Verification for Non-Automatic Weighing Instruments (NAWI)

Every instrument should be accurate and correct to be permitted for use in any commercial transaction, particularly at the Point Of Sale. An instrument may be accurate but may not be correct. To be accurate, the instrument must meet the applicable tolerance limit (MPE) and some metrological requirements. It should pass some specific performance tests. To be correct, an instrument, should not only be accurate, it should meet some specific legal requirements also - type (design) or model approval, appropriate class for usage, descriptive markings, proper maintenance etc.

1. Definitions.

1.1 Non-Automatic Weighing Instrument (NAWI)

Instrument that requires the intervention of an operator during the weighing process to decide that the weighing result is acceptable.

1.2 Verification scale interval, *e*

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

1.3 Actual scale interval, *d*

Value, expressed in units of mass of:

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

1.4 Number of verification scale intervals, *n*

Quotient of the maximum capacity and the verification scale interval:
$n = \text{Max} / e$

1.5 Maximum capacity (Max)

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

1.6 Minimum capacity (Min)

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

1.7 Maximum permissible error (MPE)

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 or standard weights, with the instrument being at zero at no-load, in the reference position

2. Classification of NAWI

All NAWI's are classified into four categories:

- Class I: Special accuracy - ultra micro, micro, semi micro, macro
- Class II: High accuracy - precision balances
- Class III: Medium accuracy - NAWI's for trade use
- Class IIII: Ordinary accuracy - For low accuracy trade use

2.1 Identification of NAWI classes

Identification of NAWI classes is based on the following table.

Table 1

Class	*e* value in g	Verification Scale Interval n = max/*e*	min capacity (g)
I	0.001 or above	50 000	100*e*
II	0.001 to 0.05 0.1 or above	100 to 100 000 5 000 to 100 000	20*e* 50*e*
III	0.1 to 2 5 or above	100 to 10 000 500 to 10 000	20*e* 20*e*
IV	5 or above	100 to 1000	10*e*

- Check if declared, e value matches with the accuracy class
- Find n = max/*e* and check whether it matches with the accuracy class
- Check whether min value matches with the accuracy class
- Some instruments do not declare minimum capacity. Calculate the minimum capacity from the table and check whether the instrument can measure below that quantity

3. Metrological requirements

- An instrument must be allowed to warm up before commencing test.
- All NAWIs should pass the test under normal conditions.
- Once an instrument fails in a test, it is no use carrying out any further test.
- Accuracy classes
- Verification scale interval, *e*
- Actual scale interval, *d*
- Sealing/stamping mechanism

4. Testing Procedures of NAWI other than Weighbridge.

4.1 Visual examination

All NAWI shall have a permanently fixed/engrooved descriptive plate with marking:

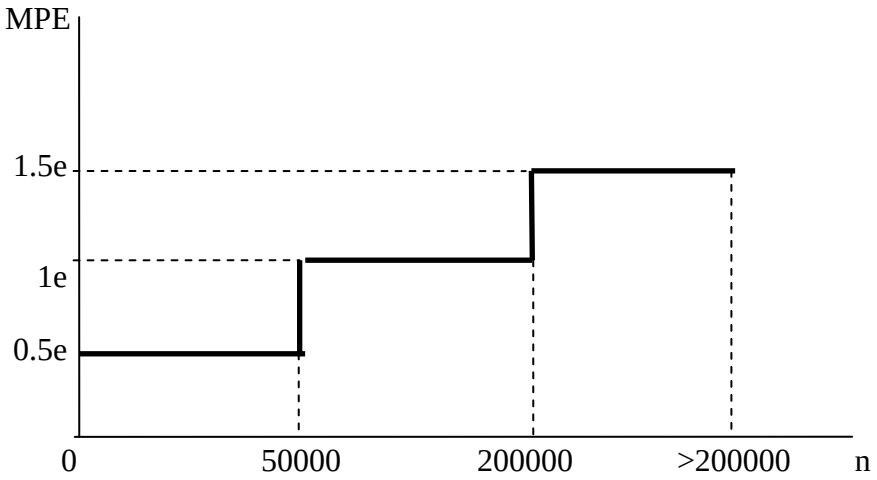
- Manufacture`s mark and model
- Accuracy class – I, II, III, IIII
- Verification scale interval, *e*
- scale interval, d (when d < *e*)
- maximum capacity (max)
- minimum capacity (min)

NOTE: Scale Class I, II and III, shall be Verified by Standard mass of class E, F and M respectively.

