MARUTI's Comprehensive Mass Standards Handbook

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Cal-Kit Weights

MARUTI's Comprehensive Mass Standards Handbook is designed for easy convenience to customer in selecting mass standards which is suitable to their application.

Comprehensive Mass Standards Handbook

Introduction – MARUTI Weightech Pvt. Ltd. is pleased to offer the **Comprehensive Mass Standards Handbook** to help clarify the various weight specifications, classifications, and physical characteristics of precision weights, mass standards and the tolerances used in their production and calibration. This publication specifically addresses mass terminology, the regulations and standards surrounding weights, proper calibration techniques, application selection guidelines, and the proper use, care and handling of all calibration masses. There is also a section that explains how to differentiate balance error from weight error.

Mass Standards — Why Accreditation?

Benefits of Accreditation include:

- **Buying with Confidence** – Products and Services available through **MARUTI Weightech Pvt. Ltd.** are held to "World Class" standards through rigorous independent third party audits.
- **International Recognition** – MARUTI's accreditations are widely recognized internationally - companies exporting products or services can avoid the cost and time in re-testing products for many markets. In addition, MARUTI's accreditations will support legal or regulatory requirements.
- **Improved Product and Service Quality –** avoid failure as a result of relying on invalid test results from poorly calibrated equipment.

MARUTI has achieved registration and accreditation in various disciplines from ISO and NABL.

ISO - The International Organization for Standardization (ISO) is a worldwide federation of national standards bodies from some 140 countries, one from each country. Established in 1947, the mission of ISO is to "promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing cooperation in the spheres of intellectual, scientific, technological and economic activity."

NABL – National Accreditation Board for Calibration & Testing Laboratories – Govt. of India, Department of Science & Technology. MARUTI Weighitech Pvt.Ltd has its own calibration laboratory – "TROeMAR Calibration Laboratory" in mechanical discipline as per NABL Category for MASS Calibration. This laboratory have the compliance with the International Standards **ISO/IEC 17025!**

Cal-Kit® Weights and TROeMAR® Calibration Services

Cal-Kit® Weights

Cal-Kit Weights offers the most comprehensive selection of Precision Masses and Mass Standards.

CAPACITY – 1 mg to 5,000 Kg,
DENOMINATION – Metric denominations available.
TOLERANCE - All OIML tolerances are available.
MATERIAL – Austentic stainless steel, stainless steel, brass, cast iron, mild steel.
SHAPE – Wire weights with designated shape, grip handle shape, slotted shape, Stackable shape, rectangular shape, hook shape, cylindrical knob shapes are available.

TROeMAR®Calibration Services

TROeMAR - NABL MASS Calibration Certificate - NABL calibrations/certifications meet all ISO, FDA, GMP, GLP, DOD, ANSI/NCSL Z540-1 and nuclear requirements and are traceable to BIPM. Procedures and processes used to generate this multi-page certificate, as well as its format and content, are prescribed by NABL. Users held absolutely accountable for their weights should request NABL certification. The document contains:

- Customer Name & Address
- Date of calibration
- Equipment and standards used in the calibration
- Accuracy class
- Uncertainty of measurement process for each weight.
- Environmental conditions during test
- Construction and density of the weight(s)
- Calibration procedure used
- A statement of traceability to NPL, India
- Helpful list of terms and definitions

TROeMAR MASS Calibration Traceable Certificate - Our Traceable Certificate includes nominal value, mass correction, uncertainty and tolerance for each weight in addition to the basic customer information such as name, address, purchase order number, date of calibration, accuracy class, density and statement of traceability to NPL, India. The Traceable Certificate measurement process includes one series of comparisons using a single standard.

Additional Troemar Mass Services
TROeMAR Balance Calibration – TROeMAR Calibrationy laboratory can calibrate the weighing balance upon specific customer requirements!

International Mass Standards - Guidelines

ASTM E 617-97 (2003): Standard Specification for Laboratory Weights and Precision Mass Standards - This specification covers various classes of weights and mass standards used in laboratories ranging from Class 0 to Class 7. Tolerances and design restrictions for each class are described in order that both individual weights and weight sets can be chosen for the appropriate applications. This specification also recognizes International Recommendation R 111 that describes classes E_1, E_2, F_1, F_2, M_1, M_2, and M_3.

OIML R 111: Weights of Classes E_1, E_2, F_1, F_2, M_1, M_2, M_3 – This international document describes the physical characteristics and metrological requirements of reference standard weights with recommendations for seven classes of weights (Classes E_1, E_2, F_1, F_2, M_1, M_2, M_3) in tiers of uncertainty.

