# Understanding Weighing

## A Grocer's Guide to Metrology



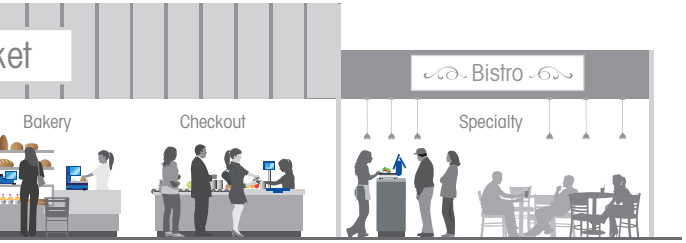
METTLER TOLEDO




# Introduction

Metrology is a term you might not be familiar with, but it's something that impacts retail grocers all day long. Metrology is the science of measurement, and the scientific tool at the heart of every service counter transaction is the weighing scale. Without an efficient, easy-to-use, and above all accurate scale, profitability and customer satisfaction would be critically compromised. Dependable product measuring is essential to managing and tracking sales volume and to maintaining compliance with industry regulations.

As the world's leading manufacturer of weighing devices, METTLER TOLEDO produces scales that can measure to the nearest one-billionth of a gram, to scales that can measure several hundred metric tons. We specialize in producing high quality, cost effective measuring devices that meet or exceed the exacting specifications for manufacturing, measuring, safety and the environment.




The purpose of this guide is to identify some of the terminology associated with retail weighing technology, and to explain the importance of each term as it applies to your day-to-day business. The terms covered in this guide include:

- Accuracy
- Accuracy Class
- Linearity
- Load Cell
- Corner Load
- Repeatability
- Temperature Stability
- Scale Intervals
- Dual Interval Scales
- Tare
- Verification
- Hysteresis
- Sensitivity
- Geolocation
- Precision vs. Accuracy
- Calibration

**www.mt.com/retail-metrology**

# Table of Contents


| | | |
|---|---|---|
| Introduction | | 2 |
|  | Accuracy | 6 |
|  | Accuracy Class | 7 |
|  | Linearity | 8 |
|  | Load Cell | 9 |
|  | Corner Load | 10 |
|  | Repeatability | 11 |
|  | Temperature Stability | 12 |
|  | Scale Intervals | 13 |
|  | Dual Scale Intervals | 14 |
|  | Tare | 15 |
|  | Verification | 16 |
|  | Hysteresis | 17 |
|  | Sensitivity | 18 |
|  | Geolocation | 19 |
|  | Precision vs. Accuracy | 20 |
|  | Calibration | 21 |
|  | Tips and Tricks | 22 |
|  | Services | 23 |

# Accuracy



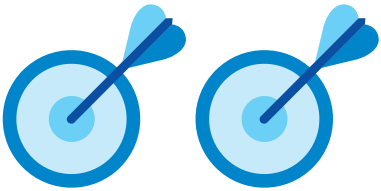
Accuracy is the fundamental goal of every weighing instrument ever built. In fact, all of the other terms that we'll discuss in this guide are factors which contribute to the accuracy of a measuring device. But what actually is "accuracy" when used in regard to weighing? Quite simply, it's how closely the measured value on the scale display equates to the actual weight of the item being measured. If those two figures were exactly the same, that would be perfect accuracy. And while perfection is always the goal, infinite accuracy is something that is physically impossible to achieve.

So when we talk about accuracy, we're really looking at the degree of accuracy, which is described as a percentage. Most often, the percentage used is not the amount of accuracy, but rather the amount of inaccuracy. So a scale with 0.001% accuracy is more accurate than one with 0.075% accuracy.

Because today's retail measuring instruments rely on complex internal mechanisms, it's important to calibrate the scale for accuracy at its ultimate location of use – rather than at its manufacturing facility. Factors such as transport, elevation, temperature and other geophysical and environmental variables can impact the device's extremely sensitive technology.

**Did you know?**
Most commercial scales in use today employ one of two technologies: strain gauge, or electromagnetic force compensation (MonoBloc). Generally speaking, scales using MonoBloc technology – which was introduced to the market by METTLER TOLEDO – are ten times more accurate than strain gauge scales.

