**Understandings of principle, structure and influence factors**

**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 characteristic related to mass.

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

**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.

**Non-automatic weighing instrument**

Instrument that requires the intervention of an operator during the weighing process, for example, to deposit on or remove from the receptor the load to be measured and also to obtain the result.
**What's Mechanical Weighing Scale?**

Mechanical weighing scales use mechanical principle such as spring and lever when weighing is measured.

---

**Various Mechanical Weighing Scales**

[Images of various mechanical weighing scales]

---

**Measurement Principle**

**Lever**

**Elasticity**

- Spring
- Load cell (electronic)

---

**Levers in Mechanical Weighing Instruments**

*First order lever*

The fulcrum is between the load and resistant. The resistant is usually either the load or less. In the case the lever has a mechanical advantage.

![Mechanical advantage diagram]

Simple beam (equal arm) Loadage 1 to 1
Second order levers
The fulcrum is at one end of the lever and the resistant is at the other. The lever has a mechanical advantage.

Third order levers
The fulcrum is at one end of the lever and the resistant is between the fulcrum and load. The lever has a mechanical advantage.

Combined of levers

Spring type

Elasticity: Spring

Hooke's law
Growth of the spring is in proportion to increased force

\[ F = -kx \]

\[ k = \frac{F}{x} = \frac{Gd^4}{8D^4} \]

- F: Reaction force caused by the spring
- k: Spring constant (N/m)
- x: Displacement by which the spring is elongated
- P: Load (N)
- d: Diameter of spring wire (mm)
- D: Diameter of the coil
- G: Modulus of elasticity (N/mm²)
Roberval mechanism

Simple lever

Roberval mechanism

Same mass and same ratio of "a" and "b"

$\Rightarrow$ Equilibrium

Different mass and different ratio of "a" and "b"

$\Rightarrow$ Not Equilibrium

---

Use example of the Roberval mechanism

---

Roberval Eccentricity

Example:

- $a = 60$ mm
- $d = 180$ mm
- $\sigma = 1$ mm
- $W = 2.5$ kg
- $e = 50$ mm

$E = \frac{W \sigma}{ad}$

Answer:

$E = \frac{2500 \times 50 \times 1}{60 \times 180} = 11.6$ g
Gravity compensation

All objects on the earth are subject to Earth's gravity all the time. No measurements of force and mass can be free from the gravity effects, as the force and mass are measured by balancing the object's weight or a lower or by converting it into a modification of elastic body. Gravity compensation is required because the gravity depends on the location on the earth (i.e., latitude, longitude, altitude). 9.80665m/s² is used as the standard gravitational acceleration.

If a measuring instrument equipped with an elastic body is calibrated at a place different from a place of use, the value of gravity compensation $E_g$ is obtained in the following equation:

$$E_g = \frac{g_p - g_i}{g_i} \times W$$

Where:
- $g_p$: gravitational acceleration at the calibration site
- $g_i$: gravitational acceleration at the place of use
- $W$: mass corresponding to inspection weight

A range of the gravity in Japan:

- 9.606 m/s² to 9.791 m/s²
- Hokkaido: 9.806 m/s²
- Tohoku: 9.800 m/s²
- Chugoku: 9.791 m/s²

$$E_g = \frac{(9.806 \text{ m/s}^2) - (9.606 \text{ m/s}^2)}{9.606 \text{ m/s}^2} \times W = 0.003 \times W$$

Example:

- $W = 100 \text{ kg}$
- $E_g = 0.003 \times 100 \text{ kg} = 0.3 \text{ kg}$

$$m = \frac{0.3 \text{ kg}}{9.806 \text{ m/s}^2} = 0.03 \text{ kg}$$

$0.03 \text{ kg}$ is the value of gravity compensation.
Verification procedure for NAWIs

[ OIML R76 Edition 1992 ]

Contents of OIML R76 1992

1. Terminology

1.1.2 Non automatic weighing instrument

Instrument that requires the intervention of an operator during the weighing process, for example to deposit on or remove from the receptacle the body 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: Terms such as "indicate", "indicating component" and their derivatives do not include printing.

A non automatic weighing instrument may be:
- graduated or non-graduated,
- self-indicating, semi-self indicating or non-self-indicating.
T.1.2.1 Graduated instrument
Instrument allowing the direct reading of the complete or partial weighing result.

T.1.2.2 Non-graduated instrument
Instrument not fitted with a scale numbered in units of mass.

T.1.2.3 Self indicating instrument
Instrument in which the position of equilibrium is obtained without the intervention of an operator.

T.1.2.4 Semi self indicating instrument
Instrument with a self indication weighting range, in which the operator intervenes to adjust the limits of this range.

Example

Measurement procedure
1. Load applies to load receptor
2. Remove inside weights by 1 knob
3. Repeat until it is balanced in a weighing range
4. Load = value read + reading of indicator
Knob = 40g
Indicator = 4.3g
Load = 44.3g

T.1.2.5 Non self indicating instrument
Instrument in which the position of equilibrium is obtained entirely by operator.

Example

Measurement procedure
1. Load applies to load receptor
2. Weight applies to take the rough equilibrium
3. Sliding moves to complete equilibrium
4. Load = Total weight + reading of sliding
T.2.1 Main device

T.2.1.1 Load receptor
Part of the instrument intended to receive the load.

T.2.1.2 Load-transmitting device
Part of the instrument for transmitting the force produced by the load acting on the load receptor to the load measuring device.

T.2.1.3 Load measuring device
Part of the instrument for measuring the mass of the load by means of an equilibrium device for balancing the force coming from the load transmitting device, and an indicating or printing device.

T.2.4 Indicating device (of a weighing instrument)
Part of the load measuring device on which the direct reading of the result is obtained.

T.2.4.1 Indicating component
Component indicating the equilibrium and/or the result.
On an instrument with several positions of equilibrium it indicates only the equilibrium (so-called zero).
On an instrument with several positions of equilibrium it indicates both the equilibrium and the result. On an electronic instrument, this is the display.

T.2.4.2 Scale mark
A line or other mark on an indicating component corresponding to a specified value of mass.

T.2.4.3 Scale base
An imaginary line through the centers of all the shortest scale marks.

T.2.7.2 Zero setting device
Device for setting the indication to zero where there is no load on the load receptor.

T.2.7.2.1 Non automatic zero setting device
Device for setting the indication to zero by an operator.

T.2.7.4 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),
- Reducing the weighing range for net loads (subtractive tare device).

It may function as:
- A non automatic device (load balanced by an operator),
- A semi automatic device (load balanced automatically following a single manual command),
- An automatic device (load balanced automatically without the intervention of an operator).
T.3.2 Scale divisions

T.3.2.1 Scale spacing (instrument with analogue indication)
Distance between any two consecutive scale marks, measured along the scale base.

T.3.2.2 Actual scale interval (d)
Value expressed in units of mass:
- The difference between the values corresponding to two consecutive scale marks, for analogue indication; or
- The difference between two consecutive indication values, for digital indication.

T.3.2.3 Verification scale interval (e)
Value, expressed in units of mass, used for the classification and verification of an instrument.

T.3.2.4 Scale interval of numbering
Value of the difference between two consecutive numbered scale marks.