NVLAP Handbook 150: Procedures and General Requirements Outlines the quality system and all of the procedures required in order to be NVLAP accredited. NVLAP Handbook 150 also contains all requirements specified in ISO/IEC 17025.

ISO/IEC 17025 (formerly ISO Guide 25): General Requirements for the Competency of Testing and Calibration Laboratories – This guide sets out the general provisions which a laboratory must address to carry out specific calibrations or tests. ISO/IEC 17025 provides the laboratory direction for the development and implementation of a fundamental quality management system.

ANSI/NCSL-Z540-1-1994: Calibration Laboratories and Measuring and Test Equipment-General Requirement (ANSI/NCSL) - This standard provides a mechanism for promoting confidence in requirements. Calibration certificates received by NVLAP-accredited testing and calibration laboratories with new or re-calibrated equipment shall meet the requirements of ISO/IEC Guide 17025 augmented by ANSI/NCSL Z540-1-1994. The certificates must include appropriate statements of uncertainty.

NIST Handbook 105-1: Specifications and Tolerances for Field Standard Weights – These specifications and tolerances are specific for reference and field standard weights (NIST Class F). This document sets minimum requirements for standards used primarily to test commercial or legal for trade weighing devices for compliance with NIST Handbook 44. These devices include but are not limited to delicatessen scales, jewelry scales, postal and parcel post scales and dairy product test scales. This specification permits the use of a weight at its nominal value in normal testing operations, where the tolerance on the item under test is at least three times as great as the tolerance of the weight. This specification also specifies the design, marking, adjusting cavities, and density of these weights. Any variation in design from Handbook 105-1 must be submitted to NIST for approval.

NIST Handbook 44: Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices - This publication sets forth the specifications, tolerances, and other technical requirements for weighing and measuring devices. Handbook 44 is published in its entirety each year following the Annual Meeting of the National Conference on Weights and Measures. All of the specifications, tolerances, and other technical requirements of this booklet are recommended by the National Conference on Weights and Measures for official promulgation and use by the states in exercising their control of commercial weighing apparatus!

All the described standards are available at MARUTI Weightech Pvt.Ltd, 255-258,2nd Floor, Shukan Mall, Science City Road, Sola, Ahmedabad – 380061, India

Mass Standards — Terminology

Definitions –

Tolerance: The maximum amount by which the conventional mass of the weight is allowed to deviate from the assigned nominal value. Also defined as Maximum Permissible Error.

Correction: The difference between the actual value of the mass and the assigned nominal value. Also defined as Error. If the correction on your weight calibration certificate is a negative number, the weight is below nominal value by that amount. A positive correction means that the weight is heavier than the nominal value by that amount.

Uncertainty: A parameter associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand. Typically reported at a 95% confidence level.

Readability: The mass value of the smallest scale or digital interval displayed by the weighing machine.

Repeatability: A measure of a weighing machine's ability to display the same result when repeated measurements are made under the same weighing conditions.

Linearity: Plus or minus deviation from the theoretically straight-lined course of two interdependent values. In balances, this expression is applied to the plus or minus deviation of the indicated measurement value from the true value of the load.

Austenitic - Pertaining to or describing a solid solution in iron of carbon and sometimes other solutes that occurs as a component of steel under certain conditions. Austenitic stainless steels usually offer many advantages such as increased strength, corrosion resistance, lower magnetic susceptibility, and desirable mechanical and magnetic properties.

Calibration - The act of determining the mass difference between a standard of a known mass value and an "unknown" test weight or set of weights. The process uses a comparison method and a series of calculations to establish the mass value and conventional mass value of the "unknown" and determines a quantitative estimate of the uncertainty to be assigned to the measurement process as well as the mass or conventional mass value for the "unknown."

Conventional Mass - The conventional value of the result of weighing in air, in accordance to International Recommendation OIML R 33. For a weight taken at 20º C, the conventional mass is the mass of a reference weight of a density of 8000 kg/m^3, which it balances in air density of 1.2 kg/m^3.

Correction - Mass values are traditionally expressed by two numbers, one being the nominal mass of the weight and the second being a correction. The mass of the weight is the assigned nominal value plus the assigned correction. Positive corrections indicate that the weight embodies more mass than is indicated by the assigned nominal value.

Nominal Mass – The mass value as marked on a weight.

Reference Standard - A standard, generally of the highest metrological quality available at a given location, from which measurements made at that location are derived.