# Accuracy Class



In the course of your experience with scales, you may have come across certain designations stating whether a device was a Class I, Class II, Class III or even Class IIII scale. And you may have wondered what these designations mean. Simply put, a scale's class designation is another way of expressing its Accuracy Class – which lets you know what range of accuracy the device is designed to deliver (and also how many distinct divisions you can expect the device to display).

A Class I scale is the most sensitive and accurate type of scale. Primarily intended for laboratory use, it is used to weigh amounts greater than or equal to 1 milligram. A Class II scale is also likely to be used in a laboratory, or perhaps a jewelry store. One type of Class II scale is designed to weigh amounts ranging from 1 to 50 milligrams, while a second type is designed to weigh amounts greater than or equal to 100 milligrams. There are also two types of Class III scales – and these might be found in various retail settings, including the post office. The range of these scales is measured either in grams, pounds or ounces. The largest scales are referred to either as Class IIIL or Class IIII scales – and these are used to weigh things like trucks, railroad cars and other very heavy objects.

**Did you know?**
The unit of measurement used in the world's most sensitive scales is something called a yoctogram (or one septillionth of a gram). Here is how one yoctogram would be written numerically – 0.000000000000000000000001 g. What kind of objects would be measured in yoctograms? Well, a single proton from an atom of the elemental gas xenon has been weighed at 1.7 yg.

# Linearity



Linearity, as you will notice, comes from the word "line." With regard to weighing technology, it means that a scale's sensitivity will be the same across the entire spectrum of its weighing capacity. In other words, on a 1,000 gram-capacity scale, the reading for a 50 gram test weight will be 50 grams, the reading for a 500 gram test weight will be 500 grams, and the reading for a 1,000 gram weight will be 1,000 grams. When a scale is in perfect linearity, there is no noticeable deviation when weighing different amounts – so whether you're weighing one slice of cheese or an entire block, you can be sure the reading is accurate.

All high-sensitivity scales are linearized by the manufacturer, but can gradually develop unacceptable deviations over time. You can perform a routine test for the linearity of your scale by using calibrated and verified test weights that, when all weighed together, register the same (or a little less than) the instrument's maximum capacity. Start with a light weight, and note the readout's accuracy. Do the same with increasingly heavy loads, each time checking for accuracy. Finally, do the same with all of the weights on the scale. In each case, the readings should be identical to the verified test weights. If you observe that there is a meaningful disparity (more than one division) at one or more points along the weighing range, the instrument may need to be adjusted. Contact your METTLER TOLEDO representative to have your measuring device evaluated by an authorized professional.

**Did you know?**
The presence of static electricity can impact the weighing performance of a measuring device. Minimizing the potential for static electricity in the weighing environment (e.g. rubber floor mats, adequate humidity) can help ensure more accurate readings.

# Load Cell (Strain Gauge Transducer)

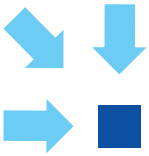


Many, if not most, of the commercial scales in use today depend on something called load cell technology. What is a load cell? Well, first of all it's a transducer – a device that converts one form of energy to another. Most retail scale load cells typically have four "strain gauges" that help measure the amount of force being applied by the object being weighed. These strain gauges are usually made of metallic foil or film that adheres to a flexible metal beam typically made of aluminum or steel alloys. As the beam bends (due to the weight of the object on the scale), the strain gauges deform – which causes a change in the electrical signal passing through them. This change is in direct proportion to the amount of weight on the scale.

Because there is bending and flexing in the load cell during weighing, it's very important to consider the scale's maximum capacity when weighing materials you think might be in excess of the rated capacity. While METTLER TOLEDO scales are specifically designed to protect load cells from being overloaded, other devices may not have this fail-safe option. So, when overloaded beyond the scale's rating, the load cell may not return to its original shape afterward, and future readings will no longer be accurate. When used properly, strain gauge load cell scales are dependable, durable and cost efficient. But as with all commercial equipment, care and good sense must always be exercised when using these devices.

**Did you know?**
When strain gauge load cells were first introduced, they were only moderately sensitive, and consequently were used primarily for weighing very heavy loads (for which precise accuracy was not critical). But the technology – and the accuracy – has improved significantly since then, due largely to METTLER TOLEDO's pioneering efforts in developing and patenting strain gauge solutions.