T.3.2.5 Number of verification scale intervals (single-interval instrument)
Quotient of the maximum capacity and the verification scale interval:

\[ n = \frac{\text{Max}}{e} \]

T.4 Metrological properties of an instrument

T.4.1 Sensitivity

\[ (k) \]
For a given value of the measured mass, the quotient of the change of the observed variable \( f \) and the corresponding change of the measured \( M \):

\[ k = \frac{\Delta f}{\Delta M} \]

Verification procedure for NAWIs

Verification Item (6.3 initial verification)
- Visual Inspection (6.3.2)
- Tests (6.3.3)
- Error of indication (Weighing tests:)
  - Value of maximum permissible error
  - Maximum permissible errors for net values
  - Tare weighing device
- Accuracy of zero setting and tare devices
- Repeatability
- Rectangularity
- Discrimination
- Sensitivity of non self indication instruments
Visual inspection (8.3.2)

Before testing, the instrument shall be visual inspected

- Confirmation of markings: Accuracy class, Max, Min, e, d
- Confirmation of condition of instrument
- Confirmation of level of instrument

*Results of the visual inspection should be recorded in the test report, including test date and observer, etc.

Tests (8.3.3)

Value of maximum permissible error

Maximum permissible error for verification

Accuracy classes for NAWI's (3.2)

- Class 1 Special accuracy
  - ultra micro-, micro-, semi micro, macro-

- Class 2 High accuracy
  - precision balances

- Class 3 Medium accuracy
  - NAWI's for trade use

- Class 4 Ordinary accuracy
  - NAWI's for lower accuracy
Accuracy classes for NAW's (3.2)

<table>
<thead>
<tr>
<th>Accuracy class</th>
<th>Verification scale interval</th>
<th>Number of verification scale interval (Minimum)</th>
<th>Number of verification scale interval (Maximum)</th>
<th>Minimum capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe (I)</td>
<td>0.001g ≤ e &lt; 0.05 g</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>High (II)</td>
<td>0.1 g ≤ e &lt; 2 g</td>
<td>500</td>
<td>1000</td>
<td>50</td>
</tr>
<tr>
<td>Medium (III)</td>
<td>5 g ≤ e</td>
<td>500</td>
<td>1000</td>
<td>20</td>
</tr>
<tr>
<td>Ordinary (IV)</td>
<td>5 g ≤ e</td>
<td>100</td>
<td>1000</td>
<td>10</td>
</tr>
</tbody>
</table>

Verification scale interval (\(e\))

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

Number of verification scale interval (\(n\))

Quotient of the maximum capacity and the verification scale interval.

\[ n = \frac{Max}{e} \]

Maximum permissible error (3.5.1)

<table>
<thead>
<tr>
<th>Minimum permissible error</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>±0.5 g</td>
<td>0 ≤ m ≤ 500</td>
<td>0 ≤ m ≤ 500</td>
<td>0 ≤ m ≤ 600</td>
<td>0 ≤ m ≤ 600</td>
</tr>
<tr>
<td>±1.0 g</td>
<td>500 ≤ m ≤ 2000</td>
<td>1000 ≤ m ≤ 900</td>
<td>1000 ≤ m ≤ 2000</td>
<td>1000 ≤ m ≤ 2000</td>
</tr>
<tr>
<td>±1.5 g</td>
<td>2000 ≤ m ≤ 10000</td>
<td>2000 ≤ m ≤ 10000</td>
<td>2000 ≤ m ≤ 16000</td>
<td>2000 ≤ m ≤ 16000</td>
</tr>
</tbody>
</table>

Exercise

Determine MPE and MPE change points.
Exercise 1

Determine MPE and MPE change points for verification

Specification of NAWI is

**Max:** 3 kg,
**Verification scale interval (e):** 1 g,
**Accuracy class 3**

---

**Answer**

Max: 3 kg, Verification scale interval (e): 1 g, Accuracy class 3

<table>
<thead>
<tr>
<th>MPE (g)</th>
<th>Class 3 (mass)</th>
<th>MPE change points</th>
</tr>
</thead>
<tbody>
<tr>
<td>±0.5 g</td>
<td>0 g &lt; m &lt; 500 g</td>
<td>500 g (change point 1)</td>
</tr>
<tr>
<td>±1.0 g</td>
<td>500 g &lt; m &lt; 2 kg</td>
<td>2 kg (change point 2)</td>
</tr>
<tr>
<td>±1.5 g</td>
<td>2 kg &lt; m &lt; 5 kg (Max)</td>
<td>-</td>
</tr>
</tbody>
</table>

---

Exercise 2

Determine MPE and MPE change points for verification

Specification of NAWI is

**Max:** 6 kg,
**Verification scale interval (e):** 2 g,
**Accuracy class 3**
### Exercise 3

**Determine MPE and MPE change points for verification**

**Specification of NAWI is**

**Max : 5 kg.**  
**Verification scale interval (e): 10 g.**  
**Accuracy class 3 or class 4**

---

### Answer

**Max : 6 kg. Verification scale Interval (e): 2 g. Accuracy class 3**

<table>
<thead>
<tr>
<th>MPE (g)</th>
<th>Class 3 (mass)</th>
<th>MPE change points</th>
</tr>
</thead>
<tbody>
<tr>
<td>±1 g</td>
<td>0 g ≤ m ≤ 1 kg</td>
<td>1 kg (change point 1)</td>
</tr>
<tr>
<td>±2 g</td>
<td>1 kg &lt; m ≤ 4 kg</td>
<td>4 kg (change point 2)</td>
</tr>
<tr>
<td>±3 g</td>
<td>4 kg &lt; m ≤ 6 kg (Max)</td>
<td>-</td>
</tr>
</tbody>
</table>

### Accuracy classes for NAWI's (3.2)

<table>
<thead>
<tr>
<th>Accuracy class</th>
<th>Verification scale Interval (e)</th>
<th>Number of verification scale interval</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Maximum capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special (I)</td>
<td>0.001 g ≤ e ≤ 0.05 g</td>
<td>50 000</td>
<td>-</td>
<td>130 000</td>
<td></td>
</tr>
<tr>
<td>High (II)</td>
<td>0.01 g ≤ e ≤ 0.1 g</td>
<td>100</td>
<td>103 000</td>
<td>10 000</td>
<td></td>
</tr>
<tr>
<td>Medium (III)</td>
<td>0.1 g ≤ e ≤ 2 g</td>
<td>500</td>
<td>500 000</td>
<td>20 000</td>
<td></td>
</tr>
<tr>
<td>Ordinary (IV)</td>
<td>5 g ≤ e</td>
<td>100</td>
<td>1600</td>
<td>1000</td>
<td>10 e</td>
</tr>
</tbody>
</table>
Answer: case of class 3
Max: 5 kg, Verification scale interval (e): 10 g, Accuracy class 3

<table>
<thead>
<tr>
<th>MPE (g)</th>
<th>Class 3 (mass)</th>
<th>MPE change points</th>
</tr>
</thead>
<tbody>
<tr>
<td>±5 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>±10 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>±15 g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MPE (g)</th>
<th>Class 3 (mass)</th>
<th>MPE change points</th>
</tr>
</thead>
<tbody>
<tr>
<td>±5 g</td>
<td>0 kg &lt; m ≤ 5 kg (Max)</td>
<td></td>
</tr>
<tr>
<td>±10 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>±15 g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Case of class 3
For loads, m expressed in verification scale intervals, e

