General definitions

Weighing instrument

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

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

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

Non-automatic weighing instrument

Instrument that requires the intervention of an operator during the weighing process to decide that the weighing result is acceptable, for example to deposit on or remove from the receptor, the load to be measured and also to obtain the result.

The instrument permits direct observation of the weighing results either displayed or printed; both possibilities are covered by the word "indication".

Note: Deciding that the weighing result is acceptable includes any intelligent action by the operator that affects the result, such as taking an action when an indication is stable or adjusting the mass of the weighed load, and to make a decision regarding the acceptance of each weighing result on observing the indication or releasing a print out. A Non-automatic weighing process allows the operator to take an action (i.e. adjust the load , adjust the unit price, determine that the load is acceptable, etc.) which influences the weighing result in the case where the weighing result is not acceptable [As per OIML R 76; 2006(E), T.1.2]

Automatic weighing instrument

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

Metrological characteristics of an instrument

Actual scale interval (d)

Value expressed in units of mass of,—

the difference between the values corresponding to two consecutive scale marks, for analogue indication, or

the difference between two consecutive indicated values, for digital indication

Verification scale interval (e) –

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

Scale interval of numbering –

Value of the difference between two consecutive numbered scale marks.

Number of verification scale intervals (single interval instrument)

Quotient of the maximum capacity and the verification scale interval:

n= Max/e

Units of measurement –

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

(ii) For special application e.g. trade with precious stones, the metric carat (1 carat = 0.2 g) may be used as unit of measurement. A symbol for the carat shall be "c".

Metrological requirements

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

Instruments are classified according to:

- the verification scale interval,
- the number of verification scale intervals.
- A minimum capacity (Min) is specified to indicate that the instrument should not be used for measuring loads below that limit.

Principles of classification

Accuracy classes

The accuracy classes for instrument and their symbols shall be as given in Table 15.

TABLE 15

Class	*Symbol*
Special accuracy	I
High accuracy	II
Medium accuracy	III
Ordinary accuracy	IIII

Verification scale interval

(i) *Verification scale interval shall be in the form*

$1 \times 10^k, 2 \times 10^k, 5 \times 10^k$

k being a positive or negative whole number or equal to zero.

(ii) The verification scale interval for different types of instruments shall be as given in Table 16.

TABLE 16

Type of instrument	*Verification scale interval*
Graduated, without auxiliary indicating device	e = d
Graduated, with auxiliary indicating device	e is chosen by the manufacturer according to requirement in sub-paragraph (3) and clause (iii) of sub-paragraph (5) of this paragraph
Non-graduated	e is chosen by the manufacturer according to sub-paragraph (3) of this paragraph.

Classification of instruments (sub paragraph -3)

(i) The verification scale interval, number of verification scale intervals and the minimum capacity, in relation to the accuracy class of an instrument, shall be as given in Table 17.

Table 17.

Accuracy class	*Verification scale interval e*	*Number of verification scale intervals n = Max/e*		*Minimum Capacity*
		minimum	maximum	
Special I	0.001 g ≤ e (1 mg≤ e)	50 000*		100 e
High II	0.001g ≤ e ≤ 0.05 g (1mg ≤ e ≤ 50 mg)	100	100 000	20 e
	0.1 g ≤ e (100mg ≤ e)	5000	100 000	50 e
Medium III	0.1 g ≤ e ≤ 2 g (100mg ≤ e ≤ 2g)	100	10 000	20 e
	5 g ≤ e	500	10 000	20 e
Ordinary IIII	5 g ≤ e	100	1000	10 e

Note: for value of e less than 1 mg in respect of class I accuracy instruments, e shall be taken to be equal to 1 mg for verification/inspection

Clause (iii) sub-paragraph (5) of this paragraph.

Verification scale interval

The verification scale interval e shall be determined by the expression

$$d < e \leq 10\,d$$

such that $e = 1 \times 10^k$ kg, 2×10^k kg, 5×10^k kg

k being a positive or negative whole number, or zero. This condition shall not apply to an instrument of class I with d > 1 mg. In that case e shall uniformly be 1 mg.

The value of e, calculated following this rule, are, for example,

TABLE 19

d =	0.1 g	0.2 g	0.5 g
e =	1 g	1 g	1 g

Maximum permissible errors

Values of maximum permissible errors on verification/ reverification

The maximum permissible errors allowed for increasing or decreasing loads shall be as given Table 20.