# Corner Load



In the real world, it's not always possible (or practical) for retail associates to place items directly in the center of the weighing pan. But it's important that the scale delivers an accurate reading no matter where the product is placed. When the readout varies depending on the location of the item on the scale, this is known as "corner load error," "off-center loading error" or even "eccentric loading error." When this type of error occurs, it tends to become more pronounced as both the weight – and the distance from center – increase.

However, if the readout remains consistent regardless of where the item is placed on the weighing pan, the scale can be described as having no corner load deviation. This designation should be the goal of every scale, especially those that are used in fast-paced retail environments.

**Did you know?**
You can test your weighing equipment for corner load deviation by placing an item in the center of the pan, and then weighing that same item in each of the four corners of the pan (after zeroing the display between each measurement). Then check to see if the deviation (if any occurs) is within the manufacturer's specifications.

# Repeatability



With a high-precision weighing device, the readout should not deviate when tested over and over again under identical conditions. In order to test for repeatability, the measurements must be carried out by the same operator, using the same weighing method, in the same location on the weighing platter, in the same installation location, under constant ambient conditions (e.g. temperature, air currents, vibrations, humidity, etc.) and without interruption. This is the essence of repeatability. After multiple tests have been performed, any variations noted will be expressed as the standard deviation for that device.

It's essential to understand that repeatability, in and of itself, is not a substitute for accuracy. It's possible that a scale could give the same inaccurate reading over and over again. Nonetheless, repeatability is an essential characteristic of retail weighing equipment. When properly calibrated, a dependable scale should consistently deliver test results that are either absolutely identical, or have an extremely low standard of deviation.

**Did you know?**
When testing a weighing device for repeatability, you should use a test weight that is at least half, and preferably close to, the maximum load for that device. If possible, use an object designed to be used as a test weight. If none are available, be sure to use an object that is solid, non-porous, non-magnetic, static free and impervious to dust and dirt.

# Temperature Stability



The sensitivity of weighing instruments can be affected by changes in temperature, and as a consequence this can affect the device's accuracy. Load cell scales have been shown to deflect at a reduced rate in cold conditions, and consequently, a "temperature coefficient of sensitivity" has been calculated in an attempt to account for the discrepancy. But this approach is certainly less than ideal, resulting in nothing more than an approximation of accuracy.

When operated within the manufacturer's recommended temperature range (usually between 14° and 104°F or -10° and 40°C), METTLER TOLEDO's retail scales will deliver consistent, accurate readings that will not vary with moderate changes in ambient temperature. However, when moving a scale from one climate to another, it's best to give the scale's internal components plenty of time to adjust to the new temperature before calibrating the device.

**Did you know?**
While it's possible to operate a weighing device outside of its recommended temperature range, inaccurate readings will become more common – and more pronounced – if operation of the scale continues in extreme conditions. Sensitive electronic components intrinsic to the scale's accuracy are not designed to operate outside of their recommended temperature ranges.

# Scale Intervals



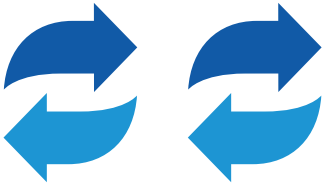
When you weigh something on a scale – any scale – the precision of the measurement is determined by the scale "intervals" (also known as scale divisions) that the device employs – or in other words, by the smallest possible increment between two measured values.

On retail scales featuring electronic digital displays, that "smallest difference" might be a gram, or perhaps one one-hundredth of a pound (0.01 lb.). While in truth the actual weight of an item is most likely somewhere within the interval, the reading will show the closest increment either above or below it.

Scale intervals vary greatly depending on the type of loads that the instrument is designed to weigh. Obviously, the scale intervals of a device built to measure the weight of a highway truck will be far different than the intervals of a scale designed to measure spices or tea.

**Did you know?**
Even though two measuring devices might have the same scale intervals (e.g. 0.01 lb.), they can still possess different levels of sensitivity. A scale with a 100-pound maximum load that has intervals of 0.01 lb. offers greater sensitivity than a scale with a 10-pound maximum load and intervals of 0.01 lb. because it has 10 times as many measurable increments.

# Dual Interval Scales



Traditionally, scales have been designed to employ a single scale interval. Depending on the size of the loads it measures and the type of working environment, that interval may be one kilogram, one pound, one ounce, one gram or possibly an increment that's even smaller. And in most cases, the single interval scale provides a measurement that is precise enough for the application being used.