<table>
<thead>
<tr>
<th>Class</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>±1.5 e</td>
<td>0 kg &lt; m ≤ 500 g</td>
<td>0 kg &lt; m ≤ 500 g</td>
<td>0 kg &lt; m ≤ 500 g</td>
<td>0 kg &lt; m ≤ 500 g</td>
</tr>
<tr>
<td>±1.0 e</td>
<td>500 g &lt; m ≤ 2000 g</td>
<td>2000 g &lt; m ≤ 8000 g</td>
<td>8000 g &lt; m ≤ 20000 g</td>
<td>20000 g &lt; m ≤ 100000 g</td>
</tr>
<tr>
<td>±0.5 e</td>
<td>20000 g &lt; m</td>
<td>20000 g &lt; m</td>
<td>20000 g &lt; m</td>
<td>20000 g &lt; m</td>
</tr>
</tbody>
</table>

Case of class 4
For loads, m expressed in verification scale intervals, e

<table>
<thead>
<tr>
<th>Class</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>±1.5 e</td>
<td>0 kg &lt; m ≤ 500 g</td>
<td>0 kg &lt; m ≤ 500 g</td>
<td>0 kg &lt; m ≤ 500 g</td>
<td>0 kg &lt; m ≤ 500 g</td>
</tr>
<tr>
<td>±1.0 e</td>
<td>500 g &lt; m ≤ 2000 g</td>
<td>2000 g &lt; m ≤ 8000 g</td>
<td>8000 g &lt; m ≤ 20000 g</td>
<td>20000 g &lt; m ≤ 100000 g</td>
</tr>
<tr>
<td>±0.5 e</td>
<td>20000 g &lt; m</td>
<td>20000 g &lt; m</td>
<td>20000 g &lt; m</td>
<td>20000 g &lt; m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MPE (g)</th>
<th>Class 4</th>
<th>Class 3 (mass)</th>
<th>MPE change points</th>
</tr>
</thead>
<tbody>
<tr>
<td>±5 g</td>
<td>0 kg &lt; m ≤ 50 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>±10 g</td>
<td>50 g &lt; m ≤ 200 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>±15 g</td>
<td>200 g &lt; m ≤ 1000 g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Answer: case of class 4**

<table>
<thead>
<tr>
<th>MPE (g)</th>
<th>Class 4 (mass)</th>
<th>MPE change points</th>
</tr>
</thead>
<tbody>
<tr>
<td>±5 g</td>
<td>0 g &lt; m &lt; 500 g</td>
<td>500 g</td>
</tr>
<tr>
<td>±10 g</td>
<td>500 g &lt; m &lt; 2 kg</td>
<td>2 kg</td>
</tr>
<tr>
<td>±15 g</td>
<td>2 kg &lt; m &lt; 5 kg (Max)</td>
<td></td>
</tr>
</tbody>
</table>

**Exercise 4**

Determine MPE and MPE change points for verification

**Specification of NAWI is**

Max: 6 kg

\[ e_1: 1 g \ (0 - 3 kg) \]
\[ e_2: 2 g \ (3 - 6 kg) \]

Class 3

* Multi interval instrument

---

**Max: 6 kg (e_1: 0 - 3 kg, e_2: 3 - 6 kg)**

\[ n_1 = \text{Max} / e_1 = 3 \text{ kg} / 1g = 3000 \]

\[ n_2 = \text{Max} / e_2 = 6 \text{ kg} / 2g = 3000 \]

<table>
<thead>
<tr>
<th>Accuracy class</th>
<th>Verification scale interval</th>
<th>Number of verification scale intervals</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Minimum capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special Class 1</td>
<td>0.001 g ≤ c ≤ 0.005 g</td>
<td>160</td>
<td>100 000</td>
<td>20 e</td>
<td>100 e</td>
</tr>
<tr>
<td>Class 2</td>
<td>0.1 g ≤ c ≤ 0.2 g</td>
<td>160</td>
<td>100 000</td>
<td>50 e</td>
<td></td>
</tr>
<tr>
<td>Mctum Class 3</td>
<td>0.5 g ≤ c ≤ 2 g</td>
<td>160</td>
<td>10 000</td>
<td>20 e</td>
<td></td>
</tr>
<tr>
<td>Ordinary Class 4</td>
<td>5 g ≤ c</td>
<td>160</td>
<td>1 000</td>
<td>10 e</td>
<td></td>
</tr>
</tbody>
</table>

---

**Applied \( e_1 \) (1 g)**

<table>
<thead>
<tr>
<th>MPE (g)</th>
<th>Class 3 (max)</th>
<th>MPE (g)</th>
<th>Class 3 (mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>±0.5 g</td>
<td>0 ≤ m ≤ 500 g</td>
<td>±0.5 g</td>
<td>0 ≤ m ≤ 500 g</td>
</tr>
<tr>
<td>±1.0 g</td>
<td>500 &lt; m ≤ 2 000</td>
<td>±1.0 g</td>
<td>500 &lt; m ≤ 2 000</td>
</tr>
<tr>
<td>±1.5 g</td>
<td>2 000 &lt; m ≤ 10 000</td>
<td>±1.5 g</td>
<td>2 000 &lt; m ≤ 10 000</td>
</tr>
</tbody>
</table>

**Applied \( e_2 \) (2 g)**

<table>
<thead>
<tr>
<th>MPE (g)</th>
<th>Class 3 (max)</th>
<th>MPE (g)</th>
<th>Class 3 (mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>±0.5 g</td>
<td>0 ≤ m ≤ 500 g</td>
<td>±0.5 g</td>
<td>0 ≤ m ≤ 500 g</td>
</tr>
<tr>
<td>±1.0 g</td>
<td>500 &lt; m ≤ 2 000</td>
<td>±1.0 g</td>
<td>500 &lt; m ≤ 2 000</td>
</tr>
<tr>
<td>±1.3 g</td>
<td>2 000 &lt; m ≤ 10 000</td>
<td>±1.3 g</td>
<td>2 000 &lt; m ≤ 10 000</td>
</tr>
</tbody>
</table>
Exercise 5

Specification of NAWI is
Max : 150 kg
e : 100 g
Class 3

Exercise 6

Specification of NAWI is
Max : 60 kg
e : 20 g
Class 3

Exercise 7

Specification of NAWI is
Max : 500 g
e : 5 g
Class 4

Exercise 8

Specification of NAWI is
Max : 3 kg
e : 0.1 g
Class 2

Answer

Specification of NAWI is
Max : 6 kg, \( e_1 : 1 \text{ g (0–3 kg)} \), \( e_2 : 2 \text{ g (3–6 kg)} \)

*Multi interval instrument

<table>
<thead>
<tr>
<th>MPE (g)</th>
<th>Class 3 (Gram)</th>
<th>Mpe change points</th>
</tr>
</thead>
<tbody>
<tr>
<td>±0.5 g</td>
<td>0 g ( \leq m \leq 500 \text{ g} )</td>
<td>500 g</td>
</tr>
<tr>
<td>±1.0 g</td>
<td>500 g &lt; ( m \leq 3 \text{ kg} )</td>
<td>2 kg</td>
</tr>
<tr>
<td>±1.5 g</td>
<td>3 kg &lt; ( m \leq 4 \text{ kg} )</td>
<td>3 kg</td>
</tr>
<tr>
<td>±2.0 g</td>
<td>4 kg &lt; ( m \leq 6 \text{ kg} )</td>
<td>4 kg</td>
</tr>
</tbody>
</table>
Exercise 9
Specification of NAWi is
Max : 1 kg
e : 0.2 g
class 3

Exercise 10
Specification of NAWi is
Max : 15 kg
e1 : 2 g (0 ~ 6 kg)
e2 : 5 g (6 ~ 15 kg)
* Multi interval instrument

Verification Standards (3.7)
Weights 3.7.1
The standard weights or standard masses used for the verification of an instrument shall not have an error greater than 1/3 of the maximum permissible error of the instrument for the applied.