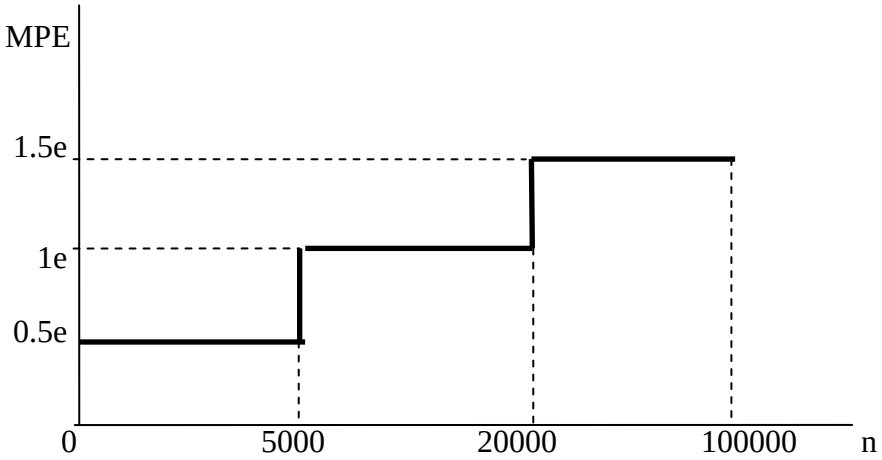
4.2 Determination of maximum permissible error (MPE)

In every class of digital scale has MPE which corresponds to verification intervals of the scale (*e).* See the graphs below.