But in certain applications – particularly in the retail grocery environment – the same scale may be used to weigh large, bulky items one minute and the next minute be asked to provide an accurate measurement for items weighing less than a hundredth of an ounce. Imagine one customer transaction involving the purchase of ten pounds of basmati rice, followed immediately by the purchase of two or three fine threads of saffron. It was precisely for these types of situations that METTLER TOLEDO developed weighing instruments with built-in dual scale intervals. These scales will auto-adjust, selecting the appropriate scale interval for the item being weighed.

**Did you know?**
Because of their advanced precision with smaller, lighter items, METTLER TOLEDO's dual interval retail scales reduce the "minimum weight threshold" – or the lowest amount of measurable product that is legally allowed to be sold (legal for trade). With their ability to weigh even the smallest quantities, these scales help retailers maximize their profitability – particularly on the sale of very light (but expensive) items.

# Tare



The word tare comes from an old Arabic word meaning "the thing deducted or rejected" – and refers to the container that's holding the material you want to know the actual weight of. Most retail scales will have a tare button that can be used to reset the display to zero when the empty container is sitting on the weighing pan.

Here's how the tare button works: if the scale is reading 0.00 kg, you place an empty container on the scale and it reads 0.05 kg (0.11 lb.). You press the tare button, and the scale display now reads 0.00 kg. You fill the container with product, and the scale display reads 0.56 kg (1.23 lb.). This is the actual weight of the product. When you remove the container from the scale, it would now read –0.05 kg (–0.11 lb.).

Here's a real life example: Consider the actual weight of a single piece of deli paper is 0.0015 kg (0.0033 lb.). Many retail scales use a single interval and would therefore have to round up to show 0.005 kg (0.01 lb.). This means 0.0035 kg (0.0067 lb.) is being given away! With dual interval scales, the lowest interval is now reduced considerably and shows 0.002 kg (0.005 lb.), thus, now only 0.0005 kg (0.0017 lb.) is given away. Therefore, METTLER TOLEDO dual interval scales save retailers several cents per transaction and, over the course of hundreds of transactions per day, a retailer can save thousands of dollars per year for each scale in use.

**Did you know?**
METTLER TOLEDO retail scales give retailers the ability to program specific tare amounts by PLU, simply by configuring a preset tare key. This feature improves the accuracy of fast-paced, high-volume weighing. It also reduces the labor time required to process a transaction, which can add up to significant savings.

# Verification



Retail scales must be verified to comply with local, state or national regulations in order to be used. Verification protects consumers from the consequences of incorrect measurements, and safeguards a company's reputation against the damaging effects of public perception of unfair weighing practices. Consequently, verification of compliance is essential if the retailer wishes to stay in business or avoid paying heavy fines.

The verification process for scales can be either a one-step or two-step process, depending on the model, the manufacturer or the location at which the scale is used. First-step verification takes place at the manufacturing site (typically only in Europe). The second step of the verification process must be carried out at the retail location, and be performed either by authorized METTLER TOLEDO service personnel or by a local Weights and Measures official.

Verification regulations vary greatly from country to country, in terms of period of coverage, date on equipment seal, and the verifying body itself. In Germany, verification must be performed every two years by Weights and Measures. In the U.S., scales must be verified by Weights and Measures annually. In the Netherlands, there is no defined period of coverage, and the verifying body is METTLER TOLEDO. Every country has a different set of regulations – so having METTLER TOLEDO as your knowledgeable verification partner eliminates all of the confusion.

**Did you know?**
The more diverse and complex a retail business becomes, the more difficult it can be to manage the verification process for all of the weighing equipment throughout the enterprise. METTLER TOLEDO Verification Management provides a complete range of functions and services to keep of your equipment compliant, accurate and precise.

# Hysteresis



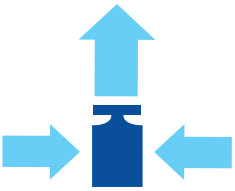
The term hysteresis derives not from the word history but rather from an ancient Greek word that means "lagging behind." Nevertheless, history does play a major role when it comes to weighing equipment hysteresis. It occurs when the reading you get for a particular load is affected by the previous load and consequently produces a reading that is inaccurate. For example, when a light item weighing 0.11 kg (0.25 lb.) is placed on the scale immediately after an item weighing 6.8 kg (15 lb.) is weighed, the reading for the lighter weight may register as more than its actual weight.

