor on each associated apron.

B.3 For instruments not covered by B.2, a calibration correction shall be determined by application of the alignment calibration procedure in B.4. This calibration correction shall be added to each totalized wagon weight to determine the mass of each reference wagon.

B.4 The alignment calibration is conducted with the use of a single empty uncoupled wagon of a wheelbase similar to those wagons used for in-motion testing. An example of an alignment calibration is given in B.5.

B.4.1 While motionless, each axle shall be weighed in the center and at each end of the load receptor.

B.4.2 The six weight indications noted in B.4.1 shall be summed up and the result divided by three.

B.4.3 Standard weights, as specified in B.4.4, shall be evenly distributed over the empty wagon and the weighing procedure in B.4.1 and B.4.2 shall be repeated.

B.4.4 The sum of the standard weights referred to in B.4.3 shall be at least equal to the larger of the following values:

- the difference between the maximum capacity and 1.5 times the weight of the wagon as determined in B.4.2, with the result rounded down to the nearest 1 tonne;
- 10 tonnes.

B.4.5 The difference between the results of the computations in accordance with B.4.2 and B.4.3 shall be subtracted from the total value of the standard weights, the result being the calibration correction.

B.5 Example of alignment calibration test sheet

Accuracy class: 1
Maximum capacity: a = 35 t
Typical wagon tare weight: b = 11.5 t
Mass of standard weights required: c = 17 t (a – 1.5 b, rounded down)
Scale interval: 0.1 t
Scale interval for stationary load: 0.01 t

Table 12

	Position on load receptor	Indicated weight (t)	
		Empty wagon	Loaded wagon
First axle	Leading end	5.76	14.27
	Middle	5.75	14.26
	Trailing end	5.75	14.26
Second axle	Leading end	5.75	14.25
	Middle	5.75	14.25
	Trailing end	5.74	14.24
Total of six weighings		34.50	85.53
Divide total by three		d = 11.50	e = 28.51
Derived mass of standard weights		f = e – d = 17.01	
Calibration		c – f = –0.01	

The calibration correction shall be added to the totalized indicated weight of each reference wagon weighed while stationary and uncoupled. In the case given above, the minus sign should be noted. Therefore, if the totalized indicated weight is 41.38, the corrected weight will be:

$$41.38 + (–0.01) = 41.37$$

Note: The calibration correction computed in this example is not intended to be typical.

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).

Printed in France

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130, rue Général-de-Gaulle, 10000 Troyes