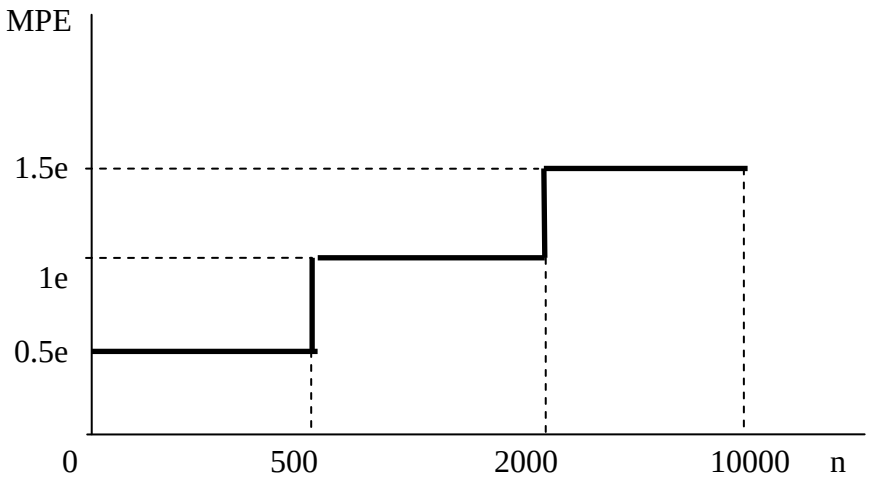
Class I



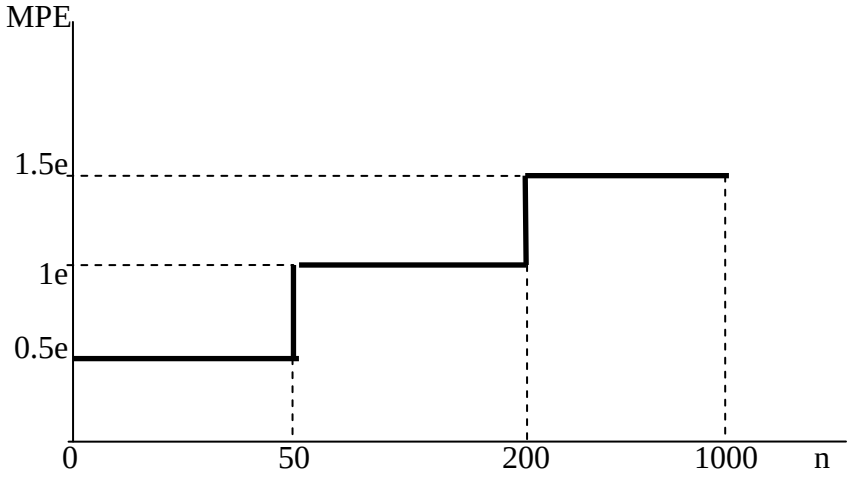
Class II



Class III



Class IIII



The above graphs are simplified in Table 2 below:

Table 2: MPE for initial verification.

	Class I	**Class II**	**Class III**	**Class IIII**	**MPE ±**
Load in *e*	min to 50 000	min to 5 000	min to 500	min to 50	0.5*e*
Load in *e*	50 001 to 200 000	5 001 to 20 000	501 to 2 000	51 to 200	1*e*
Load in *e*	above 200 000	20 001 to 100 000	2 001 to 10 000	201 to 1 000	1.5*e*

NOTE: For subsequent verification , MPE is twice of initial MPE

From the minimum and maximum value obtained for particular scale, this will show where the scale falls between boundaries of MPE, eg. 0.5*e*, 1*e*, 1.5*e*.

Example: Class III, Max Capacity 8000g, e=1g

Minimum Capacity = $n_{min} \times e$

Maximum Capacity = $n_{max} \times e$

When Minimum capacity is not given, refer to Table 1 above for class III which is 20*e*.

n_{min} = Minimum number of verification scale intervals

n_{max} = Maximum number of verification scale intervals

$$n_{min} = \frac{\text{Min. Capacity}}{e}$$

$$\therefore n_{min} = \frac{20e}{e} = 20 \text{ intervals.}$$

$$n_{max} = \frac{\text{Max. Capacity}}{e}$$

$$= \frac{8000}{1}$$

= 8000 intervals

From the graph of class III, our weighing instrument 8000g capacity lies between three boundaries as follows.

(i) 20 – 500 (boundary i)
(ii) 501 – 2000 (boundary ii)
(iii)2001 – 8000 (boundary iii)

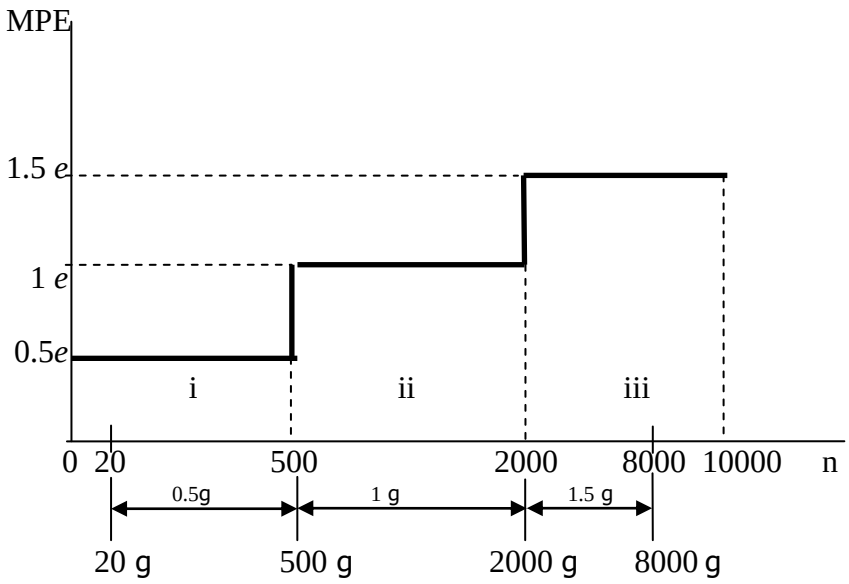
So the MPE for these 3 boundaries are as follows.
Boundary i: MPE = 0.5e = 0.5(1) = ± 0.5g
Boundary ii: MPE= 1e = 1(1) = ± 1g
Boundary iii: MPE= 1.5e = 1.5(1) = ± 1.5g

Convert the number of scale intervals into Mass (grams) by $n \times e$.

