
# Lexicon of Basic Metrological Terms

radwag.com

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1st edition
RADWAG Wagi Elektroniczne
26-600 Radom, ul. Toruńska 5
Tel. 48 48 3848800, fax 48 48 3850010
e-mail: radom@radwag.pl
http://www.radwag.com

**CONTENTS**

## ACCLIMATIZATION

Acclimatization is the process of stabilizing the electronic balance after connecting it to the mains when there is a significant temperature or humidity difference between the balance and the environment in which it is to be used. The acclimatization period depends on the resolution of the balance and the temperature difference between the balance and the working environment. Practically, the balance acclimatization time is about 12 hours. It is possible to use the balance while it is stabilizing, but the potential variability during acclimatization should be taken into account.

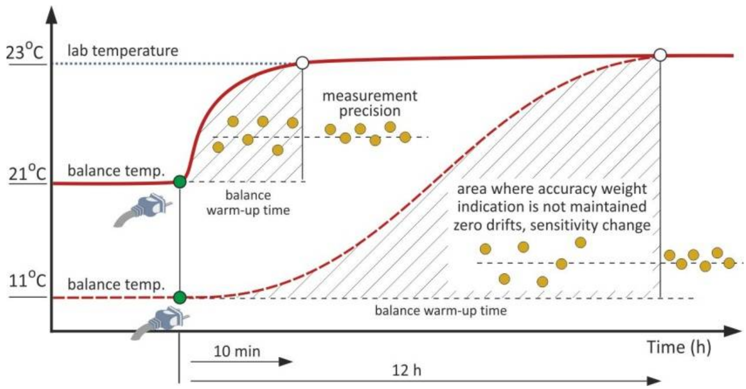


Figure 1. Acclimatization - the general principle of operation


Figure 2. Environmental conditions control – MYA 5.5Y microbalance

## ACCURACY

Accuracy is the degree of agreement between the measurement result and the reference value. Accuracy is a qualitative concept, not a quantitative one. For this reason, accuracy cannot be expressed by a number. A measurement can be said to be accurate when the systematic and random error of the measurement has an acceptable value, i.e. it is within the defined limits.

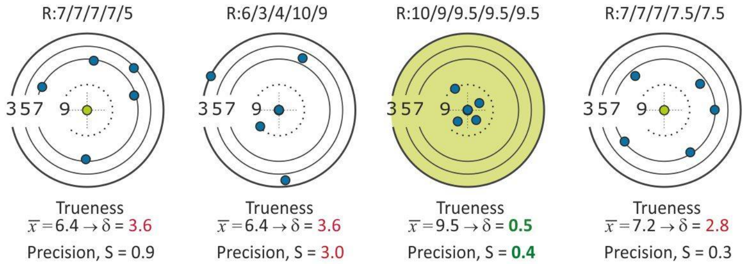


Figure 3. Systematic error (trueness) and random error (precision) of measurements

Figure 4. Piston pipette volume control - assessment of systematic and random error

## ADJUSTMENT

A set of activities as a result of which a measuring instrument is made to operate in accordance with its intended use. In the case of electronic scales, the balance sensitivity is corrected by comparing the weighing result of the internal adjustment standard with its reference value. Adjustment is performed in automatic cycles, controlled by temperature and time changes, or semi-automatic, controlled by the operator.

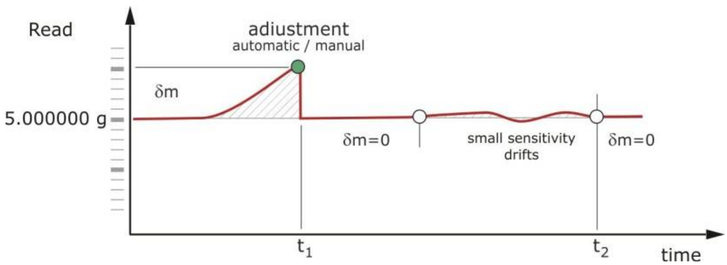


Figure 5. The principle of adjustment

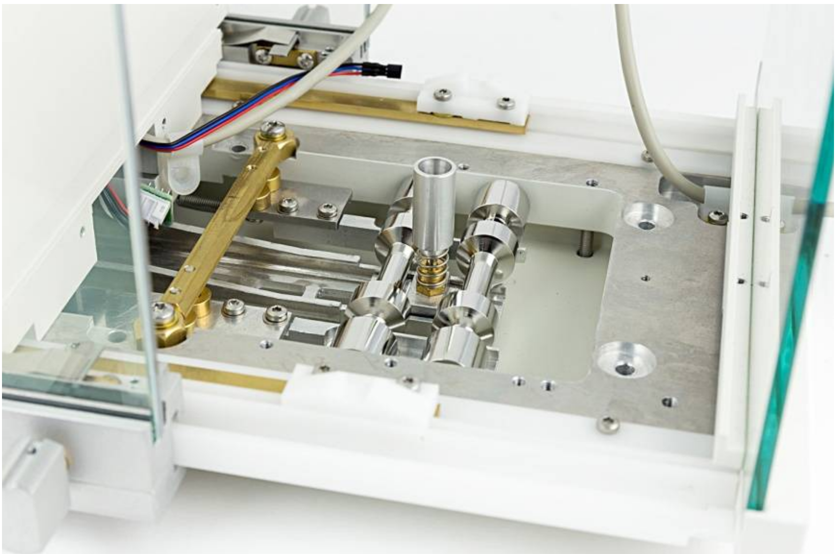

Figure 6. XA series balances automatic adjustment system

## BALANCE

A measuring device used to determine the mass of a body by using the force of gravity on that body. The term "mass" is used to mean "conventional mass" or "conventional value of the result of weighing in air" according to OIML R111 or D28. The balance can also be used to determine other quantities, quantities, parameters or properties depending on the mass, e.g. density, number of details, percentage deviation from the standard, etc.

Figure 7. Non-automatic balance PS 1000.X2 with the set of standard mass

The scale can work in manual mode (non-automatic scale) or in automatic mode in the production line, then it is equipped with additional devices for labelling and selecting controlled products.