Mass in a Vacuum – The mass of a weight as if it were measured in a vacuum. Also known as True Mass.

Tolerance (Adjustment Tolerance or Maximum Permissible Error) - The maximum amount by which the conventional mass of the weight is allowed to deviate from the assigned nominal value.

Traceability - Property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties. In other words, in order to establish traceability there must be an unbroken and valid relationship to some nationally or internationally recognized standard. A standard itself can not really be traceable, but the value assigned to it can.

Uncertainty - Parameter associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurement. This is the range of values within which the true value is estimated to lie. In other words, the uncertainty is a measure of how confident you are in the accuracy of the results resulting from a measurement.

U.S. National Prototype Standard - Platinum-iridium kilogram identified as K20, maintained at the National Institute of Standards and Technology (NIST), with a value assigned relative to the International Prototype Kilogram.

Weight (Mass standard) -An object representing a specific mass, regulated in regard to its physical and metrological characteristics: shape, dimension, material, surface quality, nominal value, and maximum permissible error.

Mass Standards — Weight Selection Guidelines

Guide – 1: Selecting the proper calibration weight by using the Accuracy/Redability of Electronic Weighing Balance.

- Refer to the balance operating manual to determine the calibration load.
- If the calibration load cannot be determined through documentation, contact the manufacturer or put the balance in the calibration mode. Many times the calibration weight needed will flash on the display.
- Determine the readability/accuracy of the balance.
- Determine the calibration weight accuracy by dividing the readability by 3. Refer to the Tolerance Table for the given weight and select the tolerance that meets or exceeds the requirement.
- In some cases, the readability will exceed the best available weight tolerance. In this case, purchase the weight with the tolerance that is 1/3 of the accuracy required for your measurement.

Example:

A calibration weight is needed for a 1000 g balance.

1. Referring to the operating manual, it is determined that a 1000 g weight is needed to calibrate the balance.
2. To verify this information, switch the balance into calibration mode. The balance displays a flashing 1000 g which verifies that 1000 g is the calibration load.
3. Checking the balance display, it is determined that the balance reads to 0.01 g or 10 mg.
4. Divide 10 mg by 3. The tolerance of the 1000 g weight needed should be 3 mg or better. Checking the OIML F1 Tolerance Table, it lists a tolerance of 5 mg for 1000 g. In this case, you should purchase a 1000 g OIML F1 weight to calibrate the balance.

Guide – 2: Selection of weights by using the Application Load of Weighing Balance.

- Determine at what load the balance will be used.
- Determine what accuracy is required for the application. Be sure that the weighing equipment can satisfy the measurement accuracy requirements.
- The tolerance for the weight should be at least 1/3 of the accuracy needed for the application.
- Review the Tolerance Table to determine the correct calibration weight for the application.

Example:

A range of samples from 10 g to 15 g needs to be weighed. An accuracy of 0.5 mg is required. The balance has a 100 g capacity and a readability of 0.00001 g. The balance needs to be verified at the minimum and maximum of the range of samples.

1. The correct weights to select are one 10 g weight and one 5 g weight. To check the balance at 15 g, use the 5 g and the 10 g weights together.
2. The accuracy of the 10 g and 5 g weights should be 1/3 times 0.5 mg or 0.166 mg. The cumulative tolerance of both weights should be applied at the 15 g load and should be considered when selecting the tolerance for both weights.
3. Reviewing the Tolerance Table at 10 g, OIML F1 has a tolerance of 0.200 mg. The 5 g tolerance at OIML F1 is 0.150 mg. The total tolerance at 15 g is 0.350 mg. OIML Class F1 or better should be chosen as the tolerance for this application.

Guide – 3: The following method establishes step-by-step performance parameters and verification using calibrated weights for electronic balances. Weights with weight calibration certificates are required.

Using calibrated weights, it is possible to determine balance error resulting from internal calibration processes. To verify proper balance performance using calibrated weights, one needs to establish two parameters. The first is to determine the balance's ability to repeat measurements (Repeatability). This is accomplished by calculating a standard deviation and multiplying it by 2 to achieve a 95% confidence interval. The second is to determine how much error (or offset) is introduced when the balance is calibrated.