$\therefore$ n_1e = 20×1 = 20g
n_2e = 500×1 = 500g
n_3e = 2000×1 = 2000g
n_4e = 8000×1 = 8000g

Graph

Class III



Range intervals and MPEs shown in table 3,

Table 3

Range	MPE (g)
20g to 500g	±0.5
>500g to 2000g	±1.0
>2000g to 8000g	±1.5

4.3 Weighing Performance Test

On carrying out performance test, the instrument must be allowed to warm up, and then loaded with a known mass not exceeding maximum capacity at least three times. The Instrument is tested by loading the mass in the following sequence

(i) Loading in ascending order up to maximum capacity

(ii) Unloading in descending order to zero.

4.3.1 Procedures:

(a) Select at least five different standard mass :

- Minimum capacity of instrument.
- 20% of the maximum capacity of the instrument.
- 40% of the maximum capacity of the instrument.
- 60% of the maximum capacity of the instrument.
- 80% of the maximum capacity of the instrument.
- 100% of the maximum capacity of the instrument.

NOTE: MPE of the instrument must be known according the class of weighing instrument and standard mass used.

(b) Determine E_o (error calculated at/or near zero) by putting the smallest mass that can be detected.

(c) Put the selected mass as stipulated in part (a) above in turn on the instrument and note the indications (The same procedure repeated backwards). On every indication (*I*) observed above, add smallest mass (*ΔL)* that will change the readings.

From the above procedure error is calculated by the following formula.

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

Now error corrected.

$E_c = E - E_0$ with E_0 = error calculated at or near zero

All results should be recorded in the following table, Arrow indications ↓ and ↑ means forward and backwards respectively.

Table 4

Load, L	Indication, I		Add Load ΔL		Error, E		Corrected error, E_c		MPE
	↓	↑	↓	↑	↓	↑	↓	↑	

In every test if $|Ec| \leq |mpe|$, the instrument ***Passed***

Remarks:……

4. Eccentricity Test

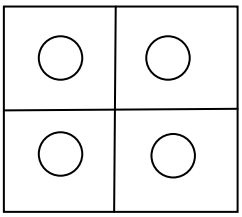
The aim of the test , regardless position of load on instrument, the instrument must indicate actual value of load within MPE.

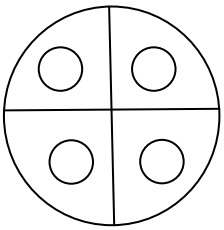
Procedures

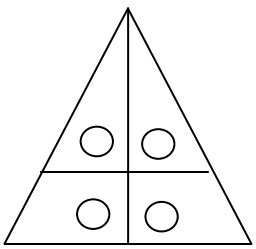
- Determination of Load receptor. Check whether the load receptor of instrument has :
  - ✓ Four or less points of support.
  - ✓ More than four points of supports.

  In most cases weighing scales other than Weighbridges have four or less points of supports.

  Instruments with four or less points of support a load corresponding to one-third of the maximum capacity shall be applied as follow:







O – Loading Position

When commencing test observe corresponding MPE of ⅓ of the maximum capacity for particular instrument.

(i) Set instrument at zero
(ii) Apply ⅓ of maximum capacity in all marked load position in-turn.
(iii) Record the load (L) and indication (*I*)
(iv) In all position add and record smallest mass (ΔL) that will be detected.
(v) In every test, Calculate E by using formula $E = I + ½\ e - \Delta L - L$ *and* $E_c = E - E_0$
(vi) Record the results above in Table 5

Table 5

location	Load, L	Indication, I	Add Load ΔL	Error, E	Corrected error, E_c	MPE
1						
2						
3						
4						

If $|Ec| \leq |MPE|$, the instrument ***Passed***

The indications for different positions of a load shall meet the MPEs, when the instrument is tested.