TABLE 20

Maximum permissible errors on verification/ reverification	*For loads m expressed in verification scale intervals e*			
	Class I	*Class II*	*Class III*	*Class IIII*
± 0.5 e	Min ≤ m ≤ 50 000	Min ≤ m ≤ 5000	Min ≤m ≤500	Min ≤m ≤50
±1 e	50000< m ≤ 200 000	5000< m ≤ 20 000	500 ≤ m ≤ 2000	50 < m ≤200
±1.5 e	200000 < m	20000<m≤100000	2000 < m ≤ 10000	200 < m ≤ 1000

Values of maximum permissible errors in inspection

The maximum permissible errors during inspection shall be **twice** the maximum permissible errors allowed on verification.

Multi-interval instrument

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

Additional requirements for a multi-interval instrument

(i) *Partial weighing range*

Each partial range (index $i = 1, 2...$) shall be defined by:

–its verification scale intervals e_i, $e_{i+1} > e_i$

its maximum capacity Max_i

its minimum capacity $Min_i = Max_{(i-1)}$ (for $i = 1$ the minimum capacity is $Min_1 = Min$)

The number of verification scale intervals n for each partial range is equal to

$$n_i = Max_i/e_i$$

(ii) *Accuracy class*

e_i and n_i in each partial weighing range, and min_i shall comply with the requirements given in Table 17 according to the accuracy class of the instrument.

(iii) *Maximum capacity of partial weighing ranges*

With the exception of the last partial weighing range, the requirements in Table 18 shall be complied with, according to the accuracy class of the instrument.

TABLE 18

Class	*I*	*II*	*III*	*IV*
Max_i/e_{i+1}	≥ 50 000	≥ 5 000	≥ 500	≥ 50

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

Multiple range instrument

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

➢ On multiple range instruments, if the verification scale intervals are e_1, e_2.... e_r with $e_1 < e_2 < ... < e_r$, Min, n and Max shall be indexed accordingly.

➢ On multiple range instruments each range shall be treated as an instrument with one range.

➢ For special application that are clearly marked on the instrument, an instrument may have weighing ranges in classes I and II or in classes II and III. The instrument as a whole shall then comply with the more severe requirements of sub-paragraph (9) of this paragraph applicable to either of the two classes.

Marking of an instrument

(i) Descriptive markings

All instruments shall carry, in order, the following markings:

(i) *Compulsory in all cases*

- manufacturer's mark, or name written in full,
- indication of accuracy class in the form

for special accuracy	I
for high accuracy	II
for medium accuracy	III
for ordinary accuracy	IIII

- maximum capacity in the form Max =
- minimum capacity in the form Min=
- verification scale interval in the form e =

(ii) *Compulsory if applicable*

- mark of manufacturer's agent for an imported instrument,
- identification mark on each unit of an instrument consisting of separate but associated units.
- pattern approval mark,
- scale interval if < e in the form d =
- maximum additional tare effect in the form T = +...
- maximum subtractive tare effect if different from Max in the form T = – ...
- maximum safe load in the form Lim =
- the special temperature limits within which the instrument complies with the prescribed conditions of correct operation in the form °C/ ..... °C/
- counting ratio on a counting instrument -in the form 1 : ..... or 1/.....
- range of plus/minus indication of a digital comparator instrument in the form +.....mg/g/kg/t

(iii) *Presentation of descriptive markings*

The descriptive marking shall be indelible and of a size shape and clarity allowing easy reading.

They shall be grouped together in a clearly visible place either on a descriptive plate fixed to an instrument, or on a part of the instrument itself.

The markings: Max.....

Min.....

e.....

d if d = e and

Accuracy class.....

shall also be shown near the display of the result if they are not already located there. It shall be possible to seal the plate bearing the descriptive marking.

(a)*Markings in special cases :*

In special case, some of the markings shall be in the form of a table as illustrated below:—

For a multi-interval instrument	*For an instrument with more than one weighing range (W_1, W_2)*		*For an instrument with weighing ranges in different classes*	
	W_1	W_2	W_1	W_2
			II	III
Max 2/5/15 kg	Max 20 kg	100 kg	Max 1000 g	5000 g
Min 20 g	Min 200 g	1 kg	Min 5 g	40 g
e = 1/2/5 g	e = 10 g	50 g	e = 0.1 g	2 g
			d = 0.02 g	2 g

(b) Dimensions :

When several plates are placed one above the other (as for example in the case of an instrument consisting of several separate devices) they should be of the same width. This common width is fixed at 80 mm.