Max : 3 kg, Verification scale interval (e) : 1 g, Mn : 20 g, Class 3

<table>
<thead>
<tr>
<th>Test weight</th>
<th>Test load</th>
<th>MPS 1 (g)</th>
<th>MPS 2 (g)</th>
<th>MPS 3 (g)</th>
<th>MPS 4 (g)</th>
<th>Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0.5 g</td>
<td>0.5 g</td>
<td>0.17 g</td>
<td>-</td>
<td>M2 (3kg)</td>
</tr>
<tr>
<td>0.2 g</td>
<td>20 g</td>
<td>0.5 g</td>
<td>0.5 g</td>
<td>0.17 g</td>
<td>-</td>
<td>M2 (3kg)</td>
</tr>
<tr>
<td>500 g</td>
<td>100 g</td>
<td>1.0 g</td>
<td>1.0 g</td>
<td>0.19 g</td>
<td>-</td>
<td>M2 (75kg)</td>
</tr>
<tr>
<td>1,000 g</td>
<td>200 g</td>
<td>1.0 g</td>
<td>1.0 g</td>
<td>0.33 g</td>
<td>-</td>
<td>M2 (150kg)</td>
</tr>
<tr>
<td>1,500 g</td>
<td>300 g</td>
<td>1.5 g</td>
<td>1.5 g</td>
<td>0.33 g</td>
<td>-</td>
<td>M2 (225kg)</td>
</tr>
<tr>
<td>3,000 g</td>
<td>600 g</td>
<td>3.0 g</td>
<td>3.0 g</td>
<td>0.65 g</td>
<td>-</td>
<td>M2 (450kg)</td>
</tr>
</tbody>
</table>

OIML R 111: Weights of classes E1, E2, F1, F2, M1, M2, M2-3 and M3

Minimum accuracy class of weights
The accuracy class for weights used as standards for the verification of weights or weighing instruments shall be in accordance with the requirements of the relevant OIML Recommendations.

The OIML weight classes are defined as follows:
Class E1: Weights intended to ensure traceability between national mass standards (with values derived from the International Prototype of the Kilogram) and weights of class B2 and lower. Class E1 weights or weight sets shall be accompanied by a calibration certificate (see 15.2.2.1).
Class E2: Weights intended for use in the verification or calibration of class F1 weights and for use with weighing instruments of special accuracy class I. Class E2 weights or weight sets shall be accompanied by a calibration certificate (see 15.2.2.2). They may also be used as class E1 weights if they comply with the requirements for surface roughness, magnetic susceptibility, stability, and magnetization in class E1 weights and if their calibration certificate gives the appropriate data (see 15.2.2.1).
Class F1: Weights intended for use in the verification or calibration of class F2 weights and for use with weighing instruments of special accuracy class I and high accuracy class II.

Note: The error in a weighing instrument shall not exceed 1/3 of the maximum permissible error for an instrument. These values are listed in section 3.1.1 of OIML R 10 Non-ferromagnetic Weighing Instruments (1992).
Test set up

- Inspection environment
- Set up to solid table
- Vibration
- Influence by the wind

Preparations for:
- Weights
- Report sheet

Test producer

Part 1: Self indicating instrument (analog indication);
Spring type

Part 2: Non-self indicating instrument
Lever type

Test producer - part 1

Self indicating instrument (analog indication)

Spring type

Value of maximum permissible error
[ Weighing performance test ]

Test loads (A4.4.1 and 8.3.3)

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

Determining the verification for weighing tests at least 5 shall be selected. The test loads selected shall include Max, and Min, and values at or near those at which the mpe changes.
Weighing Performance Test
Determine the test loads and mpe

**Example**: Max: 3 kg, e: 10 g, Min: 100 g, class 4

<table>
<thead>
<tr>
<th>Test load</th>
<th>mpe</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero</td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td></td>
</tr>
<tr>
<td>Mpe change 1</td>
<td></td>
</tr>
<tr>
<td>Mpe change 2</td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td></td>
</tr>
</tbody>
</table>

*Any load*        |     |

### Class 4
For loads, m expressed in verification scale intervals, e

<table>
<thead>
<tr>
<th>m (Gram)</th>
</tr>
</thead>
<tbody>
<tr>
<td>±0.3 e</td>
</tr>
<tr>
<td>±1.5 e</td>
</tr>
<tr>
<td>±1.5 e</td>
</tr>
<tr>
<td>±1.5 e</td>
</tr>
</tbody>
</table>

Weighing Performance Test
Determine the test loads and mpe

**Example**: Max: 3 kg, e: 10 g, Min: 100 g, classes 4

<table>
<thead>
<tr>
<th>Test load</th>
<th>mpe</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero</td>
<td>0 g</td>
</tr>
<tr>
<td>Min</td>
<td>100 g</td>
</tr>
<tr>
<td>Mpe change 1</td>
<td></td>
</tr>
<tr>
<td>Mpe change 2</td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>3 kg</td>
</tr>
</tbody>
</table>

*Any load*        |     |

### Class 4
For loads, m expressed in verification scale intervals, e

<table>
<thead>
<tr>
<th>m (Gram)</th>
</tr>
</thead>
<tbody>
<tr>
<td>±0.5 e</td>
</tr>
<tr>
<td>±1.0 e</td>
</tr>
<tr>
<td>±1.5 e</td>
</tr>
<tr>
<td>±2.0 e</td>
</tr>
</tbody>
</table>

Weighing Performance Test
Determine the test loads and mpe

**Example**: Max: 3 kg, e: 10 g, Min: 100 g, class 4

<table>
<thead>
<tr>
<th>Test load</th>
<th>mpe</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero</td>
<td>0 g</td>
</tr>
<tr>
<td>Min</td>
<td>100 g</td>
</tr>
<tr>
<td>Mpe change 1</td>
<td>500 g</td>
</tr>
<tr>
<td>Mpe change 2</td>
<td>2 kg</td>
</tr>
<tr>
<td>Max</td>
<td>3 kg</td>
</tr>
</tbody>
</table>

*Any load*        |     |
Weighing Performance Test

Determine the test loads and mpe

Example: Max: 3 kg, e: 10 g, Min: 100 g, class 4

<table>
<thead>
<tr>
<th>Test load</th>
<th>mpe</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero</td>
<td>0 g</td>
</tr>
<tr>
<td>Min</td>
<td>100 g</td>
</tr>
<tr>
<td>Mpe change 1</td>
<td>500 g</td>
</tr>
<tr>
<td>Any load</td>
<td>1 kg</td>
</tr>
<tr>
<td>Mpe change 2</td>
<td>2 kg</td>
</tr>
<tr>
<td>Max</td>
<td>3 kg</td>
</tr>
</tbody>
</table>

Weighing Performance Test

Test loads and MPE are recorded in the test report.

