THE RISK OF AN INAPPROPRIATE USE OF A WEIGHING INSTRUMENT

Luljeta Disha[1], Defrim Bulku[1], Antoneta Deda[2]
[1]*General Directorate of Metrology, 1000 Tirana, Albania*
[2] *Faculty of Natural Science, 1000 Tirana, Albania*
E-mail: luljeta.disha@dpm.gov.al

Abstract

Inaccurate measurements in the weighing operation during trading causes unfair trade transactions. Selection of a balance depends on the applications purposes and accuracy requirements. Normally weighing instruments take measurement of mass making use of absolute gravity value and their calibration must be performed in the place of use. If a weighing instrument is relocated from its original place of calibration, it requires taking into consideration the change of absolute gravity value "g". This change in the value of gravity causes a difference in the indication errors of the weighing instrument at the new location. In this paper will be presented the performance of a weighing instrument with capacity Max = 30 kg and a scale division d = 10g, after it changes the place of use from Italy to Albania and the correction method applied to eliminate the errors of indication. This weighing instrument belongs to a customer of Mass Laboratory in General Directorate of Metrology in Albania which has requested a calibration for this instrument. The results show that the weighing instrument should be used after a correct adjustment, according to manufacturer advice because of the change of "g".

Keywords: *weighing instrument, displacement, error of indication, correction, calibration*

INTRODUCTION

In order to ensure that measurements and their results are made on the same basis throughout the world, each country should have a National Metrology Institute (NMI) that provides the traceability of all units and disseminates them with consistent accuracy among the country. In Albania this institute is represented by General Directorate of Metrology (GDM). Mass Laboratory in Albania is responsible for maintaining and developing the national standards of mass unit, to provide the traceability and disseminate it for the scientific, industrial needs measurements etc by calibration service.

Actual paper is a continuation of a previous study of the performance of a weighing instrument when it changes the place of use from one city to another city in Albania. The weighing instrument with Max = 4kg and a scale division d = 0.01g (class II) has changed the place of use from Tirana to Vlore and as a result a sensitivity error occurs [1]. Therefore the effect of absolute gravity value for this weighing instrument is very essential and should be corrected. In order to see the differences in mass readings there are performed measurements using a weighing instrument with capacity Max = 30 kg and a scale division d = 10g (class III), when it changes the place of use from one country to another country. The weighing instrument belongs to a customer of Mass Laboratory in Albania, which is an Italian Company and has requested a calibration for this instrument after it has changed the place of use from Italy to Albania. This customer produces shoes here in Albania and after that, it transports them to Italy. For several days it was having problems with the custom as it was declaring there a different mass of shoes than it really had. As a result a bad presentation was being introduced to the respective company leading to a damaged image of it. The risk analysis of using an inappropriate weighing instrument aims to: obtaining a high quality product, money saving, expenses cut and also obtaining conformity with legal requirements that are currently valid in a country. So, assessing mass measurement error influences on product quality and on the whole process risk.

MATERIALS AND METHOD

Since the weighing results obtained from a measurement process are often of critical importance and in many cases can lead to wrong decisions, it is necessary that anyone carrying out mass measurements must be ensured of the reliability of the results obtained during a weighing process.

If a weighing instrument is moved to another location after the calibration, possible effects that could influence in the performance of the instrument and may invalidate the calibration are: difference in local gravity acceleration, variation in environmental conditions, mechanical and thermal conditions during transportation. The indication of an instrument is proportional to the force exerted by an object of mass *m* on the load receptor (1) [2]:

$$I = m\, g \left(1 - \frac{\rho_a}{\rho}\right) k_s \tag{1}$$

where:

g - local acceleration gravity
ρ_a - density of the surrounding air
ρ - object density
k_s - adjustment factor