5. Discrimination

This test is done to check if the instrument is capable of sensing a small change in load.

The actual scale interval for a class I or II digital instrument may be *d* and not *e*. As the majority of instruments to be verified will be class III or IIII where $e = d$, *e* is used in the procedure. If the instrument to be tested has $d \neq e$ then e becomes d in this instance for the whole procedure.

Procedure

Select three different standard mass as stipulated below:

(i) Minimum capacity of the instrument
(ii) Half capacity of the instrument
(iii) Maximum capacity of instrument

Start putting the selected standard mass on the instrument and note the indication (I). On every indication (I_1) observed above add *1.4d* and note indication (I_2) where d is the actual scale interval which is the difference between the values corresponding to two consecutive indicated values.

In all three tests compute $I_2 - I_1$

Results are recorded in Table 6

Table 6

Load, L	Indication, I_1	Extra load = 1.4*d*	Indication, I_2	$I_2 - I_1$

Finally, in every tests if $I_2 - I_1 \geq$ d the instrument *Passed*

6. Repeatability

This test is designed to check whether the instrument gives consistent reading for the same load when the load is placed on the same position on the receptor for a number of times.

Procedures

Repeatability test is done at half load of the maximum capacity of the instrument.

NOTE: MPE of the instrument must be known at the particular load.

Start putting selected half load on the instrument for about 10 times and add smallest mass (ΔL) that will change the indications

Calculate E by using the formula.

$E = I + \frac{1}{2}e - L - \Delta L$

Record results calculated above in Table 7.

Table 7

Load	Indication	Add. Load ΔL	E	MPE

Finally in every tests: If $E \leq$ MPE and $E_{max} - E_{min} \leq |MPE|$ the instrument ***Passed.***

TEST FORM FOR NAWI (ELECTRONIC) OTHER THAN WEIGHBRIDGES

Owner Name and Address…….

……

General Examination:

Type…… **Model…….**

Value of *e*…… **Value of *d*……...**

Serial Number…… **Last Verification ……**

Sealing Mechanism (Provide/not Provide)……

Maximum Capacity …… **Minimum Capacity……..**

Visual Examination:

(a) ……
(b) ……
(c) ……

☐ **Passed** ☐ **Failed**

1. **WEIGHING PERFOMANCE TEST.**

Table

Load, L	Indication, I ↓	Indication, I ↑	Add Load ΔL ↓	Add Load ΔL ↑	Error, E ↓	Error, E ↑	Corrected error, E_c ↓	Corrected error, E_c ↑	MPE

Check if $|E_c| \leq |MPE|$ the instrument ***Passed***

☐ **Passed** ☐ **Failed**

Remarks……

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2. ECCENTRICITY TEST

Table

location	Load, L	Indication, I	Add Load ΔL	Error, E	Corrected error, E_c	MPE
1						
2						
3						
4						

Check if $|E_c| \leq |MPE|$ the instrument *Passed*

☐ **Passed** ☐ **Failed**

Remarks……

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3. DISCRIMINATION TEST

Table

Load, L	Indication, I_1	Extra load = 1.4*d*	Indication, I_2	$I_2 - I_1$

Finally, in every tests if $I_2 - I_1 \geq d$ the instrument *Passed*

☐ **Passed** ☐ **Failed**

Remarks……

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4. REPEATABILITY

Table

Load	Indication	Add. Load ΔL	E	MPE

Finally in every tests: If $E \leq MPE$ and $E_{max} - E_{min} \leq |MPE|$ the instrument *Passed.*

☐ **Passed** ☐ **Failed**

Remarks……

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Final Remarks:

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Name of Inspector: …… Name of Owner/Agent:……..

Signature: ……...…... Signature: ……

Date: …… Date: ……..