Figure 8. Automatic scale (Checkweigher) with with feeder and sorting system

## BALANCE DISCRIMINATION

Discrimination is the scale's ability to respond to small changes in load. The discrimination threshold is the value of the smallest additional load that is gently placed on or removed from the carrier and causes a noticeable change in indication. The discrimination of the balance can be important when dosing very small amounts of substance or in processes where variability of balance indications is observed when the sample is still placed on its carrier.


Figure 9. Dosing of ingredients during the production of paints

### COMMENT

Too little discrimination of the balance may cause excessive relative errors. During typical weighing processes, when the mass of the sample is large, discrimination is not a significant metrological factor.

## BALANCE RESOLUTION

In the case of electronic scales, the resolution is the difference of the weighing result indications by the unit of the least significant digit. Typical resolutions of laboratory balances range from $10^{-2}$ to $10^{-7}$ g.

Figure 10. Volume control of piston pipettes

**COMMENT**

The term resolution is not synonymous with accuracy of balance indications. The accuracy of the balance depends on many factors (sum of systematic and random errors). Some processes require the use of a scale with a specific resolution, e.g. volume control of piston pipettes.

## BALANCE SENSITIVITY

The sensitivity of the electronic balance is the quotient of the change in the indication of the measuring system (ΔR) and the corresponding change in the value of the measured quantity (Δm).

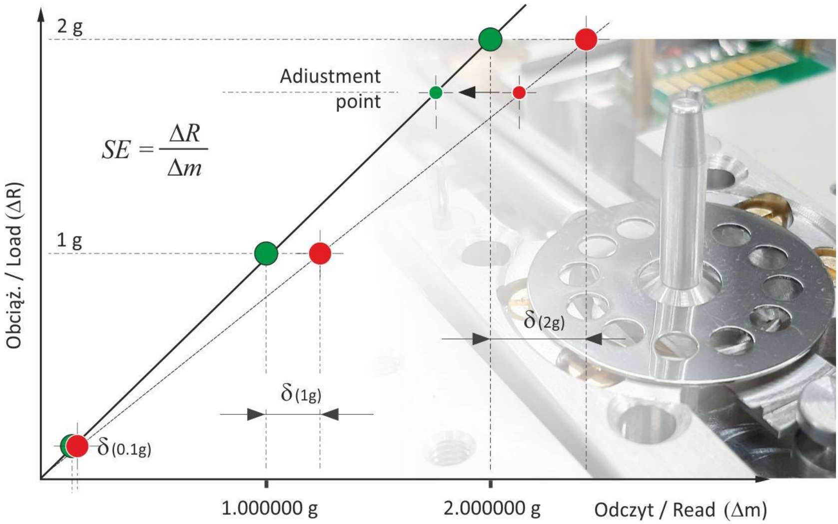


Figure 11. Adjustment of sensitivity - view of the internal adjustment mass standard of MYA 5Y microbalances

Ze względu na niedoskonałość metod i przyrządów pomiarowych czułość wagi oscyluje wokół wartości docelowej. Regulację czułości wykonuje podczas adiustacji wagi, automatycznie lub półautomatycznie.

Figure 12. Balance sensitivity control with mass standards – QC Radwag

## BALANCE VERIFICATION UNIT

Verification unit (e) – conventional value used for evaluation and classification of scales. The term comes from OIML legal metrology. The smallest value of the verification unit is 1 mg ($10^{-3}$g) and it is the smallest mass of the weight that can be made (OIML R111-1).


Figure 13. Fragment of the display of MYA 5.5Y microbalances

The value of the scale interval (d) of laboratory balances can be in the range of $10^{-4} \div 10^{-7}$ and is significantly lower than the value of the legalization interval. Such a relationship forces the use of other methods when checking the accuracy of balance indications. This is especially visible in the case of microbalances and ultra-microbalances - the errors of mass standards and the uncertainty of their determination may be too large.


Figure 14. Microbalance MYA series - verification unit (e) and reading unit (d)

## BUDGET OF UNCERTAINTY

A set of all factors that affect the accuracy of the weighing process. Parameters such as scale division, indication repeatability, indication error, etc. are taken into account, but the assessment may also apply to other areas, as long as they contain relevant information. The uncertainty budget should include only those components that have a significant impact on the mass measurement.

## CALIBRATION

Calibration, a term historically associated with the balance adjustment process (see adjustment). It probably has its source in the English word Calibration, which means calibration, i.e. determining the deviations of a measuring instrument. Before calibration, the balance is in the reference position, adjustments are made (if possible) and then the systematic error and random error of the balance are determined. Calibration results are given together with the uncertainty of their determination.

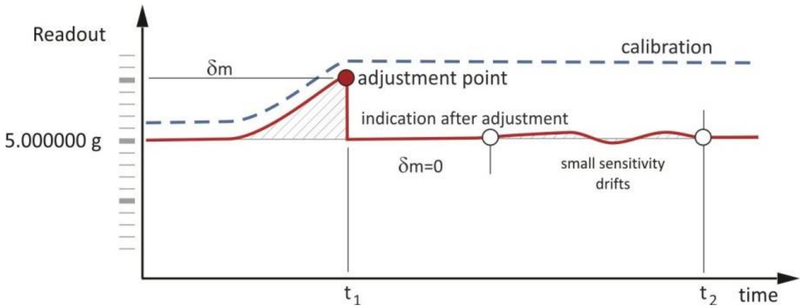


Figure 15. Difference between adjustment and calibration

## CALIBRATION CERTIFICATE

A set of activities establishing the relationship between the values of the measurand indicated by the balance (weighing result) and the corresponding values of physical quantities represented by the measurement standard (reference standard mass). Calibration features are measurement error, measurement uncertainty and measurement traceability.

**RADWAG Wagi Elektroniczne Witold Lewandowski**
26-600 Radom, ul. Toruńska 5
**CENTRUM METROLOGII, BADAŃ I CERTYFIKACJI - LABORATORIUM POMIAROWE**
26-600 Radom, ul. Starowiejska 17A
tel. /38/ 386 64 70; fax /48/ 385 00 11

PCA Polskie Centrum Akredytacji
WZORCOWANIE
AP 069
ilac-MRA

Calibration laboratory accredited by
Polish Centre for Accreditation, a signatory to EA MLA and ILAC MRA
that include recognition of calibration certificates.
Accreditation No AP 069.