The basic equation used for calculation of the indication errors in the calibration of the weighing instrument is the equation (2):

$$E = I - m_{ref} \tag{2}$$

where:

m_{ref} – reference value of mass
I – the indication of balance which corresponds to the reference value of mass with combined uncertainty calculated with equation (3) [3], [4]:

$$u(E) = \sqrt{u^2(I) + u^2(m_{ref})} \tag{3}$$

The most accurate methods of eliminating the effect of variation in the acceleration of gravity are: internal or external adjustment of the balance. The internal adjustment is a system of internal automatic calibration, realized through application of a weight installed inside the weighing instrument casing. Otherwise, the external adjustment consists on loading either an external mass with nominal value, or an external mass with conventional value as prescribed in the procedure of the balance`s user manual. The standard weights used for the adjustment of weighing instruments must have been traceable to the International System of Units (SI).

Actually, the link between the SI unit of mass and the GDM national standards of mass is maintained through periodic calibrations of the national standard at the two high levels NMIs, National Institute of Metrological Research (INRIM) Italy and Physikalisch-Technische Bundesanstalt (PTB) Germany. These two NMIs provide their traceability of Mass Unit at the International Bureau of Weights and Measures BIPM, France. Figure 1 shows the traceability scheme for the mass unit in Albania until 2016 [5].

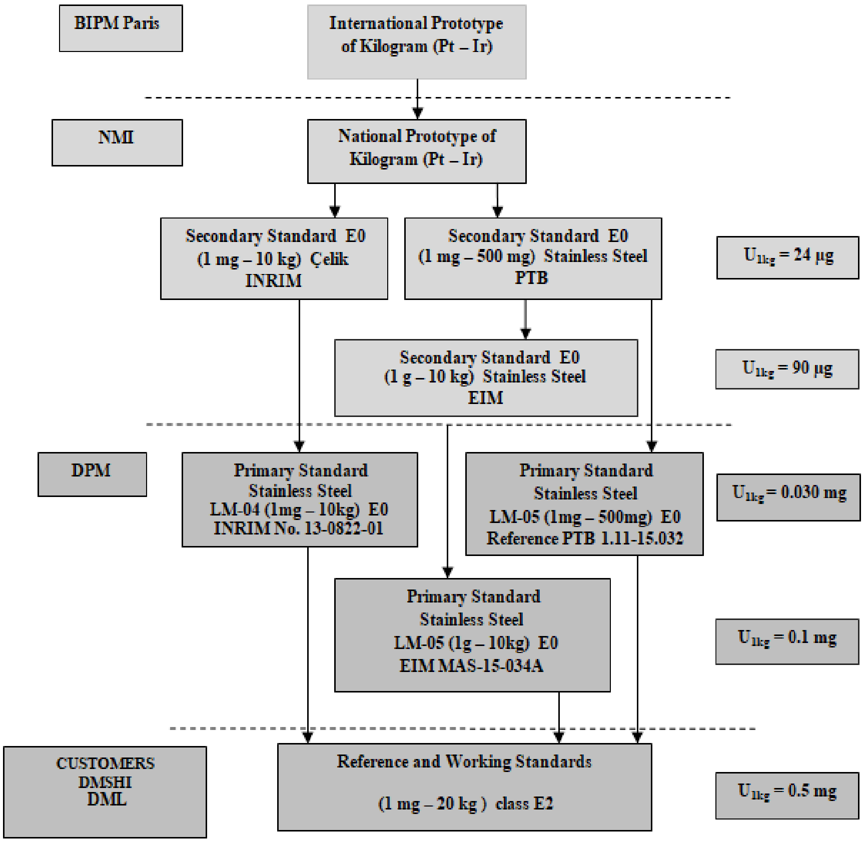


Figure 1. Traceability scheme for the mass unit in Albania 2016

For routine calibrations of weighing instruments Mass Laboratory in Albania is based on ISO/IEC 17025 standard "General requirements for the competence of testing and calibration laboratories". Normally the calibration of a wighing instrument is performed in a full range, but when a customer uses the instrument only in one range it can be calibrated only in this range. The procedure used for calibration is a documented one and it includes measurments that show the actual weighing instrument performance.