Example: Max: 3 kg, e: 10 g, Min: 150 g, class 4

<table>
<thead>
<tr>
<th>Load</th>
<th>Indication</th>
<th>Error</th>
<th>Corrected error</th>
<th>MPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 g</td>
<td>100 g</td>
<td>5 g</td>
<td>5 g</td>
<td></td>
</tr>
<tr>
<td>500 g</td>
<td>5 g</td>
<td>5 g</td>
<td>5 g</td>
<td></td>
</tr>
<tr>
<td>1 kg</td>
<td>10 g</td>
<td>10 g</td>
<td>10 g</td>
<td></td>
</tr>
<tr>
<td>2 kg</td>
<td>10 g</td>
<td>10 g</td>
<td>10 g</td>
<td></td>
</tr>
<tr>
<td>3 kg</td>
<td>15 g</td>
<td>15 g</td>
<td>15 g</td>
<td></td>
</tr>
</tbody>
</table>

Weighing Performance Test

Self indication instrument

If it's possible, read of 0.1 e
### Weighing Performance Test

**Calculate of Error**

\[
\text{Error (E)} = I - L
\]

where:
- \( I \) = Indication
- \( L \) = Load

**Corrected error (Ec) = \( E - E_0 \)**

- \( E \) = Error of each test load
- \( E_0 \) = Initial zero error

*If initial zero error is not zero, this formula shall be applied.*

### Record the indication value of the instrument when put on the test load

<table>
<thead>
<tr>
<th>Load</th>
<th>Indication</th>
<th>Error</th>
<th>Corrected error</th>
<th>Mpa</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 g</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5 g</td>
</tr>
<tr>
<td>100 g</td>
<td>101</td>
<td>1 C1</td>
<td>1</td>
<td>5 g</td>
</tr>
<tr>
<td>500 g</td>
<td>503</td>
<td>5 C3</td>
<td>5</td>
<td>5 g</td>
</tr>
<tr>
<td>1 kg</td>
<td>1 005</td>
<td>1 003</td>
<td>10</td>
<td>10 g</td>
</tr>
<tr>
<td>2 kg</td>
<td>2 005</td>
<td>2 010</td>
<td>20</td>
<td>20 g</td>
</tr>
<tr>
<td>3 kg</td>
<td>3 010</td>
<td></td>
<td></td>
<td>30 g</td>
</tr>
</tbody>
</table>

**Initial zero error**

**Pass or Fail**

**Pass**
Example
Corrected error shall be applied in the case of the following results

<table>
<thead>
<tr>
<th>Load (g)</th>
<th>Indication</th>
<th>Error</th>
<th>Corrected error</th>
<th>mpe</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>5</td>
<td>5 g</td>
<td></td>
</tr>
<tr>
<td>100 g</td>
<td>105</td>
<td>5</td>
<td>5 g</td>
<td></td>
</tr>
<tr>
<td>500 g</td>
<td>505</td>
<td>5</td>
<td>5 g</td>
<td></td>
</tr>
<tr>
<td>1 kg</td>
<td>1 010</td>
<td>10</td>
<td>10 g</td>
<td></td>
</tr>
<tr>
<td>2 kg</td>
<td>2 015</td>
<td>10</td>
<td>10 g</td>
<td></td>
</tr>
<tr>
<td>3 kg</td>
<td>3 015</td>
<td>15</td>
<td>15 g</td>
<td></td>
</tr>
</tbody>
</table>

Pass or Fail: Initial zero error

Repeatability (A 4.10)

The difference between the results of several weighings of the same load shall not be greater than the absolute value of the maximum permissible error of the instruments.

Two series of weighings shall be performed, one with a load of about 50% and one with a load close to 100% of Max. Normally no more than 3 weighings on class 3 and 4 or 6 weighings on classes 1 and 2 are necessary.

Repeatability test
Self indication instruments: analogue indication

Example: Max = 3 kg, e = 0.1 kg, Min = 0.1 kg, class 4

Determine test load and mpe:

\[
\frac{1}{2}\text{Max} = 0.5\times3\text{kg, mpe is }0.05\text{kg}
\]

\[
\text{Max} = 3\text{kg, mpe is }0.10\text{kg}
\]

Record in test report

<table>
<thead>
<tr>
<th>No.</th>
<th>Load (kg)</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Max</td>
<td>Min</td>
<td>Max - Min</td>
</tr>
</tbody>
</table>

AIST

Advanced Industrial Science and Technology Institute
Repeatability test

Self-indicating instrument: analogue indication

Example: Max: 3 kg, e: 10 g, Min: 100 g, class 4

- Determining test load and mpe:
  1/2 Max = 1.5 kg, mpe = 10 g
  Max = 3 kg, mpe = 15 g

- Record in test report

<table>
<thead>
<tr>
<th>No.</th>
<th>Load</th>
<th>Indication</th>
<th>Load</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5 kg</td>
<td>3 kg</td>
<td>3 kg</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.5 kg</td>
<td>3 kg</td>
<td>3 kg</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.5 kg</td>
<td>3 kg</td>
<td>3 kg</td>
<td></td>
</tr>
</tbody>
</table>

Max-Min

Pass or Fail

---

Repeatability test

- Remove to test load
- Applied to test load (No. 1)
- Remove to test load (Zero check)

Pass
**Discrimination test (A3.8)**

Self indication instruments: analogue indication

An extra load equivalent to the absolute value of the maximum permissible error for the applied load when gently placed 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 extra load.

This test shall be performed with three different loads.

\[ \text{Min, } \frac{1}{2}\text{Max, Max} \]

---

**Discrimination test**

Self indication instruments: analogue indication

**Example:** Max: 3 kg, e: 10 g, Min: 100 g, class 4

- Determine test load and extra load:
  - Min = 100 g; extra load: 5 g
  - \( \frac{1}{2}\text{Max} = 1.5 \text{ kg; extra load: 10 g} \)
  - Max = 3 kg; extra load: 15 g

- Record in test report

<table>
<thead>
<tr>
<th>Load</th>
<th>Indication 11</th>
<th>Extra load</th>
<th>Indication 12</th>
<th>I2:11</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 g</td>
<td></td>
<td>5 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5 kg</td>
<td>10 g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 kg</td>
<td>15 g</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Discrimination test**

Self indication instruments: analogue indication

**Example:** Max: 3 kg, e: 10 g, Min: 100 g, class 4

- Determine test load and extra load:
  - Min = 100 g; extra load: 5 g
  - \( \frac{1}{2}\text{Max} = 1.5 \text{ kg; extra load: 10 g} \)
  - Max = 3 kg; extra load: 15 g

- Record in test report

- Initial reading: 0 g
- Same reading is recorded at 100 g, 1.5 kg, and 3 kg loads.
- Extra load is applied: 5 g, 10 g, and 15 g.
- Indication 11 and 12 compared.
**Discrimination test**

**Self indication instruments : analogue indication**

Example: Max: 3 kg, e: 10 g, Min: 100 g, class 4

<table>
<thead>
<tr>
<th>Load</th>
<th>Indication 1</th>
<th>Extra load n mpc</th>
<th>Indication 2</th>
<th>I2{-1}</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 g</td>
<td>100 g</td>
<td>5 g</td>
<td>105 g</td>
<td>5 g</td>
</tr>
<tr>
<td>1.5 kg</td>
<td>1500 g</td>
<td>10 g</td>
<td>1510 g</td>
<td>16 g</td>
</tr>
<tr>
<td>3 kg</td>
<td>3000 g</td>
<td>15 g</td>
<td>3012 g</td>
<td>12 g</td>
</tr>
</tbody>
</table>

Check if I2{-1} ≥ 0.7 mpc

Pass or Fail

---

**Eccentricity tests (A4.7)**

The indications for different positions at a load shall meet the maximum permissible errors, when the is tested according to following.