**CALIBRATION CERTIFICATE**

Date of issue: 17 June 2021 Certificate No: 6076/2252/21 Page: 1 / 2

| | |
|---|---|
| OBJECT OF CALIBRATION | Non-automatic electronic weighing instrument - single range<br>Manufacturer RADWAG Wagi Elektronicze<br>Type / symbol MYA 5.4Y<br>Serial No 702517<br>Capacity *Max* 5,1 g<br>Scale interval *d* 1 mg |
| APPLICANT | RADWAG Wagi Elektronicze<br>ul. Toruńska 5, 26-600 Radom |
| USER | |
| PLACE OF CALIBRATION | RADWAG Wagi Elektronicze Laboratorium Pomiarowe<br>ul. Starowiejska 17A, 26-600 Radom |
| CALIBRATION METHOD | Calibration Procedure: PW 01 rev. XIII of 28 February 2018 |
| ENVIRONMENTAL CONDITIONS | Air temperature: ( 22,59 ÷ 22,94 ) ± 0,20 °C<br>Relative humidity: ( 54,3 ÷ 56,3) ± 1,1 % |
| DATE OF CALIBRATION | 17 June 2021 |
| TRACEABILITY | This certificate is issued under the agreement EA MLA in the field of calibration and provides treecability of measurement results to the International System of Units (SI) |
| CALIBRATION RESULTS | The results have been presented on page 2 of this certifictae including uncertainty of measurement. |
| UNCERTAINTY OF MEASUREMENT | Uncertainty of measurement has been evaluated in compliance with EA-4/02 M:2013<br>The expanded uncertainty assigned corresponds to a coverage probability of 95 %<br>and the coverage factor k = 2. |

Akredytowane Laboratorium Wzorcujące AP 069

Kierownik ds. technicznych Laboratorium Pomiarowego
mgr inż. Tomasz Kasprzak

This certificate may be presented or copied as whole document only

Figure 16. calibration certificate (example)

## DIGITAL WEIGHING AUDITOR

Preparing the balance ready for operation is the first step to getting an accurate weight measurement. Digital Weighing Auditor is an advanced weighing application that monitors the state of the balance on-line, informing about the need to perform adjustments, leveling, excessive changes in temperature and humidity in the working environment. All information is recorded in a database with the possibility of their reproduction (Audit trail).


Figure 17. AP 12.5Y - Volume control of piston pipettes in automatic mode

Metrological supervision of the balance is necessary not only during mass measurements, but also in any other process that uses mass measurement, e.g. verification of the volume of piston pipettes, control of percentage deviations from the standard, determination of sample density, etc.

### COMMENT

The Digital weighing Auditor function is one of the elements of the so-called Audit trail, which guarantees data security and reliability. This solution allows you to reconstruct the course of events in the process of mass measurement, data entry, reporting and making significant changes to balance settings. It is required by the pharmacy in accordance with the FDA (21 CFR Part 11), but can be used in any quality management system.

## DRIFT

Changeability of balance indications during its use, drift of zero indication of the balance can be observed during its acclimatization. This process disappears after thermal stabilization is achieved. Drift of the weighing result is the variability of balance indications when the weighing pan is loaded with a load, sources of instability: processes of moisture sorption by the sample, electrostatics, excessive air movement, ground vibration.

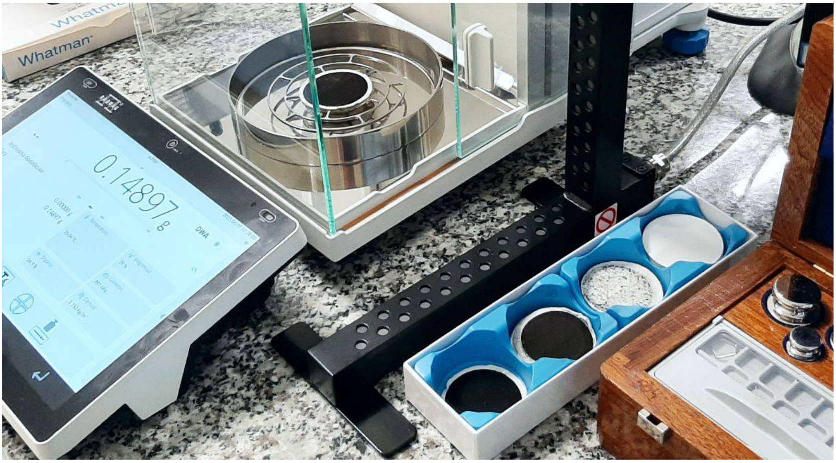


Figure 18. Static electricity in filter mass measurement – Ionizer DJ-04

**COMMENT**

Variability of balance indication (drift) for typical weighing is an adversely phenomenon that should be minimized. However, in some research processes, the observation of sample mass variability during sorption or desorption is used. Detection of even very small mass changes is possible with professional analytical balances of the XA.5Y series. Observation of changes in sample weight is then performed in automatic mode - the balance sends the weighing result to an external application with an interval or continuously.

## ECCENTRICITY DEVIATION

Eccentricity deviation acc. OIML R76 is determined by placing a standard with a mass of ⅓ of the maximum load of the balance in the center of each of the 4 segments of the balance pan. The mass standard weighing error should be smaller than the maximum permissible error for the applied load.

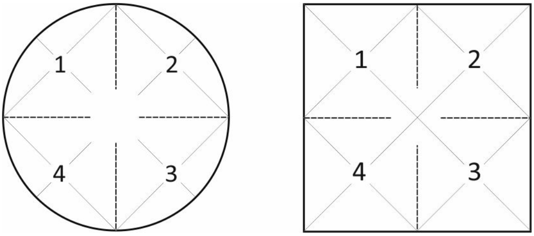


Figure 19. Balance centricity test - measuring point

Differential centricity deviation*) is the difference between indications when the standard is placed outside the center of the weighing pan and an indication when the same standard is set exactly in the center of the pan.