Why does hysteresis occur? Often, it's due to elasticity of the scale's internal assembly. The component retains a "memory" of the previous load, and consequently gives an inaccurate reading when the next load is weighed. Other factors that can produce varying degrees of hysteresis include mechanical friction, the presence of strong magnetic forces, and even the elapsed time between measuring loads.

METTLER TOLEDO's high-quality, high-precision scales are designed to reduce or eliminate hysteresis – and deliver a consistently accurate measurement regardless of the load weighed immediately before it.

**Did you know?**
The effect of hysteresis can also depend on the surface upon which the weighing instrument is placed. To demonstrate this phenomenon, try weighing something with the scale on a hard surface, and a second time with the scale on a thick carpet. The readings are indeed different (and the reading taken with the scale on a hard surface will most likely be the more accurate one).

# Sensitivity



When used in regard to weighing technology, the term sensitivity is so "sensitive" it can actually mean different things, depending on the context of the discussion. The first and most obvious meaning has to do with a scale's ability to detect smaller and smaller changes in the items being weighed. In other words, how much of the item you need to add – or subtract – to make the scale display a different weight reading. Factors that might have an impact on a device's sensitivity include the age of the equipment, the amount of friction between the scale's moving parts, and even the steadiness of the scale operator.

Another way in which the term sensitivity is applied to weighing technology has to do with the way variations in temperature affect the accuracy of measured values. It's a bit complicated, but what it boils down to is a measurable relationship between temperature changes of the item being weighed, and how those changes affect the displayed reading for the item. There's actually a formula you can use to determine the offset expected for a particular temperature change, but it's better to simply remember that weighing something when it's very hot, very cold, or at room temperature can produce discrepancies in the measured readings.

**Did you know?**
For industries that must comply with strict quality control regulations, regular testing – sometimes daily – for weighing equipment sensitivity is required. As part of its GWP® Good Weighing Practice™ global standard, METTLER TOLEDO provides online resources that walk users through the step-by-step procedures to make sure their devices are operating at the highest possible level of accuracy.

# Geolocation

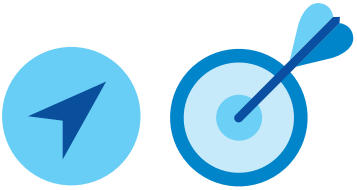


This term, when used in regard to weighing equipment, means the exact location on earth where a particular scale is being operated. The two main factors that contribute to geolocation-based variability are elevation and latitude. Changing the geolocation of a scale will impact the accuracy of an item's measured weight. (In other words, if a scale is perfectly calibrated for one location – and then sent to another location – it will likely produce different readings for the same test weight.) It's important that configuration of any instrument be set for its ultimate location of operation. This can be accomplished by doing the configuration on site or by using the METTLER TOLEDO geocode adjustment feature.

A little science lesson: what we call "weight" is a function of the gravitational force of Earth acting upon the gravitational force of the object being weighed. The further an object is from the center of the earth, the lower its measured weight. So the weight of an object at sea level is fractionally higher than its weight at 1,000 feet above sea level – even though its mass remains constant. Secondly, the centrifugal acceleration caused by Earth's rotation works to subtly counteract the force of gravity. This acceleration is greatest at the equator and diminishes as one moves toward the poles – so an object literally becomes heavier as it gets further from the equator. Because of these factors, it is a sound practice to reconfigure your scale after changing either its elevation, latitude or geolocation.

**Did you know?**
"Weight" and "mass" are used interchangeably, but they are actually two different things. Weight is a force that's equal to mass times gravitational acceleration (see Newton's 2$^{nd}$ Law) – so a 50 kg weight – on Earth – is actually 50 kg of mass x 9.8 m/sec$^2$. And that "weight" (or more literally, "force") would be measured not in kilograms, but in Newtons – in this case, 490 Newtons.