1. Set-up the balance according to the manufacturer's specifications. Allow the balance to "settle" for at least a 24-hour period to achieve thermal equilibrium.
2. Calibrate the balance using the internal calibration function of the balance and an appropriate calibration weight (see the balance's operation manual for proper calibration weight selection). Some balances have built in calibration weights. It is recommended that an external calibration weight be used.
3. Select a verification weight that represents the mass of a typical sample size or a weight that is in the range of the majority of samples.
4. Tare or zero the balance so the display reads all zeros.
5. Using the verification weight, make at least 20 measurements and record the results of each measurement. Zero the balance before each measurement. After all of the measurements are made, calculate a single standard deviation.
6. Multiply the standard deviation by 2. This is the random error or repeatability that is expected for the balance with a 95% confidence level. The number becomes the upper and lower control limits for the performance verification.
7. Check the weight calibration certificate and obtain the correction of the weight that was used to calibrate the balance. This is the error that was introduced when the balance was calibrated at that load. Most calibration functions in electronic balances set the linear function for the balance from the calibration load down to zero. It is important to note that the error introduced at the calibration load is reduced by 50% at 1/2 of the load and by 75% at 1/4 of the load. In other words, as the load on the balance is reduced, the linear error introduced by the correction of the calibration weight is reduced. An estimation of the linear error of the calibration can be made with the following equation:

Linear error = -1 x Error of cal weight x Load/Calibration load

If the balance is calibrated using the internal balance weights, the linear error cannot be determined without the value of the internal weights.

8. The expected value for your performance verification is calculated as:

Expected value = Actual mass value
+ Linear error

Where: **Actual mass value** = Nominal value
+ Conventional Mass vs. 8.0 correction

9. Verification: Zero the balance and place the verification weight on the balance. The verification passes if the actual reading is within the random error established in Step 6 of the expected value.

NOTE: Should the single standard deviation be significantly greater than the manufacturer's specification for repeatability, try another location for the balance, and be sure the operator is following good measurement practices. Look for sources of vibration or air currents that may be causing the balance to perform poorly. If other locations do not improve the results, contact the manufacturer and explain the problem. The manufacturer may be able to provide other solutions.

Recommendations:

A. Perform verifications at different times during the day. If the verifications fail during some time periods but pass during others, the laboratory's environmental conditions are changing throughout the day.

B. Troemner recommends that calibration weights be recalibrated at least annually to verify that they are not changing in value. Actual usage will determine the calibration interval.

C. Chart the actual value after each verification. This may identify trends of drifting or systematic errors that are working into your process.

D. Recalculate the random error periodically to see if the repeatability of your balance is changing.

Example:

Given: 100 g capacity balance is readable to 0.1 mg Calibration load: 100 g Samples tested at: 10 g 100 g Class 1 weight with a correction of +0.10 mg and an uncertainty of +/- 0.025 mg 10 g Class 1 weight with a correction of +0.010 mg and an uncertainty of +/- 0.018 mg

Taking 20 measurements, the standard deviation is found to be 0.3 mg. The random error is 2 times 0.3 mg or 0.6 mg for a 95% confidence interval.

Linear Error = -1 X (0.10 mg X 10 g/100 g) = -0.01 mg

Expected value = 10.00001 g + (-0.01 mg) = 10.00000 g

Verification Range = 10.00000 g +/- 0.6 mg

Over the next 3 days, 7 verifications are performed and are shown below. The Balance Verification Chart below illustrates that the 2nd and 5th measurements failed, but the rest of the measurements passed. Using control charts like this is an effective method in identifying measurement problems before the quality of your work is affected. Investigation and Corrective Action should be made when measurements fall out of acceptable range.

There are numerous steps that one can take in order to improve the quality of a mass measurement system. However, they usually fall within three main categories: the equipment, the environment, and the operator. If even one of these areas is neglected, it can have a dramatic negative impact on your results. Although these suggestions are not meant to be all encompassing or all-inclusive, the improvements that can be made following these simple guidelines are extraordinary.

Equipment –

- Select weights that have a tolerance that is one third or better than the accuracy you require for your application. This way the error of the weight will not dramatically impact the quality of your measurements. For more information, see Weight Selection Guidelines section on page 72.
- The equipment must be of sufficient readability to calibrate or measure the weight or sample under test.
- The balance should be placed on a stable platform free from the effects of vibration. The most common type of setup involves placing the instrument onto a balance table that is constructed of marble or granite.
- Never use a balance or scale as soon as it is turned on. The internal electronic components need to stabilize and "warm-up" for at least twenty-four hours once the equipment has been energized. Troemner recommends that you leave this instrument plugged in twenty-four hours a day, seven days a week.
- Never use a balance that has been idle for several hours without first "exercising it" and calibrating it. A balance is exercised by repeatedly placing and removing weights from the balance pan. We recommend that this be done at least ten times each with a weight that is 100% of the maximum capacity of the balance. After exercising, the balance should be calibrated. If these two techniques are consistently employed, a noticeable improvement will result in both linearity and stability of the measurement.
- When weights are not in use, store them in the case(s) in which they are supplied. If the weights were not supplied with a case, either purchase one or use a clean container to protect the surface(s) – this will keep airborne particles from getting on your weights between uses. Weights should be in thermal equilibrium with the balance so store weights near your balance(s). Another option is to leave calibration masses commonly used inside the weighing chamber when not in use – this assures your weights are in thermal equilibrium with the balance producing a better measurement.