There are a number of tests that can be carried out to determine the performance level of weighing instruments and some of these are suitable for all instruments. The tests implemented in the procedure used by Mass Laboratory in Albania during calibration of a weighing instrument are:

1 – Preloading
2 – Repeatability test
3 – Eccentric loading test
4 – Linearity test

After performing these tests, the uncertainty of measurements is calculated and all the results should be noted on the calibration certificate. In order to see the differences in the indication errors of the weighing instrument all these tests of the weighing instrument are performed in two stages, before adjustment and after adjustment process.

The weights used for the adjustment process and calibration as well, are generally be drawn from classes defined in [6] and for sure of a class which is suitable for the weighing instrument being calibrated as reported in Table 1.

Table 1. weights used for calibration of a specific weighing instrument

Range of measurement	Scale division d							
	100g	10g	1g	100mg	10mg	1mg	0.1mg	< 0.1mg
Up to 50g		-	-	-	-	F2	E2	E1
Up to 100g	-	-	-	-	M1	F1	E1	
Up to 500g	-	-	-	M2	F2	E2		
Up to 1kg	-	-	M2	M1	F1			
Up to 5kg	-	-	M1	F2	E2			
Up to 10kg	-	-	F2	F1				
Up to 50kg	-	M2	F1					
Up to 100kg	-	M1						
Up to 500kg	M2	F2						

RESULTS AND DISCUSSION

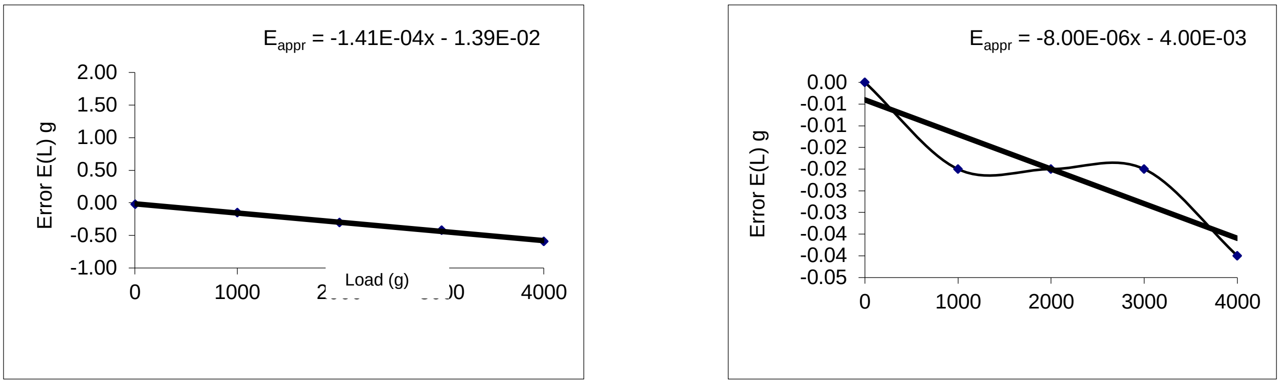
From the analysis of the results it was assumed that the repeatability test and the eccentric loading test of the weighing instruments were not influenced by the change of absolute gravity value "g". So in table 2 are reported the values of the weighing instrument with Max= 4kg indications and the respective errors before and after adjustment, when it is displaced from Tirana to Vlore. These values belong to the linearity test.

Table 2. values of weighing instrument with Max= 4kg indications and errors before and after adjustment in Vlore

Nominal Value (g)	Indication before adjustment (g)	Error of indication (g)	Indication after adjustment (g)	Error of indication (g)
1	0.98	-0.02	1.00	0.00
1000	999.85	-0.15	999.98	-0.02
2000	1999.70	-0.30	1999.98	-0.02
3000	2999.58	-0.42	2999.98	-0.02
4000	3999.41	-0.59	3999.96	-0.04

For the maximum load before the adjustment process, the indication error is in the range 5.9×10^{-1} g and after the adjustment process this error is in range 4×10^{-2} g that means the indication of the weighing instrument has a considerable difference.