# Precision vs. Accuracy



Ideally, any weighing instrument would be both precise and accurate. But in reality, it could be one or the other, and not necessarily both. Here's how the two terms compare and contrast with one another: 1) accuracy refers to how close a measured value relates to the actual value of the item being measured; 2) precision is the degree of consistency to which the measured value of an item persists in producing identical results.

To understand this discrepancy better, let's imagine two hypothetical scales – Scale A and Scale B. Each scale will measure a test weight of 1.000 lb. five times. In the five measurements, Scale A obtains readings of 1.002, 1.004, 0.998, 1.001 and 0.995 lb. For Scale B, the five displayed readouts are 1.133, 1.134, 1.132, 1.134 and 1.135 lb. Which of the scales is more accurate, and which is more precise? The readouts of Scale B vary from each other only by an amount of 0.0003 lb. – though they all deviate by at least 0.132 lb. from the actual test weight. So because of their consistency, Scale B can be described as having a higher level of precision than Scale A (which is certainly more accurate, having only deviated from the true test weight by 0.005 lb. in any of the tests).

**Did you know?**
While absolute accuracy is unquestionably the goal for any weighing device, the importance of precision is something that should not be taken lightly. This is particularly true when careful testing can determine both the degree of precision and the amount of deviation from the true actual weight.

# Calibration



Calibration is a metrology term that, while almost universally understood, is also almost universally misused. The reason for the misuse is that calibration, in and of itself, is simply the act of establishing the relationship between a known value and its measured value, under specified measuring conditions. In other words, it's taking a known weight (e.g. 1 kg) and noting any deviation from that value on the display. Some scales offer internal, motorized calibration weights that can be used to determine the deviation, but all weight measuring devices can be externally calibrated as well. Calibration helps determine what kinds of adjustments may be necessary to return the scale to the state of accuracy required for its acceptable use.

Scales undergo a certain amount of wear and tear over time as a result of high use. Consequently, it's essential that any working scale is calibrated on a regular basis, and that adjustments are made when necessary. In the retail grocery business, all scales that are used to determine product pricing are inspected on a regular basis to ensure that their accuracy meets or exceeds local regulations. When a scale fails to comply with those standards, the penalties to the business owner can be quite severe. To avoid these penalties (and to minimize lost profitability due to inaccurate measurements), many retailers agree that investing in high quality scales – along with regularly scheduled calibration service – is money well spent.

**Did you know?**
In order for a scale's accuracy to be "certified" – i.e., in accordance with local requirements – it must be calibrated on site. METTLER TOLEDO certified technicians will calibrate and certify your equipment at your location, ensuring legal compliance with local Weights and Measures regulations.

# Tips and Tricks



Maintaining your retail weighing scale will extend the life of your equipment and reduce your overall cost of ownership. Follow some of these basic tips to ensure maximum uptime and accurate performance.

- Follow a regular preventive maintenance schedule.
- Thoroughly clean scale at least once per day.
- Ensure area around the scale is free of debris.
- Ensure the scale is always level. Adjust the leveling feet as needed.
- Keep scale away from any vibrating surfaces.
- Monitor accuracy by testing for corner load deviations.
- Do not place scales directly under air currents.
- Do not place scales where temperatures can change often and quickly (i.e., near the store doors during the winter season).

Learn more at:
**www.mt.com/retail-metrology**

# Services



**Ensure Uptime, Increase Performance**

METTLER TOLEDO Service understands what it takes to suit your specific business needs. Benefit from the experience of the market leader and ensure optimal equipment uptime, performance, compliance and the expertise necessary to maximize your investment. These pillars of our approach take METTLER TOLEDO to the next level in service far beyond the competition.

METTLER TOLEDO Service offerings cover your equipment's complete life cycle. Our goal is to maximize the efficiency and productivity of your operational processes. Find out more about how our tailor-made service offerings can add value to your business operations. Learn about the following service offerings:

- Repair Services
- Calibration Services
- Installation Services
- Training Services
- Professional Services
- Software and Remote Services

Learn more at:
**www.mt.com/retail-service**

**www.mt.com/retail**

For more information

**Mettler-Toledo GmbH**
Heuwinkelstrasse 3, 8606 Nänikon
Tel. +41 44 944 22 11
Fax +41 44 944 30 60

Subject to technical changes
© 02/2017 Mettler-Toledo GmbH
RT1264.0EE
Global MarCom 2094 RK