Environment –

- The more stable your environment, the better your measurement results. Changes in temperature, pressure and humidity affect balance performance and weight stability. Ideal room conditions are 20^0C with a relative humidity between 45% and 60%. Fluctuations in temperature should not exceed 1^0C per hour. Humidity fluctuations should not exceed 10% per hour.
- Balances should not be placed in close proximity to anything that shakes, vibrates, or stirs violently. Avoid placing your equipment near centrifuges, vortexers, or shakers.
- Do not place your balance and/or scale near anything that generates heat. Heat will cause the balance chamber to warm and due to the effects of the thermal expansion introduce large errors into your measurement. Do not place the balance near a window. Sunlight can penetrate the window, warm the balance chamber at different rates during the day, and affect the quality of your work.
- Avoid placing the balance near sources of drafts, extreme air currents, or near air conditioning vents. These positions can cause your readings to be unstable and can dramatically cool the balance chamber when the air-conditioning system begins to run.

- The measurement environment should be clean and free of excessive contaminants. Contaminants such as dirt and grease can adversely affect the weight of an object.

Operator –

- **Never touch a weight with your bare hands!** Oils and contaminants from your hand will be transferred to the weight and introduce a significant error. It is recommended that all weights be manipulated with gloved hands or forceps. The two types of gloves that are commonly used and accepted are either latex (powderless) or cotton. Avoid any metal to metal contact when handling or storing weights – this will cause scratches that may introduce error. All weight forceps and weight lifters should be either nonmetallic (plastic or wood) or if metal, covered with a soft protective coating or material to avoid scratches.
- Place the weight or sample near the center of the balance pan. A small offset from center can have a pronounced effect and introduce undue variation.
- Take special care not to breathe onto the weight or into the balance chamber. Back away from the instrument. This will prevent any thermal transfer of heat from your breath or body to the balance, the weight or sample.
- Time your measurements. Consistent sample times will provide more consistent measurements.

Cleaning – No cleaning method is perfect. It is important to understand that certain cleaning procedures may alter a calibrated mass value of a weight. Substance, whether dirt or actual material, may be removed during the cleaning process. If proper cleaning procedures are not followed, residual dirt or solvent may be left on the mass standard, which will also affect the mass value of the weight. There are different recommended cleaning methods for sheet metal and non-sheet metal weights, because of their different physical characteristics. There are also different cleaning methods for periodic or daily cleaning and "spot" cleaning, which is a more vigorous method to be used when daily/periodic cleaning methods do not remove foreign matter.

Daily/Periodic Cleaning –
Non-sheet metal weights - Before each use clean all weights with a camel hair or other suitable soft brush to remove any particles that might have settled on the weight. Remember to pay special attention to the bottom surfaces, since these tend to be overlooked. One may also use a syringe bulb or compressed air to remove loose particles. If compressed air is used, especially if it comes from a can, the temperature of the weight may be affected and the weight should not be used for at least 4 hours to allow the weight to return to thermal equilibrium with the environment. If particles are not removed easily, spot cleaning may be necessary.