Figure 20. XA 220.5Y balance - eccentricity test

*) I-CAL-GUI-018/v4.0/2015-10-01

## ENVIRONMENTAL MODULE OF BALANCES

Control of basic environmental parameters (temperature, humidity, pressure, floor vibrations) is carried out automatically by internal sensors of the balance. Determining the limit values and the dynamics of changes in these quantities with simultaneous visualization is an ergonomic and efficient work tool.


Figure 21. XA 82/220.5Y balance with additional environmental sensor

It is also possible to connect external sensors to the balance. In this case, we have information about the environmental conditions exactly at the workplace. External sensors may have a calibration certificate.

## FORCE OF BUOYANCY

The buoyant force is the force acting on a submerged body in a liquid or gas in the presence of gravity. The buoyant force is directed vertically upwards, against the gravitational force. The value of the buoyant force is equal to the weight of the fluid displaced by this body, according to the relationship:

$$F_w = \rho \cdot g \cdot V$$

where:
ρ – density of the medium in which the body is located (liquid or gas)
g – gravitational acceleration
V – the volume of fluid displaced equals the volume of the part of the body immersed in the fluid.

The consequence of the presence of the buoyancy force in mass measurements is the distinction between the conventional mass of a body (conventional mass) and the physical mass, which is the amount of matter that a given body has. If the physical mass of the body is known, the value of the conventional (conventional) mass can be calculated in accordance with the OIML D 28 guidelines "Conventional value of the result of weighing in air" from the following relationship:

$$m_c = \frac{(1 - \rho_0)/\rho}{(1 - \rho_0)/\rho_c}$$

where: $m_c$ – conventional mass
ρ – density of weighing body
$\rho_0$ – air density
$\rho_C$ – density of the mass pattern (8000 $kg/m^3$)

## GMP – GOOD MANUFACTURING PRACTICE

GMP - Good Manufacturing Practice, a set of standards used in industrial production that guarantee high quality of the finished product. They also ensure control over the quality and origin of raw materials. GMP standards were originally developed for the pharmaceutical industry, but are now also used by cosmetic companies, manufacturers of nutritional supplements, etc.

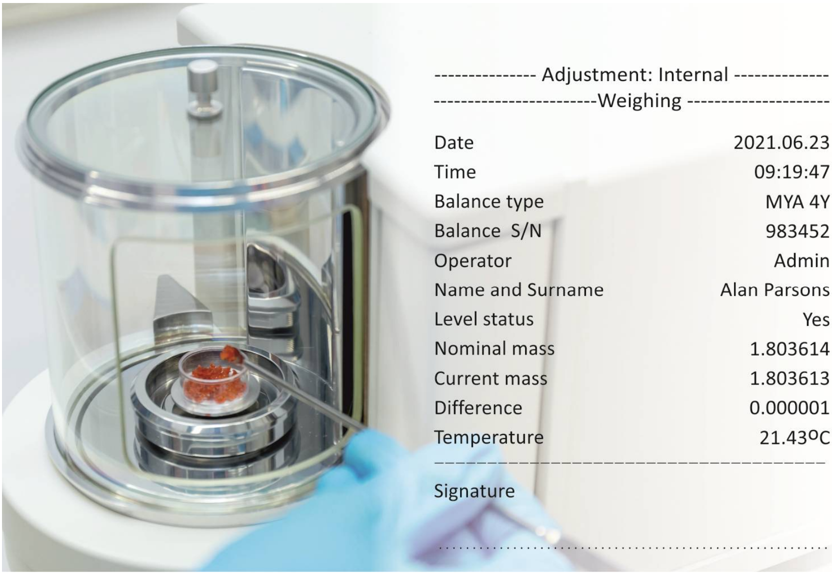


Figure 22. Internal adjustment report

### COMMENT

For mass measurements, GMP means the verifiability of all processes related to weighing, such as logging, measurement, printing, data transfer, report. Each element of the process is associated with the operator and the time in which the process was started and completed.

## GRAVITY

The force of gravitational attraction between two bodies. Any two bodies attract each other with a force directly proportional to the product of their masses and inversely proportional to the square of the distance between them (law of universal gravitation).

Each electronic balances measures the gravitational force with which the weighed sample is attracted by the Earth. The gravitational force is variable depending on the latitude and height above sea level, hence the need to adjust the balances after they are moved to the place of use.

$$F = m \cdot g$$

Figure 23. Comparison of mass standards in automatic mode

## COMMENT

Due to differences in density between mass standards (approx. 8g/cm$^3$) and real samples, the mass of real samples is the so-called conventional mass. Knowing the density of a weighed sample, its true mass can be determined using the 5Y balance application.

## KILOGRAM

Formerly, it was the mass of an iridium-platinum cylinder with a diameter equal to the height, which was stored in Sèvres near Paris. Unfortunately, over the years, significant variability of the reference mass was recorded. This prompted scientists to develop a new formula to describe the mass of 1 kg. Currently, the definition of 1 kg uses Planck's constant and the technical one is implemented using a Watt current balance..

Kilogram definition - unit of mass, notation kg, is defined by taking a fixed numerical value of Planck's constant *h* of 6.626 070 15 × $10^{-34}$, expressed in the unit Js, which is equal to kg $m^2$ $s^{-1}$, where meter and second are defined in terms of with c and $\Delta v^{Cs}$.

$$m = \frac{UI}{gv}$$

where *U – voltage; I – current ; g – gravity accelaration*
*v – Speer of coil movement*

**COMMENT**

In order to reproduce the 1 kg unit of measurement, two experiments are performed, the first with a load, when a current I flows through a stationary coil. The electrodynamics force that occurs between two wire-wound coils is measured and then used to calculate the current. The current flowing in the coils is measured, which is needed to keep the balance in the equilibrium position when the balance is loaded with mass. In this way, the mass standard can be reproduced using the strength of the magnetic field.

$$w = m \cdot g = B \cdot L \cdot I$$

Dynamic experiment, no load - the same coil moves in the same magnetic field with a known speed v, with no current flowing through the coil. When a coil of coil wire movess with a known speed v in a magnetic field w, then, according to Faraday's law of electromagnetic induction, a voltage U is generated at the ends of the wire.

$$U = B \cdot L \cdot v$$

## LINEARITY

Deviation of the balance linearity characteristics from the straight line which describes the ideal balance equation. In practice, there are no ideal balances, therefore the characteristics of the balance are never a straight line. In the balance production process, its parameters are corrected so that the balance's linearity characteristics are as good as possible.