- Instrument with a load receptor having n points of support, with $n < 4$
  - Test load: $(\text{Max} + \text{Additive tare effect}) / 3$
- Instrument with a load receptor having n points of support, with $n > 4$
  - Test load: $(\text{Max} + \text{Additive tare effect}) / (n-1)$
- Instrument with a load receptor subject to minimal off-center loading
  - Test load: $0.1 \text{Max} + \text{Additive tare effect}$
- Instrument used for weighing rolling loads
  - Test load: usual rolling load, the heaviest and the most concentrated one which may be weighed, but not exceeding 0.8 times the sum of the Max and Additive tare effect.
Eccentricity test

Self indication instruments: analogue indication

Example: Max : 3 kg, e : 10 g,
Min : 100 g, class 4

Determine type of load receptor, test load and mpe

This instrument has 2 points of support

\[ n \text{ points of support with } n \leq 4 \]

Test load = \( \frac{(\text{Max} + \text{Additive tare effect})}{3} \)

\[ mpe = \frac{?}{g} \]


Eccentricity test

Self indication instruments: analogue indication

Example: Max : 3 kg, e : 10 g,
Min : 110 g, class 4

Determine type of load receptor, test load and mpe

This instrument has 2 points of support

\[ n \text{ points of support with } n \leq 4 \]

Test load = \( \frac{(\text{Max} + \text{Additive tare effect})}{3} \)

\[ mpe = 10 g \]


Eccentricity test

Determine of different position

Surface of the loading receptor is evenly divided into four

Load positions


Eccentricity test

Record in test report

<table>
<thead>
<tr>
<th>Location</th>
<th>L</th>
<th>I</th>
<th>E</th>
<th>Mpe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1 kg</td>
<td>10 g</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>1 kg</td>
<td>10 g</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>1 kg</td>
<td>10 g</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>1 kg</td>
<td>10 g</td>
<td></td>
</tr>
</tbody>
</table>
Self-indicating instruments: analogue indication

Setting type:
- Ex: 3 kg, e = 0.02 kg, Min: 0 kg, class 4

After zero setting, the effect of zero deviation on
the result of the weighing shall not be more than
0.25% of the maximum error for the instrument with auxiliary
indication devices; this effect shall be not more
than 0.5%.

Zero setting accuracy

Test producer - part 2

Non-self-indicating instrument

Platform instrument

Lever type
**Value of maximum permissible error**

**[Weighing performance test]**

**Test loads**

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

Determining the verification for weighing tests at least 5 shall be selected. The test loads selected shall include Max, and Min, and values at or near those at which the mpe changes.

---

**Weighing Performance Test**

**Determine the test loads and mpe**

**Example:** Max: 150 kg, e: 50 g, Min: 1 kg, class 3

<table>
<thead>
<tr>
<th>Test load</th>
<th>mpe</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>Min</td>
<td>1 kg</td>
</tr>
<tr>
<td>Mpe change 1</td>
<td>25 g</td>
</tr>
<tr>
<td>Mpe change 2</td>
<td>100 kg</td>
</tr>
<tr>
<td>Max</td>
<td>150 kg</td>
</tr>
<tr>
<td>*Any load</td>
<td>50 kg</td>
</tr>
</tbody>
</table>

---

**Weighing Performance Test**

Non self indication instruments Platform instrument

---

**Weighing Performance Test**

Zero Min Max
### Weighing Performance Test

Test loads and MPE are recorded in the test report.

**Example:** Max : 150 kg, e : 50 g, Min : 1 kg, classes 3

<table>
<thead>
<tr>
<th>Load</th>
<th>Indicator</th>
<th>Small weights</th>
<th>Error</th>
<th>MPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>25 g</td>
<td></td>
</tr>
<tr>
<td>1 kg</td>
<td>25 g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 kg</td>
<td>25 g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 kg</td>
<td>50 g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 kg</td>
<td>50 g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150 kg</td>
<td>75 g</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Zeroing

1. Small Weights put on the load receptor of no-load after preload.
2. Zero setting device to equilibrium position.

### Test load (Min)

1. Min weight put on load receptor.
2. Confirm to position of indicator.
   - If indicator is accord with equilibrium position, the error is 0.
   - If indicator balanced above equilibrium position, Small weights shall be removed until equilibrium position comes to the indicator. (−)
   - If indicator balanced below equilibrium position, Small weights shall be put on until equilibrium position comes to the indicator. (+)
### Weighing Performance Test

Test loads and MPE are recorded in the test report.

**Example:** Max : 150 kg, e : 50 g, Min : 1 kg, classes 3

<table>
<thead>
<tr>
<th>Load</th>
<th>Indication</th>
<th>Small weights</th>
<th>Error</th>
<th>MPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 kg</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-10 g</td>
</tr>
<tr>
<td>1 kg</td>
<td>1000</td>
<td>1000</td>
<td>+15 g</td>
<td>+10 g</td>
</tr>
<tr>
<td>25 kg</td>
<td>25000</td>
<td>25000</td>
<td>+15 g</td>
<td>-10 g</td>
</tr>
<tr>
<td>50 kg</td>
<td>50000</td>
<td>50000</td>
<td>+15 g</td>
<td>-10 g</td>
</tr>
<tr>
<td>100 kg</td>
<td>100000</td>
<td>100000</td>
<td>+15 g</td>
<td>-10 g</td>
</tr>
<tr>
<td>150 kg</td>
<td>150000</td>
<td>-50 g</td>
<td>75 g</td>
<td></td>
</tr>
</tbody>
</table>

---

### Weighing Performance Test

Calculate of Error

Non self indicating instruments

**Error (E) = I - L + S**

\[ I = \text{Indication} \quad L = \text{Load} \quad S = \text{small load} \]

### Weighing Performance Test

Test loads and MPE are recorded in the test report.

**Example:** Max : 150 kg, e : 50 g, Min : 1 kg, classes 3

<table>
<thead>
<tr>
<th>Load</th>
<th>Indication</th>
<th>Small weights</th>
<th>Error</th>
<th>MPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 kg</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-10 g</td>
</tr>
<tr>
<td>1 kg</td>
<td>1000</td>
<td>1000</td>
<td>+15 g</td>
<td>+10 g</td>
</tr>
<tr>
<td>25 kg</td>
<td>25000</td>
<td>25000</td>
<td>+15 g</td>
<td>-10 g</td>
</tr>
<tr>
<td>50 kg</td>
<td>50000</td>
<td>50000</td>
<td>+15 g</td>
<td>-10 g</td>
</tr>
<tr>
<td>100 kg</td>
<td>100000</td>
<td>100000</td>
<td>+15 g</td>
<td>-10 g</td>
</tr>
<tr>
<td>150 kg</td>
<td>150000</td>
<td>-50 g</td>
<td>75 g</td>
<td></td>
</tr>
</tbody>
</table>

Pass or Fail

---

### Weighing Performance Test

Test loads and MPE are recorded in the test report.