Sheet metal weights – Prior to each use, they should be visually inspected for foreign matter and brushed lightly with a camel hair brush. Special care must also be taken not to "over brush" these weights. Sheet metal weights are the most delicate and fragile weights manufactured. Sheet metal weights also have the largest surface to mass ratio, so any effect on a sheet metal weight's surface will have a greater impact in its mass value as compared to cylindrical weights. These weights have a tendency to attract foreign matter due to the flatness and raised markings of each piece. Sheet metal weights are adjusted by filing the edges with very fine abrading instrumentation. As a result, some of the edges may be rough or may have microscopic burrs on them. Extra care must be taken when handling and cleaning these weights. It is highly recommended that sheet metal weights be placed in a protective casing in order to prevent contamination. It is also highly recommended that compressed air not be used because compressed air is usually colder (especially if it comes out of a can) which can change the temperature of the weight and introduce undue error. Instead a syringe bulb should be used to help clean the weight and to blow off particles.
Spot Cleaning – Spot cleaning is recommended when foreign matter is observed on weights that cannot be removed using daily/periodic cleaning methods. Use cheesecloth dampened with ethyl alcohol and gently rub the weight surface in order to remove any residual or stubborn debris from the weight surface. If using alcohol does not remove the foreign debris, repeat the process using other solvents such as window cleaner or distilled water. If solvents other than distilled water and alcohol are used, the weights should be cleaned again using alcohol to remove any residual solvent from the weight. Solvents other than distilled water should never be used on brass weights or cast iron weights since they have a protective coating of lacquer and paint respectively, and solvents will deteriorate coated surfaces. For sheet metal weights or other weights made out of aluminum, alcohol should never be used since alcohol can deteriorate aluminum. After spot cleaning, the weight should not be used for a period of at least 4 hours in order for the weight to return to thermal equilibrium with the environment.

Painted cast iron weights – These weights should be brushed or compressed air should be employed to remove any foreign material. When cast iron weights are calibrated and the "as found" data has been ascertained, you may want to add a coat of paint to the weights, especially if there are signs of rust or abrasions. A calibration should be performed after any paint is applied. Use a lacquer or aluminum-based paint that goes on thin. A thick paint like an epoxy-based paint leaves too heavy a coat and is not recommended. Avoirdupois weights should be painted silver and metric weights should be painted gold.

Brass weights – The only cleaning procedure recommended for brass weights is cleaning with a clean cloth dampened with distilled water.

Cal-Kit™ Weights

Wei-ta DATA™ Weight Selector

Weights Tolerance Table - OIML

Denominations Metric	E 1		E 2		F 1		F 2		M 1		M 2	M 3
	mg		mg		mg		mg		mg		mg	mg
5000 Kg					25 000		80 000		250 000		800 000	2 500 000
2000 Kg					10 000		30 000		100 000		300 000	1 000 000
1000 Kg			1 600		5 000		16 000		50 000		160 000	500 000
500 Kg			800		2 500		8 000		25 000		80 000	250 000
200 Kg			300		1 000		3 000		10 000		30 000	100 000
100 Kg			160		500		1 600		5 000		16 000	50 000
50 kg	25		80		250		800		2 500		8 000	25 000
20 kg	10		30		100		300		1 000		3 000	10 000
10 kg	5.000		16		50		160		500		1 600	5 000
5 Kg	2.500		8.000		25		80		250		800	2 500
2 Kg	1.000		3.000		10		30		100		300	1 000
1 Kg	0.500		1.600		5.000		16		50		160	500
500 g	0.250		0.800		2.500		8.000		25		80	250
200 g	0.100		0.300		1.000		3.000		10		30	100
100 g	0.050		0.160		0.500		1.600		5		16	50
50 g	0.030		0.100		0.300		1.000		3		10	30
20 g	0.025		0.080		0.250		0.800		2.500		8.000	25
10 g	0.020		0.060		0.200		0.600		2.000		6.000	20
5 g	0.016		0.050		0.160		0.500		1.600		5.000	16
2 g	0.012		0.040		0.120		0.400		1.200		4.000	12
1 g	0.010		0.030		0.100		0.300		1.000		3.000	10
500 mg	0.008	~	0.025	~	0.080	~	0.250	~	0.800	~	2.500	
200 mg	0.006	~	0.020	~	0.060	~	0.200	~	0.600	~	2.000	
100 mg	0.005	~	0.016	~	0.050	~	0.160	~	0.500	~	1.600	
50 mg	0.004	~	0.012	~	0.040	~	0.120	~	0.400	~		
20 mg	0.003	~	0.010	~	0.030	~	0.100	~	0.300	~		
10 mg	0.003	~	0.008	~	0.025	~	0.080	~	0.250	~		
5 mg	0.003	~	0.006	~	0.020	~	0.060	~	0.200	~		
2 mg	0.003	~	0.006	~	0.020	~	0.060	~	0.200	~		
1 mg	0.003	~	0.006	~	0.020	~	0.060	~	0.200	~		

Note : This Weight Tolerance Table shows Maximum Permissible Error recommended by Internation Organization of Legal Metrology Recommendation R-111*. Blank Field indicates that Tolerance are not defined by OIML for those Denominations!