This phenomenon is due to the difference in gravitational acceleration resulting from the difference in geographic region and height above sea level. Graphs of the indication errors of the weighing instrument before and after adjustment in Vlore are presented in figure 2 a) and b) respectively, also the linear approximation equation of these errors.



a) b)

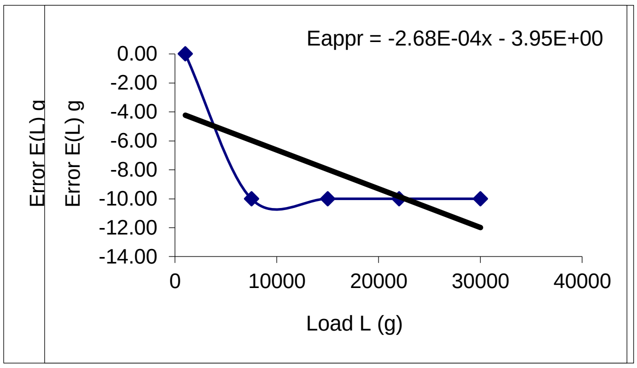
Figure 2. graphs of the indication errors of the weighing instrument before and after adjustment

In table 3 are reported the values of weighing instrument with Max = 30 kg indications and the errors before and after external adjustment, when this instrument is displaced from Italy to Tirana, Albania. Even these values belong to the linearity test. External adjustment according to the user manual of this weighing instrument is done with the nominal mass value m_N =14850g (class M1).

Table 3. values of weighing instrument with Max = 30kg indications and errors before and after external adjustment in Tirana

Nominal Value (g)	Indication before adjustment (g)	Error of indication (g)	Indication after adjustment (g)	Error of indication (g)
1000	0.98	-400.0	1000	0.0
7500	999.85	-2000.0	7490	-10.0
15000	1999.70	-3100.0	14990	-10.0
22000	2999.58	-4100.0	21990	-10.0
30000	3999.41	-4900.0	29990	-10.0

From the results reported in table 3 it can be clearly seen that before the adjustment is performed, the indication errors are really too large. For the maximum load it is 4.9 kg, and after the external adjustment this error is reduced in 10 g. Figure 3 a) and b) show the indication errors before and after adjustment and the linear approximation equation of these errors.



a)

b)

Figure 3. graphs of the indication errors before and after external adjustment

It can be seen from the results that after the adjustment process the indication errors of this weighing instrument are reduced in a significant way. It makes a lower difference that means there is no risk for the customer. Figure 4 shows the graph of the uncertainty of measurements during calibration and the linear approximation equation of these uncertainties.

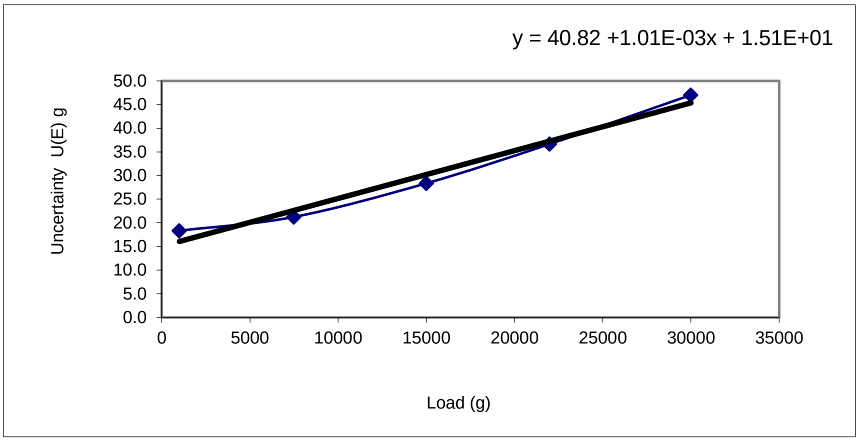


Figure 4. graph of the uncertainty U (E) before external adjustment

Figure 5 shows the graph of the uncertainty of measurements during calibration after external adjustment is performed and the linear approximation equation of these uncertainties. As it can be seen from the graphs also the uncertainty of measurements during calibration is also reduced.