**Example:** Max : 150 kg, e : 50 g, Min : 1 kg, classes 3

<table>
<thead>
<tr>
<th>Load</th>
<th>Indication</th>
<th>Small weights</th>
<th>Error</th>
<th>MPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 kg</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-10 g</td>
</tr>
<tr>
<td>1 kg</td>
<td>1000</td>
<td>1000</td>
<td>+15 g</td>
<td>+10 g</td>
</tr>
<tr>
<td>25 kg</td>
<td>25000</td>
<td>25000</td>
<td>+15 g</td>
<td>-10 g</td>
</tr>
<tr>
<td>50 kg</td>
<td>50000</td>
<td>50000</td>
<td>+15 g</td>
<td>-10 g</td>
</tr>
<tr>
<td>100 kg</td>
<td>100000</td>
<td>100000</td>
<td>+15 g</td>
<td>-10 g</td>
</tr>
<tr>
<td>150 kg</td>
<td>150000</td>
<td>-50 g</td>
<td>75 g</td>
<td></td>
</tr>
</tbody>
</table>

Pass
Weighing Performance Test

Simple method

Evaluation method; error cannot be determined

Non self Indicating instruments

◆ If indicator balanced below equilibrium position,

Applied load

If it is equilibrium position or below, PASS

Remove weights of the value mpe

Indicator

◆ If indicator balanced above equilibrium position,

Applied load

If it is equilibrium position or above, PASS

Apply weights of the value of mpe

Repeatability

The difference between the results several weighings of the same load shall not be greater than the absolute value of the maximum permissible error of the instruments.

Two series of weighings shall be performed, one with a load of about 50% and one with a load close to 100% of Max. Normally no more than 3 weighings on class 3 and 4 or 6 weighings on classes 1 and 2 are necessary.

Repeatability Test

Non self indication instruments

Example: Max : 150 kg, e : 50g, Mis : 1 kg, class 3

Determining test load and mpe:

\[
\frac{1}{2} \text{Max} = 75 \text{ kg}, \quad \text{mpe : } ? \text{ g} \\
\text{Max} = 150 \text{ kg}, \quad \text{mpe : } ? \text{ g}
\]

Record in test report

<table>
<thead>
<tr>
<th>No</th>
<th>Load</th>
<th>Indication Small weights</th>
<th>Load</th>
<th>Indication Small weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>75 kg</td>
<td>150 kg</td>
<td>2</td>
<td>75 kg</td>
</tr>
<tr>
<td>2</td>
<td>75 kg</td>
<td>150 kg</td>
<td>3</td>
<td>75 kg</td>
</tr>
<tr>
<td></td>
<td>Max-Mis</td>
<td>Max-Min</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Repeatability Test

**Non self-indication instruments**

*Example:* Max: 150 kg, m: 50 g, Min: 1 kg, class J

- Determine test load and mpe:
  - 1/2 Max: 75 kg, mpe: 50 g
  - Max: 150 kg, mpe: 75 g

- Record in test report

<table>
<thead>
<tr>
<th>No</th>
<th>Load</th>
<th>Indication</th>
<th>Small weights</th>
<th>Load</th>
<th>Indication</th>
<th>Small weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>75 kg</td>
<td>150 kg</td>
<td></td>
<td>150 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>75 kg</td>
<td>150 kg</td>
<td>+50 g</td>
<td>150 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>75 kg</td>
<td>150 kg</td>
<td>+50 g</td>
<td>150 kg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Repeatability test

- Determine test load and mpe:
  - 1/2 Max: 75 kg, mpe: 50 g
  - Max: 150 kg, mpe: 75 g

- Record in test report

<table>
<thead>
<tr>
<th>No</th>
<th>Load</th>
<th>Indication</th>
<th>Small weights</th>
<th>Load</th>
<th>Indication</th>
<th>Small weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>75 kg</td>
<td>75,000 kg</td>
<td>+50 g</td>
<td>150 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>75 kg</td>
<td>75,000 kg</td>
<td>+50 g</td>
<td>150 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>75 kg</td>
<td>75,000 kg</td>
<td>+50 g</td>
<td>150 kg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Pass or Fail**

- **Pass**
**Discrimination test**

**Non self indicating instruments**

An extra load equivalent to 0.4 times the absolute value of the maximum permissible error for the applied load when gently placed on or withdrawn from the instrument at equilibrium shall produce a visible cause of permanent displacement of the indicating element movement element.

This test shall be performed with three different loads.

\[ \text{Min, } \frac{1}{2}\text{Max, Max} \]

---

**Discrimination test**

**Non self indication instruments**

Example: \( \text{Max: 150 kg, } e: 50 \text{ g, Min: 1 kg, class 3} \)

- **Determine test load and extra load:**
  - \( \text{Min} = 1 \text{ kg} \) : Extra load = 25 g \( \times 0.4 = 10 \text{ g} \)
  - \( \frac{1}{2}\text{Max} = 75 \text{ kg} \) : Extra load = 50 g \( \times 0.4 = 20 \text{ g} \)
  - \( \text{Max} = 150 \text{ kg} \) : Extra load = 75 g \( \times 0.4 = 30 \text{ g} \)

- **Record in test report**

<table>
<thead>
<tr>
<th>Load</th>
<th>Indication</th>
<th>Extra load (0.4)</th>
<th>Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kg</td>
<td></td>
<td>10 g</td>
<td></td>
</tr>
<tr>
<td>75 kg</td>
<td>20 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150 kg</td>
<td>30 g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Discrimination test**

**Non self indication instruments**

Example: \( \text{Max: 150 kg, } e: 50 \text{ g, Min: 1 kg, class 3} \)

- **Determine test load and extra load:**
  - \( \text{Min} = 1 \text{ kg} \) : Extra load = 25 g \( \times 0.4 = 10 \text{ g} \)
  - \( \frac{1}{2}\text{Max} = 75 \text{ kg} \) : Extra load = 50 g \( \times 0.4 = 20 \text{ g} \)
  - \( \text{Max} = 150 \text{ kg} \) : Extra load = 75 g \( \times 0.4 = 30 \text{ g} \)

- **Record in test report**

<table>
<thead>
<tr>
<th>Load</th>
<th>Indication</th>
<th>Extra load (0.4)</th>
<th>Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kg</td>
<td></td>
<td>10 g</td>
<td></td>
</tr>
<tr>
<td>75 kg</td>
<td>20 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150 kg</td>
<td>30 g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Discrimination test**

**Non self indication instruments**

Example: \( \text{Max: 150 kg, } e: 50 \text{ g, Min: 1 kg, class 3} \)

- **Determine test load and extra load:**
  - \( \text{Min} = 1 \text{ kg} \) : Extra load = 25 g \( \times 0.4 = 10 \text{ g} \)
  - \( \frac{1}{2}\text{Max} = 75 \text{ kg} \) : Extra load = 50 g \( \times 0.4 = 20 \text{ g} \)
  - \( \text{Max} = 150 \text{ kg} \) : Extra load = 75 g \( \times 0.4 = 30 \text{ g} \)