(c) Fixing :

The plate shall be fixed by rivets or screws with one of the rivets of red copper or material having qualities recognised as similar. It should be possible to secure the head of one of the screws by means of a lead cap inserted in a device that cannot be dismantled. The diameter of the rivet or of the lead cap should be able to accommodate a stamp 4 mm in diameter.

(d) Dimension of the letters : The height of capital letters should be at least 2

Calculation of Error

The error of the electronic weighing machine is calculated by using the formula

$$E = I + (1/2)\, e - \Delta L - L,$$

Where,

E = Error calculated;

e = Verification scale interval;

Δ L = Additional load required to change the reading to next higher value;

L = Load kept on the Pan.

Weights

(i) The standard weights used for verification of an instrument shall not have an error greater than 1/3 of the maximum permissible error of the instrument for the applied load.

(iii) Substitution of standard weights : While verifying instrument with maximum of 1 tonne and more, instead of standard weights, any other constant load may be used, provided that standard weights of at least 1 tonne or 50% of maximum, whichever is greater, is used.

Evalulation of Error

At a certain load, L, the indicated value, I, is noted. Additional weights of say 1/10 e are successively added until the indication of the instrument is increased unambiguously by one scale interval (I + e).

The additional load ΔL added to the load receptor gives the indication P, prior to rounding by using the following formula:

$$P = I + \tfrac{1}{2}\, e - \Delta L$$

The error prior to rounding is:

$$E = P - L = I + \tfrac{1}{2}\, e - \Delta L - L$$

The corrected error prior to rounding is:

$$Ec = E - E_0 \leq mpe$$

where E_0 is the error calculated at zero or at a load close to zero (e.g. 10 e).

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

P = (1 000 + 2.5 – 1.5) g = 1 001 g

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

E = (1 001 – 1 000) g = + 1 g

If the changeover point at zero as calculated above was E0 = + 0.5 g, the corrected error is:

Ec = + 1 – (+ 0.5) = + 0.5 g

Test during Verification

i) Visual inspection; **Before testing, the instrument shall be visually inspected for metrological characteristics i.e,**

- indication of accuracy class in the form
  - ✓ for special accuracy — I
  - ✓ for high accuracy — II
  - ✓ for medium accuracy — III
  - ✓ for ordinary accuracy — IIII
- - maximum capacity in the form — Max
- - minimum capacity in the form — Min
- - verification scale interval in the form — e =
- Actual scale interval — d=
- prescribed inscription
- position for verification
- control marks
- Model approval number wherever applicable

The machine is required to be tested for at least 4 tests, namely;

(I)**Weighing test** [clause (i) of sub-para (6) of paragraph 3—Value of maximum permissible error,]

(II)Discrimination test [sub-paragraph (8) of paragraph 3—Discrimination]

(III) Eccentricity test [clause (ii) of sub-paragraph (7) of paragraph 3-Eccentric loading]

(IV) Repeatability test [clause (i) of sub-paragraph (7) of paragraph 3 repeatability (3 weighing on classes III and IIII and 6 weighing for I and II)]

Weighing test

Apply test loads from zero up to and including Max. and similarly remove the test loads back to zero.

- During verification 5 test loads shall be selected and during inspection 3 test loads.
- The test loads selected shall include Max., Min and values at or near those at which the maximum permissible error changes.
- When loading or unloading, the weights shall be progressively increased or decreased.
- If the instrument is provided with an automatic zero setting device, it shall remain in operation during test.
- Error is calculated as given above.
- Every machine is normally tested for its accuracy at load near to zero (e.g.10 e)
- The error E is calculated for every load and it is corrected by subtracting error calculated at or near zero Load
- The corrected error should be less than or equal to the mpe for that load.
- Sufficient readings are taken so that non linearity of indications against increasing and decreasing loads and hysteresis may be estimated.