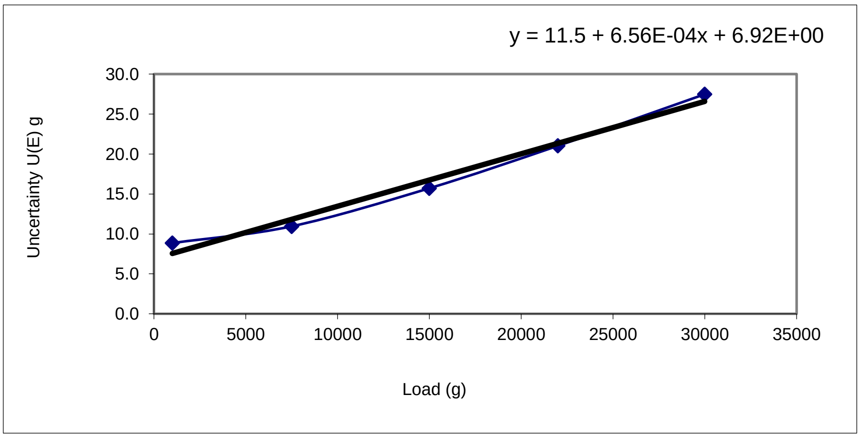


Figure 5. graph of the uncertainty of measurements after external adjustment

SUMMARY AND CONCLUSIONS

In this paper the performance of a weighing instrument with capacity Max = 30 kg and a scale division d = 10g, after it changes the place of use from Italy to Albania was presented. Due to the difference in gravitational acceleration resulting from the difference in geographic region and height above sea level for these two countries, the indication errors of the weighing instrument change. From the comparison to the previous case studied, in which a weighing instrument with capacity Max = 4kg changes the place of use from one city to another in Albania (Tirana to Vlore) it was assumed that the indication errors are larger when a weighing instrument changes the place of use from one country to another country. The risk of using this instrument without making any correction for gravity differences is very large. Uncertainty of measurements during calibration is also reduced. Risk of using a weighing instrument is not only searching for incorrect measurements cause, but also ignoring the fact that measurement is afflicted by an error. So it is very important for every customer of Mass Laboratory in Albania, to know the actual performance of their weighing instruments especially when they changes the place of use in order to reduce the risk of using an inappropriate weighing instrument.

BIBLIOGRAPHY

[1] Method of Absolute Gravity Measurement and its influence in Mass Determination, Luljeta Disha, D.Bulku, Antoneta.D, *Journal of Experimental and Theoretical Physics, Physica Macedonica*, Volume 62, 2016, ISSN 1409-7168

[2] EURAMET, cg -1 8 “Guidelines on the Calibration of Non - automatic Weighing Instruments”, Version 4.0 /2015

[3] Evaluation of measurement data, Guide for the expression of uncertainty in measurement (GUM). JCGM 100:2008

[4] European cooperation for Accreditation, EA-4/02 Expression of the Uncertainty of Measurement in Calibration, 2013

[5] Traceability of Mass Unit in the Republic of Albania, Luljeta Disha, D.Bulku, Antoneta. D, *Journal of Natural and Technical Sciences* (JNTS), Volume 41, (XXI), Science Academia of Albania, ISSN 2074-0867, 2016 (1)

[6] The International Recommendation for weights of classes E1, E2, F1, F2, M1, M1-2, M2, M2-3, M3 2004.Metrological and technical requirements, OIML, 2004