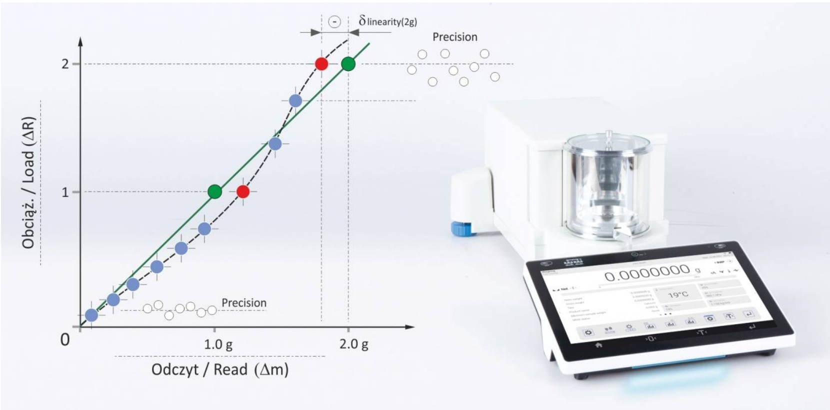


Figure 24. Hypothetical linearity curve of a microbalance

**COMMENT**

The linearity error given in the technical data of the balance is the largest deviation recorded for the measuring range. Linearity is determined with certified mass standards - this parameter cannot be determined with a real sample. There are several methods of linearity testing that can be used depending on the balance resolution.

## MASS

Mass is a measure of inertia, which is the tendency of a body to remain at rest or to move at a given velocity. It is commonly understood as the amount of matter and energy accumulated in a physical object - it has a constant value and is not dependent on the location. The mass in the weighing process may show some variability as a result of moisture sorption, e.g. weighing powders. When the phenomenon of static electricity occurs, the mass of the weighed sample shows an increasing or decreasing indication drift → see drift.

Figure 25. Comparator WAX series – mass standard weight determination

**COMMENT**

According to the International System of Units, the amount of matter is expressed in moles.

## MATERIAL MOISTURE

The relative humidity of the material (sample) is the ratio of the mass of water contained in the material to the mass of wet material. Automatic determination of relative humidity requires the use of a moisture analyzer, which determines the mass of a wet sample and the mass of the sample after drying it at a specific temperature.

$$w_{REL} = \frac{m_w - m_d}{m_w} \times 100\ \%$$

Figure 26. Moisture analyzer - drying process

Absolute humidity is the ratio of the mass of water contained in the material to the mass of completely dry material.

$$w_{ABS} = \frac{m_w - m_d}{m_d} \times 100\ \%$$

**COMMENT**

When samples are heated with a moisture analyzer, all volatile components are removed from the sample structure. The moisture content of the material is therefore the sum of all components that can be removed at the set drying temperature.

## MAXIMUM PERMISSIBLE ERROR

The maximum allowable positive or negative difference between the balance indication and the correct value, defined by reference standards of the mass unit (ref. value) or manufacturer's requirements. Each laboratory scale is inspected by the QC department, which compares the scale's indications with the metrological limits applicable at Radwag.


Figure 27. XA 82/220.5Y balances – metrological specification

## MEASUREMENT ERROR

The measurement error is the difference between the measurement result and the actual value of the measured quantity.

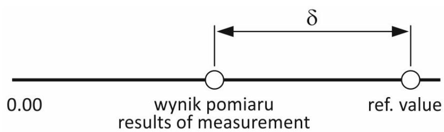


Figure 28. Determination of error for mass measurement

## MEASUREMENT PRECISION

Measurement precision is the convergence between indications (mass measurement results) obtained on the same balance under specific conditions. The measurement precision is measured by the standard deviation S of a series of measurements. Using the S value, it is possible to determine with a certain probability where the measured value is located.

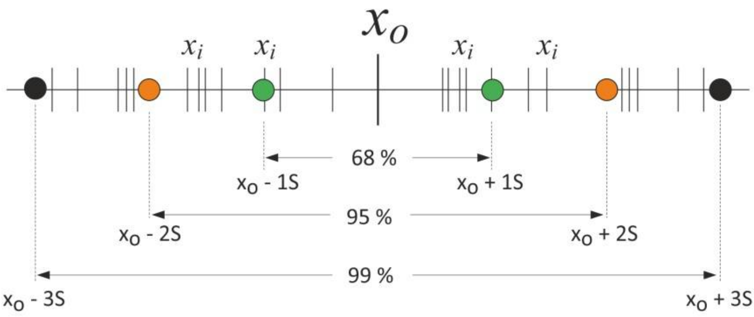


Figure 29. Measurement precision - 3 sigm rule

where $x_0$ – mean value
$x_i$ – result of measurement
$S$ – standard deviation

The smaller the standard deviation (S), the better the measurement precision. Precision of the measurement is depends on:

- test conditions (temperature, humidity, vibrations),
- size and shape of the weighed object
- weighing skills (no strokes),
- thermal stability of the balance and to a small extent
- eccentricity error

## MINIMUM SAMPLE WEIGHT

The minimum mass of the sample, the so-called MSW – is a value that determines the beginning of the weighing range of each balance. Measurements below this threshold are considered inaccurate. The following formula is used to determine the MSW:

$$MSW = 2000 \cdot S$$

Where:
S – standard deviation from 10 measurements

The relationship describing the MSW results directly from the requirements of USP 41 "Weighing on the analytical balances" and Ph. Euro. 1.2.7. where the condition for the accuracy of weighing small masses is given.

$$R = \frac{2 \cdot S}{m} \leq 0.10\% \quad \rightarrow \frac{2 \cdot S}{m} \leq 0.001$$

**COMMENT**

The smallest possible standard deviation from the series of measurements is 0.41d, so the smallest value for MSW, depending on the scale interval (d), may be:

- d = 0.01 mg → MSW = 0.41 · 0,01mg ·2000 = 8,2 mg
- d = 0.001 mg → MSW = 0.41 · 0,001mg ·2000 = 0,82 mg
- d = 0.0001 mg → MSW = 0.41·0,0001mg·2000 = 0,082 mg


Figure 30. MSW function in microbalances 5Y series

## MINIMUM CAPACITY

According to OIML R 76, the minimum capacity is the load value below which the weighing results may have an excessive relative error. The weighing range of each scale is from Min load to Max load. According to legal metrology, the value of the minimum mass is determined by the dependence related to the scale interval, depending on the scale accuracy class:

- Min = 100d (accuracy class I)
- Min = 50d or 20d (accuracy class II)


Figure 31. minimum capacity (Min) in analytical balance

**COMMENT**

PN-EN 45501:2015 "Metrological issues of non-automatic weighing instruments" is a standard that describes all the requirements related to the design, operation and marking of scales that can be used in the field of legal metrology.

## MOISTURE ANALYZER

Measuring device in which the functions of weighing and heating the sample are performed simultaneously. Based on the weight loss, the water or dry weight content of the tested product is determined. The method using a moisture analyzer requires validation, i.e. showing the correlation of the water content result with the water content result obtained using recognized (standardized) methods.


Figure 32. Moisture analyzer MA X2 series

## COMMENT

Accuracy of mass measurement is ensured by internal or external adjustment (using a mass standard). When only water content measurement is carried out, mass adjustment is not obligatory because the principle of operation of a moisture analyzer is based on differential measurement of sample mass (wet / dry). The drying temperature is factory adjusted and does not require periodic adjustment.

## NOTIFIED BODY

An organization designated by the authorities of each of the European Union Member States to perform tasks resulting from the provisions of individual New Approach Directives. The notified body performs tests of compliance of scales with legal requirements and issues type approval certificates for scales and Test Certificates for indicators.

## PERSONEL

The best results are obtained when the staff is aware of the importance of the performed activities, knowing also the measurement possibilities and limitations that result from the measurement method used and the devices it uses. In the case of mass measurements, the technique of weighing and the ability to correctly evaluate the measurement result are important. Analytical balances and microbalances by Radwag make it possible to measure the mass of samples of several milligrams (mg) with an accuracy of several micrograms (µg). A seemingly simple process can be disrupted by many external factors.


Figure 33. Personel – GLP in laboratory

Acquiring appropriate weighing skills is done only through practical tests, knowledge is completely different from skills. With this in mind, Radwag offers the opportunity to participate in cyclical theoretical and practical training.

## RANDOM ERROR

Random error is a component of measurement error that varies unpredictably in repeated measurements. For a single measurement, it is the difference between the measurement result and the average of an infinite number of measurement results of the same measurand, made under repeatability conditions.

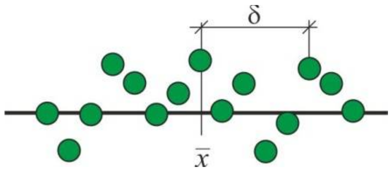


Figure 34. Random error

Source: International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM). 2007

## ROUNDING OF THE WEIGHING RESULT

Each electronic scale measures the sample mass with a much higher resolution than it is presented on the balance display. Thus, each result is rounded to the value of the interval (d) of the balance.


Figure 35. Analytical balance XA series – principle of rounding

**COMMENT**

Obtaining a "more accurate" measurement of the sample mass requires the use of a balance with a smaller value of the scale interval. At the same time, the principle that the measurement precision increases when the scale interval decreases, must be observed.

## STANDARD MASS

A mass standard is a measuring instrument designed to define, implement, maintain or reproduce a unit of measure. The shape of the mass standard can be any, however, the standard material must guarantee the stability of its mass over time, must have identification, calibration certificate with information on maintaining the measurement traceability and the estimated measurement uncertainty. Mass standards cannot be used as weights within the meaning of legal metrology. For mass standards, the basic classification is the uncertainty of measurement estimated during their calibration.


Figure 36. Testing mass standards in an automatic cycle

**COMMENT**

Periodically, weights should be verified by recalibration to determine their actual weight.

## SYSTEMATIC ERROR

Bias is the component of measurement error that remains constant or varies in a predictable way in repeated measurements. The reference value for the systematic measurement error is the actual value of the mass standard with negligible measurement uncertainty or the conventional value. Correction of the measurement result may be applied to compensate for the known systematic measurement error.

The correction of the analysis result (water content) is used in PMV 50 microwave moisture analyzers. In this case, BIAS is the result of differences between the drying methods, i.e. between the reference method (convection drying) and the microwave drying method. An example of using the bias function is below.

**--------- Drying process report ---------**

| | |
|---|---|
| Start date | 2023.08.22 |
| Start time | 12:42:36 |
| Product | Dates paste lab sample |
| Drying program | Dates paste drying par. |

**------- Drying process parameters ---------**

| | |
|---|---|
| Drying profile | Standard 105°C |
| Finish mode | Time defined 00:10:00 |
| Result | %M |
| Interval | 20s |
| Start mass | 1.8800 g |

---------------------------------------

| | |
|---|---|
| 0:00:00 | 0.0000 %M |
| 0:00:20 | ? 0.4255 %M |
| . . . . . . . . . . . . . . . . . . . . . . . . . . . | |
| 0:09:40 | ? 16.0585 %M |
| 0:10:00 | ? 16.2128 %M |

**Status Completed**

| | |
|---|---|
| Drying time | 00:10:00 |
| End mass | ? 1.5752 g |
| Result | ? 16.2128 %M |
| Bias | - 0.2500 %M |
| Corrected value | ? 15.9628 %M |

Source: International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM). 2007

## THERMOGRAVIMETRY

Thermogravimetry is a technique for determining the weight loss of a sample during its controlled heating. During this process, the weight loss of the sample, dry matter content, moisture content are calculated and the drying curve is plotted. Thermogravimetry as a physical process is the basis of moisture analyzers, which are used for quick determination of water content or dry mass of various products.


Figure 37. Termogravimetry – moisture analyzer PMV 50.5Y

## COMMENT

Testing the water content using moisture analyzers requires validation. This is an essential element to ensure that the method used is accurate and can be used interchangeably with reference methods.