- **Record in test report**

<table>
<thead>
<tr>
<th>Load</th>
<th>Indication</th>
<th>Extra load (0.4)</th>
<th>Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kg</td>
<td></td>
<td>10 g</td>
<td></td>
</tr>
<tr>
<td>75 kg</td>
<td>20 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150 kg</td>
<td>30 g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Discrimination Test**

**Non self indication instruments**

- Applied to test load
- Applied to extra load

---

**Discrimination Test**

**Non self indication instruments**

Example: Max: 150 kg, e: 50 g, Min: 1 kg, class 3

<table>
<thead>
<tr>
<th>Load</th>
<th>Indication</th>
<th>Extra load = 0.4 mpc</th>
<th>Movement (*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kg</td>
<td>1,000 kg</td>
<td>10 g</td>
<td>+</td>
</tr>
<tr>
<td>15 kg</td>
<td>75,000 kg</td>
<td>20 g</td>
<td>+</td>
</tr>
<tr>
<td>150 kg</td>
<td>150,000 kg</td>
<td>30 g</td>
<td>+</td>
</tr>
</tbody>
</table>

(*) Mark visible movement by “+”

Pass or Fail

---

**Eccentricity**

The indications for different positions of a load shall meet the maximum permissible errors, when the is tested according to following.

- Instrument with a load receptor having n points of support, with $n \leq 4$
  
  Test load: $(\text{Max} + \text{Additive tare effect}) / 3$

- Instrument with a load receptor having $n$ points of support, with $n > 4$
  
  Test load: $(\text{Max} + \text{Additive tare effect}) / (n-1)$

- Instrument with a load receptor subject to minimal off-center loading
  
  Test load: $0.1\text{Max} + \text{Additive tare effect}$

- Instrument used for weighing rolling loads
  
  Test load: usual rolling load, the heaviest and the most concentrated one which may be weighed, but not exceeding 0.3 times the sum of the Max and Additive tare effect
Eccentricity

Non self indication instruments:
Example: Max: 150 kg, e: 50 g,
Min: 1 kg, class 3

1. Determine type of load receptor, test load and mpe

This instrument has 4 points of support
n points of support with n ≤ 4

Test load = \frac{(\text{Max} + \text{Additive error effect})}{3}

mpe = \frac{\text{kg}}{\text{g}}

- \text{support}

- \text{support}

- \text{support}

- \text{support}

2. Record in test report

<table>
<thead>
<tr>
<th>Location</th>
<th>I</th>
<th>L</th>
<th>E</th>
<th>mpe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>1</td>
<td>50kg</td>
<td>0</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>50kg</td>
<td>0</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>50kg</td>
<td>0</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>50kg</td>
<td>0</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

3. Example: Max: 150 kg, e: 50 g, Min: 1 kg, class 3

Preload (Max) Zerling

Test load applied to No.1

Remove to test load

Next to location
Eccentricity

Non self indication instruments:

<table>
<thead>
<tr>
<th>Location</th>
<th>L</th>
<th>I</th>
<th>SI</th>
<th>E</th>
<th>mpe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50g</td>
</tr>
<tr>
<td>2</td>
<td>50kg</td>
<td>50,000kg</td>
<td>0</td>
<td>50g</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50g</td>
</tr>
<tr>
<td>4</td>
<td>50kg</td>
<td>50,000kg</td>
<td>-10g</td>
<td>50g</td>
<td></td>
</tr>
</tbody>
</table>

Pass or Fail

Sensitivity

Only applied on non self indicating instrument

An extra load equal to the absolute value of the NPE for the applied load, shall be placed on the instrument of equilibrium and shall cause a permanent displacement of the indicating element of at least:

- 1 mm for an instrument of class 1 or 2;
- 2 mm for an instrument of class 3 or 4 with Max<30 kg;
- 5mm for an instrument of class 3 or 4 with Max>30 kg.

The test shall be performed with a minimum of two different loads (e.g. zero and Max)

Eccentricity

Non self indication instruments:

<table>
<thead>
<tr>
<th>Location</th>
<th>L</th>
<th>I</th>
<th>SI</th>
<th>E</th>
<th>mpe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50g</td>
</tr>
<tr>
<td>2</td>
<td>50kg</td>
<td>50,000kg</td>
<td>0</td>
<td>50g</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50g</td>
</tr>
<tr>
<td>4</td>
<td>50kg</td>
<td>50,000kg</td>
<td>-10g</td>
<td>50g</td>
<td></td>
</tr>
</tbody>
</table>

Pass

Sensitivity

Non self indication instruments

Example: Max: 150 kg, ±: 50 g, Min: 1 kg, class 3

Determine test load and extra load:

- Zero = 0 kg: Extra load = ? g
- Max = 150 kg: Extra load = ? g

Record in test report

<table>
<thead>
<tr>
<th>Load</th>
<th>Extra Load mpa</th>
<th>Displacement of indicating element</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150 kg</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sensitivity

Non self indication instruments

Example: Max: 150 kg, ε: 50 g, Min: 1 kg, class 3

- Determine test load and extra load:
  - Zero = 0 kg: Extra load 25 g
  - Max = 150 kg: Extra load 75 g

- Record in test report

<table>
<thead>
<tr>
<th>Load</th>
<th>Extra load</th>
<th>Displacement of indicating element</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>25 g</td>
<td>5 mm</td>
<td></td>
</tr>
<tr>
<td>150 kg</td>
<td>75 g</td>
<td>5 mm</td>
<td></td>
</tr>
</tbody>
</table>

Sensitivity

Non self indication instruments

Applied to test load

Applied to extra load

<table>
<thead>
<tr>
<th>Load</th>
<th>Extra load</th>
<th>Displacement of indicating element</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>25 g</td>
<td>10 mm</td>
<td>5 mm</td>
</tr>
<tr>
<td>150 kg</td>
<td>75 g</td>
<td>9 mm</td>
<td>5 mm</td>
</tr>
</tbody>
</table>

Fass
Zero setting accuracy

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

Zeroing

1. Small weights put on the load receptor of no-load after preload.
2. Zero setting device to equilibrium position.

After the load is remove, Zero Indicator shall be confirmed.

Confirm to position of Indicator:

- If indicator is in accord with equilibrium position, the error is 0.
- If indicator balance at above equilibrium position.
  Small weights shall be removed until equilibrium position comes to the indicator. (-)
- If indicator balance at below equilibrium position.
  Small weights shall be put on until equilibrium position comes to the indicator. (+)
### Zero setting accuracy

**Example:** Max: 150 kg, e: 50 g, Min: 1 kg, classes 3

<table>
<thead>
<tr>
<th>Zeroing</th>
<th>Load</th>
<th>Indication</th>
<th>SI</th>
<th>Error</th>
<th>Mpe</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>150 kg</td>
<td>0</td>
<td>-10 g</td>
<td>12.5 g</td>
<td></td>
</tr>
</tbody>
</table>

Pass or Fail

### Zero setting accuracy

**Example:** Max: 150 kg, e: 50 g, Min: 1 kg, classes 3

<table>
<thead>
<tr>
<th>Zeroing</th>
<th>Load</th>
<th>Indication</th>
<th>SI</th>
<th>Error</th>
<th>Mpe</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>150 kg</td>
<td>0</td>
<td>-10 g</td>
<td>-10 g</td>
<td>12.5 g</td>
</tr>
</tbody>
</table>

Pass