Error corrected = error calculated – error calculated at or near zero Load

$E_c = E - E_o$ with E_o = Error calculated at or near zero Load(e.g. 10 e)

S. No	Load (L)	Indication (I)		Additional load (Δ L)		Error calculated (E)		Corrected Error, E_c		Max permissible error (mpe)	Remarks
		↓	↑	↓	↑	↓	↑	↓	↑		
	10 x e										

Check If $|E_c| \leq |mpe|$

ECCENTRICITY TEST

The indications for different positions of a load shall meet the maximum permissible errors, when the instrument is tested according to sub-paragraphs (a) to (d) of this paragraph.

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

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

(c) On an instrument with a load receptor subject to minimal off-centre loading (e.g. tank, hopper) a test load corresponding to one-tenth of the sum of the maximum capacity and the maximum additive tare effect shall be applied to each point or support.

(d) On an instrument used for weighing rolling loads (e.g. vehicle scale, rail suspension instrument) a rolling test load corresponding to the usual rolling load, the heaviest and the most concentrated one which may be weighted, but not exceeding 0.8 times the sum of the maximum capacity and the maximum additive tar effect, shall be applied at different points on the load receptor.

- Large weights should be used in preference to several small weights. The load shall be applied centrally in the segment if several weights are used.
- The location of the load shall be marked on a sketch in the report.
- The automatic zero-setting device shall not remain in operation during the sets.

(i) *Instrument with load receptor having not more than four points of supports*

The four quarter segments roughly equal to 1/4 of the surface of the load receptor shall be loaded in turn.

(ii) *Instruments with a load receptor having more than four points of support*

The load shall be applied over each support on an area of the same order of the magnitude as the fraction of 1/n of the surface area of the load receptor, where *n* is the number of points of support.

(iii) *Instrument with special load receptor (tank, hopper)*

The load shall be applied to each point of support.

(iv) *Instrument used for weighing rolling loads*

A rolling load shall be applied at different positions on the load receptor. These positions shall be at the beginning, the middle and at the end of the load receptor in the normal driving direction. The positions shall then be tested in the reverse direction.

S. No	Location of Load	Load (L)	Indication (I)	Additional load (Δ L)	Error calculated (E)	Corrected Error, E_c	Max permissible error (mpe)	Remarks

Check If $|Ec| \leq |mpe|$

iv) DISCRIMINATION TEST

- Discrimination is ability of an instrument to react to small variation of load.
- The discrimination threshold, for a given load, is the value of the smallest additional load that, when gently deposited on or removed from the load receptor causes a perceptible change in the indication.
- *Non-self indicating instrument*

An extra load equivalent to the value of the maximum permissible error for the applied load when gently placed or withdrawn from the instrument at equilibrium shall produce movement as required under sub-paragraph (1) of paragraph 6.

Non-self indication and analogue indication

An extra load shall be placed gently on or removed from the load receptor while the instrument is at equilibrium.

Load	Extra load = |mpe|	Permanent displacement of indicating element	Remarks
		mm	
		mm	
		mm	

Check if the permanent displacement is equal to or geater than

1mm for an instrument of accuracy class I or II

2mm for an instrument of accuracy class II or III with Max ≤ 30Kg

1mm for an instrument of accuracy class III or III with Max > 30Kg

- *Self or semi-self indicating instrument*

(a) Analogue indication

An extra load equivalent to the maximum permissible error for applied load when placed gently on or withdrawn from the instrument at equilibrium shall cause a permanent displacement of the indicating element corresponding to not less than 0.7 times the extra load.

Load	Indication I_1	Extra load = mpe	Indication I_2	$I_1 - I_2$

Check if $I_2 - I_1 \geq 0.7$ mpe

(b) Digital indication

An additional load equal to 1.4 times the actual, scale interval, when gently placed on or withdrawn from the instrument at equilibrium shall change the initial indication.

- The following tests shall be performed with three different loads, i.e. Min, 1/2 load and Max.

Digital indication :

A load plus sufficient additional weights (say 10 times 1/10 of e) shall be placed on the load receptor. The additional weights shall then be removed until the indication, I is decreased unambiguously by one actual scale interval i.e. I-d. One of the additional weights shall be replaced and a load equal to 1.4 e shall then be placed gently on the load receptor and give a result, increased by one actual scale interval above the initial indication, i.e. I+d.