## TRECEABILITY

The property of a measurement or measurement standard that can be related to references, which are generally national standards or international units of measurement, through an uninterrupted chain of comparisons, all of which have specified uncertainties.

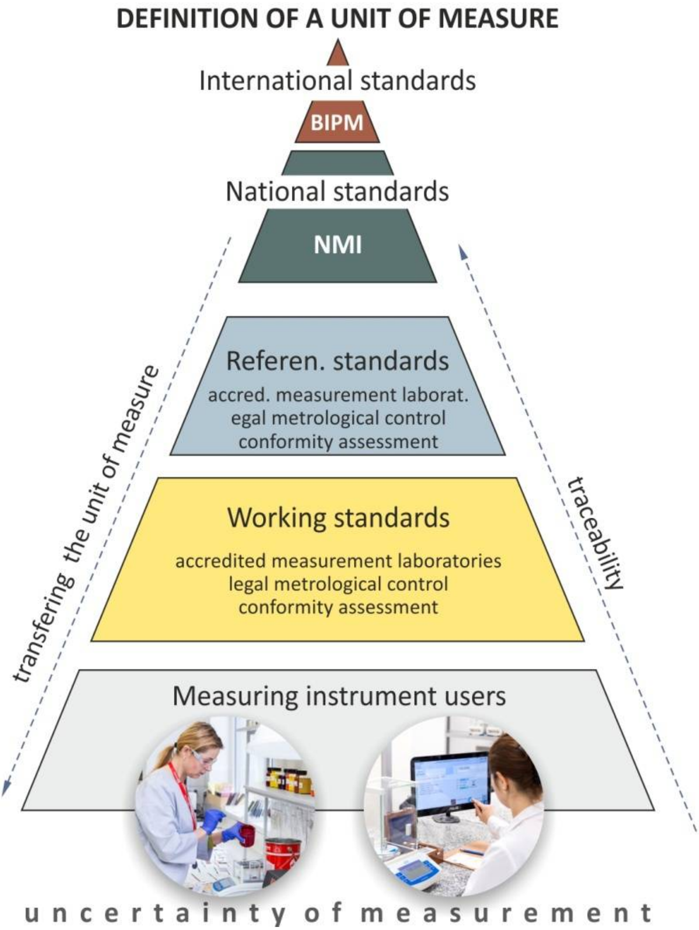


Figure 38. Traceability for mass measurement

## UNCERTAINTY OF MEASUREMENT

Measurement uncertainty is a non-negative parameter characterizing the dispersion of the measurand value, calculated on the basis of the obtained information*). Type A measurement uncertainty is defined by the standard deviation of a series of measurements and is used to assess the accuracy of weighing small mass samples.

$$u(x) = \sqrt{\frac{\sum (x_i - \bar{x})^2}{(n-1)}}$$

Type B uncertainty is estimated taking into account all relevant information about the mass measurement process, such as linearity error, centricity error, measurement point error, etc. Each sample mass measurement result should be reported together with the uncertainty of its determination.

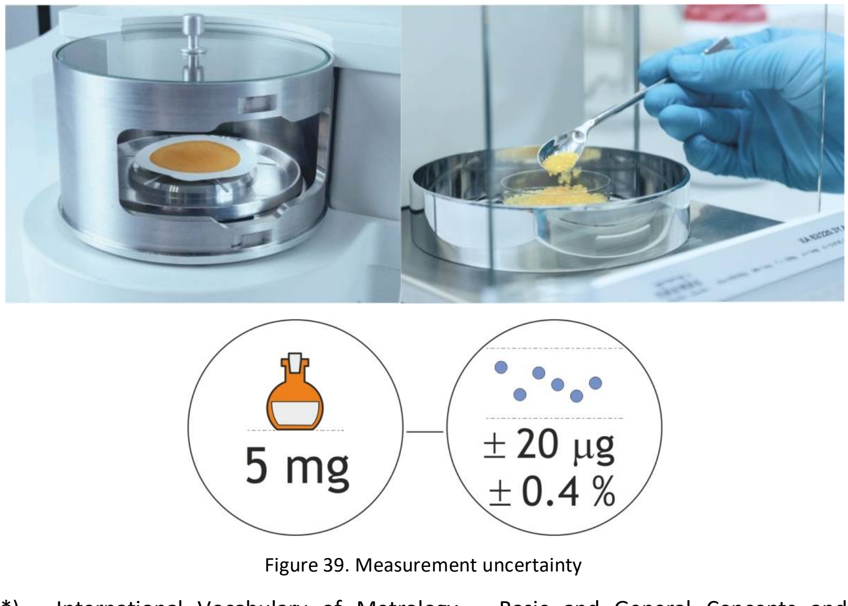


Figure 39. Measurement uncertainty

*) - International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM), 3rd Edition.

## WEIGHT

Weights are measuring instruments that are standards of measurement. Their specification is defined in such documents as OIML R111,,Weights of classes $E_1$, $E_2$, $F_1$, $F_2$, $M_1$, $M_{1-2}$, $M_2$, $M_{2-3}$ and $M_3$. Part 1: Metrological and technical requirements", ASTM E617-18 "Standard Specification for Laboratory Weights and Precision Mass Standards".

OIML - The International Organization of Legal Metrology has defined metrological requirements for weights in the area of mandatory legalization around the world. Requirements are specified regarding accuracy classes, material, shape, identification, density, magnetism, etc. Weights are used in the area of legal metrology and as measuring instruments they require re-verification.

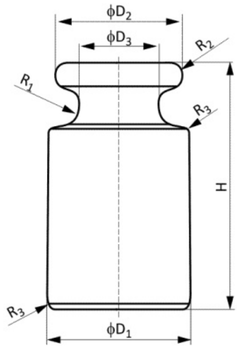


Figure 40. Weight dimension

When checking balances, weights are used that have all the same physical characteristics as weights. Mass standards have a specific mass along with the uncertainty of its determination, they are not subject to legal metrology.

Figure 41. Set of weights

## WEIGHING TIME

Weighing time is the time needed to complete the entire measurement cycle, which includes such activities as opening the weighing chamber, placing a load on the weighing pan, closing the weighing chamber, accepting the weighing result, opening the weighing chamber and removing the load from the weighing pan.

The stabilization time is the time after which the sample weighing result is within the acceptance range. The acceptance area is determined by the maximum deviation of the weighing result that can be accepted taking into account the quality requirements related to mass measurement.


Figure 42. AS 220.X2 balance – liquid measurement

**COMMENT**

The time of placing the load on the pan is difficult to estimate due to the individual characteristics and capabilities of the operators. The actual stabilization time of the sample is not significantly dependent on its mass. By modifying the balance parameters, such as the weighing profile, you can obtain shorter stabilization times, but you should remember that usually increasing the stabilization speed leads to a decrease in weighing precision.

## WEIGHING QUALITY ASSESSMENT

The principle of operation of each scale consists in measuring the force with which the Earth attracts the weighed load. Additional shocks resulting from incorrect placement of the load on the weighing pan can significantly affect the accuracy of the measurement. This is especially important when weighing small portions of a substance. The latest solutions offered in the 5Y series scales monitor the dynamics of loading, informing the user about the quality of this process. Icon in red indicates that the impact when applying the sample was too large.


Figure 43. Automatic assessment of the quality of the weighing process

### COMMENT

Impact signalling is not synonymous with the occurrence of a measurement error, but it is information about the need to increase the ability to put samples on the weighing pan or to verify the method used in the laboratory, e.g. introducing automation.

## WEIGHNIG RANGE

Interval between the minimum load (Min) and maximum load (Max) of the balance. In practice, the threshold for weighing small masses may be higher because it is determined by the requirements related to the required weighing accuracy → see Minimum Mass.

## WORKING CONDITIONS

For electronic scales with high resolution, the stability of temperature and humidity in the working environment is important. These are two key factors that have a significant impact on the accuracy of the weight measurement. In addition, there are other areas directly and indirectly related to the work environment that may have a negative impact on the quality of the process.

Depending on the type of the tested sample, the following factors can be considered: ground vibrations, moisture sorption through the sample structure, unbalanced static charges, magnetism, excessive air movement, mass variability as a result of moisture desorption, etc.

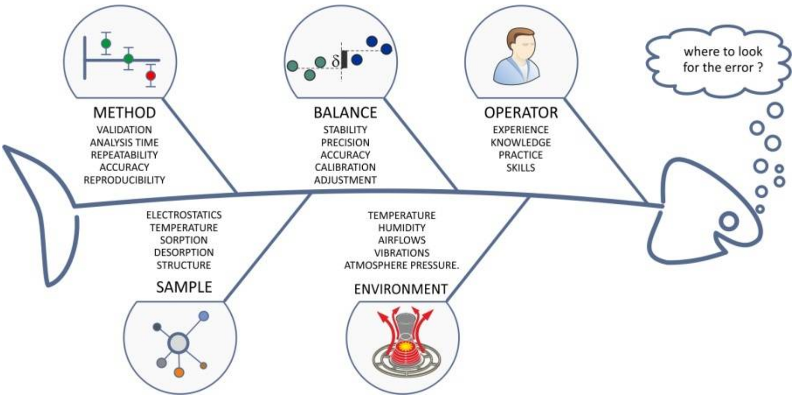


Figure 44. Factors affecting the mass measurement process

Typically, one factor related to the process of mass measurement or sample preparation for analysis is critical to weighing accuracy.

## VALIDATION

Validation is an activity aimed at confirming that procedures, processes, devices, materials, activities and systems finally give the results that were planned. For balances, validation is the control of its metrological parameters and the control result is compared to the limits - user requirements.

For drying processes, validation is the optimization of drying parameters in order to achieve precision and accuracy of analysis. In this process, the moisture reference value of the sample must be known.

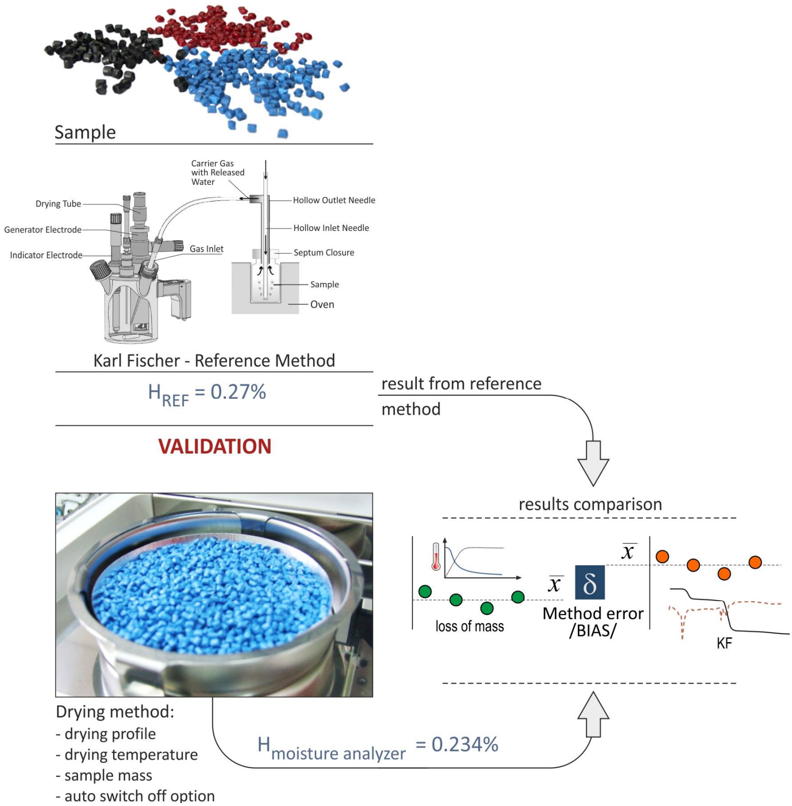


Figure 45. Validation in the water content determination process

**RADWAG BALANCES & SCALES**
26-600 Radom, Toruńska 5
Tel. 48 48 3848800, fax 48 48 3850010
e-mail: radom@radwag.pl, http://www.radwag.com