S. no	Load (L)	Indication (I_1)	Removed load	Add. 1/10 d	Extra load=1.4d	Indication (I_2)	I_2-I_1	Remarks
At Minimum load+1e								
At half load +1e								
Nearer to full load+1e								

Check if $I_2-I_1 \geq d$

v) REPEATABILITY TEST

- Ability of an instrument to provide results that agree one with the other when the same load is deposited several times and in a practically identical way on the load receptor under reasonably constant test conditions.
- The difference between the maximum and minimum results of several weighing of the same load shall not be greater than the absolute value of the maximum permissible error for the given load.
- Two series of weighing shall be performed; one at 1/2 load and the other at max. Readings shall be taken when the instrument is loaded and unloaded.

E=I + (1/2) e-ΔL-L,

	Indication of load,I	Add.Load ΔL	E $E=I+(\frac{1}{2}e-\Delta L-L)$
1			E_1
2			E_2
3			E_3
4			E_4
5			E_5
6			E_6
7			E_7
8			E_8
9			E_9
10			E_{10}

	Indication of load,I	Add.Load ΔL	E
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

E_{max}- E_{min}(weighing 1- 10) [ ]

mpe [ ]

E_{max}- E_{min}(weighing 11- 20) [ ]

mpe [ ]

Check if a) $E \leq$ mpe

b) E_{max}- $E_{min} \leq$ absolute value of mpe

Inspection

During inspection the following tests shall be carried

(I) **Accuracy test** [clause (i) of sub-para (6) of paragraph 3—Value of maximum permissible error,]

(II) **Eccentricity test** [clause (ii) of sub-paragraph (7) of paragraph 3-Eccentric loading]

✓ the seal applied during verification shall remain intact.

Stamping

Verification shall be testified by verification marks. All components whose dismantling or maladjustment might alter the metrological characteristics of the instrument should be secured by a seal.

Additional Test during verification and inspection

Creep test

Zero return tests

Influence factors

(i) Tilting

Warm up time test

Temperature tests

(i) Static temperature tests
(ii) Temperature effects on the no-load indication

Voltage Variation

Endurance test

Some other important points

Zero setting device

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

(a)*Non automatic zero setting device*

Device for setting the indication to zero by an operator.

(b)*Semi automatic zero setting device*

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

(c)*Automatic zero-setting device*

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

(d)*Initial zero-setting device*

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

Zero tracking device

Device for maintaining the zero indication within certain limits automatically.

An instrument may have one or more zero-setting devices and shall have not more than one zero-tracking device.

Maximum effect

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

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

Accuracy

After zero setting, the effect of zero deviation on the result of the weighing shall be not more than 0.25 e; however, on an instrument with auxiliary indicating device this effect shall be not more than 0.5 d.

Multiple range instruments

Zero setting in any weighing range shall be effective also in the greater weighing ranges if switching to a greater weighing range is possible while the instrument is loaded.

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).

Auxiliary indicating devices

(i) *Device for interpolation of reading (Vernier)*

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

(ii) *Complementary indicating device*

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

(iii) *Indicating device with a differentiated scale division*

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

Type and application

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

a device with a rider, or

a device for interpolation of reading, or

a complementary indicating device or

an indicating device with a differentiated scale division.

These devices shall be permitted only to the right of the decimal sign.

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

Minimum number of verification scale intervals

For an instrument of class I with **d< 0.1 mg**, n may be less than **50000**

Weighing capacity (Max)

(i) **Maximum weighing capacity,** not taking into account the additive tare capacity.

(ii) *Minimum capacity (Min)*

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

(iii) *Self-indication capacity*

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

(iv) *Weighing range*

Range between the minimum and maximum capacities.

(v) *Extension/interval of self indication*

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

(vi) *Maximum tare effect (T= +..., T = -...)*

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

Limits of indication

There shall be no indication above Max + 9e

Error (of indication)

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

Intrinsic error

The error of an instrument under reference conditions.

Initial intrinsic error

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

Maximum permissible error

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

Fault

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

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

Significant fault

A fault greater than *e*.

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

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

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

Influence and reference conditions

(1) Influence quantity

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

(i) *Influence factor*

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

(ii) *Disturbance*

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

(2) *Rated operating conditions*

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

(3) *Reference conditions*

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

(4) *Reference position*

Position of the instrument at which its operation is adjusted.