## Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Technical advances promote pioneering solutions</td>
</tr>
<tr>
<td>2</td>
<td>Rugged yet precise</td>
</tr>
<tr>
<td>2.1</td>
<td>Protection classes offer standardised safety</td>
</tr>
<tr>
<td>2.2</td>
<td>Potentially hazardous areas (Category I/II, A/B) ATEX Zone 2 or 22</td>
</tr>
<tr>
<td>3</td>
<td>Different yet precise</td>
</tr>
<tr>
<td>3.1</td>
<td>Load cells with wire strain gauge technology</td>
</tr>
<tr>
<td>3.2</td>
<td>Weighing cells with EMFR technology</td>
</tr>
<tr>
<td>3.3</td>
<td>Diversity in weighing technology</td>
</tr>
<tr>
<td>4</td>
<td>Diverse yet highly individual</td>
</tr>
<tr>
<td>5</td>
<td>Measured precisely, yet still different</td>
</tr>
<tr>
<td>5.1</td>
<td>Practical applications distinguish between static scales and checkweighers</td>
</tr>
<tr>
<td>5.2</td>
<td>Weighing timing – weighing time – response time</td>
</tr>
<tr>
<td>5.3</td>
<td>A few words on statistical data analysis</td>
</tr>
<tr>
<td>5.4</td>
<td>Accuracy is a question of resolution and legal guidelines</td>
</tr>
<tr>
<td>6</td>
<td>Precise procedures can still produce inaccurate results</td>
</tr>
<tr>
<td>6.1</td>
<td>How is the precision of a checkweigher tested?</td>
</tr>
<tr>
<td>6.2</td>
<td>Keep your eye on the entire checkweigher system</td>
</tr>
<tr>
<td>7</td>
<td>All-rounders and empty promises</td>
</tr>
<tr>
<td>7.1</td>
<td>Product diversity and service pay off</td>
</tr>
<tr>
<td>8</td>
<td>Precise and complying with all applicable legislation</td>
</tr>
<tr>
<td>9</td>
<td>Well conceived and prepared</td>
</tr>
</tbody>
</table>
"Technical advances promote pioneering solutions and knowledge forms the basis for making the right decisions."

There are hardly any industries which do not now use checkweighing equipment. Indeed, it is impossible to imagine effective quality assurance systems in today's production operations without modern checkweighers. No matter whether they operate in the pharmaceutical, chemical or cosmetic production industries, the food and drink sector, the metal processing industry or the automotive arena— all companies rely on these precision instruments. So it should come as no surprise that checkweighers have long since been a key element of production operations, as they are capable of far more than just weighing and can actually optimise production processes.

Based on the definition of the term, a “checkweigher” describes a system that weighs products as they are guided over scales on a production line. During this process, the products are grouped into predefined weight zones and then sorted/ejected based on weight classification. While it used to be necessary to manually collect large volumes of data for quality assurance purposes, modern checkweighers document everything in a fraction of a second. One key argument in favour of using checkweighers is that 100% of products are checked.

However, independent checkweighers are capable of far more than just checking weights. They are increasingly developing into quality assurance “stations” used throughout the manufacturing process. Integrating further inspection equipment then, for example, allows issues such as open flaps on boxes, missing caps or barcode labels and RFID tags to be reliably detected.

A monitoring system that has been tailored specifically to the manufacturing process in use provides protection from product flaws and product recalls, as well as supporting compliance with national metrological guidelines. In short, it lowers overall operating costs. In addition to this, implementing prudent precautions and thereby guaranteeing the requisite diligence during the production process can prove very beneficial in the event of legal disputes or when performing audits.

Spoilt for choice

Although they offer many advantages, reaching a qualified decision as to what kind of checkweigher system to use requires a sound understanding of the functional principles. This White Paper provides an overview of the basic principles and should therefore help readers gain a better understanding of the technology involved in checkweighing, the areas in which it can be most effectively used and the performance offered by the various systems.

2 Rugged yet precise

Weighing cells require various properties in order to be effective.

Checkweighers are individualists. The ultimate design of a checkweigher is defined by the respective task(s) to be performed. The key is therefore individual production deployment. A whole number of conditions have to be taken into account here, such as the ambient conditions at the place of installation, the required precision, the throughput or the article specifications. To cater to these requirements, checkweighers (and in particular their weighing cells) first need to be capable of handling the task at hand and then specifically adapted to the respective deployment.

Harsh ambient conditions require a certain degree of ruggedness. Anyone not familiar with this technology is likely to be amazed by the ability of checkweighers to provide very precise results over a long service life, while complying with the strictest of requirements. There is a good reason for this, as reputable manufacturers not only offer the right technical solutions, which themselves need to be further developed and optimised on a regular basis, but also provide their valuable experience from many successfully completed projects. It really helps when suppliers have deep knowledge and understanding of their specialist field here.

In terms of the environmental conditions, factors such as temperature, humidity and undesired vibrations all place great demands on a checkweigher.
These influences can have a negative impact both on the durability of materials and on weighing results. They place demands on the robustness and reliability of the systems, and require both technical expertise and solution competence from the respective manufacturer. Finding the best way to eliminate undesired environmental factors is often a question of practical experience.

**Market trends and the conditions of competition also take their toll when it comes to checkweighers.** Manufacturers of precision scales/balances are increasingly being confronted by new developments that have effects on the design and production of their products. Constant competitive pressure, also from overseas, is forcing companies to increase throughput in their production operations. Saving time during production offers valuable price advantages here. The practical effects of this include faster cycle times and higher conveyor speeds. However, these are also accompanied by significantly stricter requirements of checkweighers and their reliability. Achieving precise results with ever shorter measuring times requires established technical solution expertise.

Yet the pressure to save costs in companies can also lead to quite different effects. The outsourcing activities of companies, for example commissioning external personnel to perform cleaning work, can often lead to weighing equipment not being treated with the necessary care. Incorrect cleaning or the use of too much detergent can severely stress materials and systems. It is therefore a major advantage when manufacturers supply their devices with IP69k ingress protection, thereby guaranteeing a high degree of protection from the outset. And it is even better when they offer this at no extra charge.

### 2.1 Protection classes offer standardised safety

**Defined industrial standards offer recognised standards that enable consistent quality assessments when examining products from different suppliers.** Standard data allows potential buyers to immediately recognise how well a casing is protected from moisture penetration, for example during cleaning. The "National Electrical Manufacturers Association" (NEMA) has drawn up standards for industrial controllers and systems. These standards are used to assign systems to protective classes, which specify the extent to which particles and moisture are prevented from entering the casing or the connection.

**Common protective classes include:**

- **IP30** – Protection against penetration of objects > 2.5 mm (tools, thick wire, etc.).
- **IP54** – Dust penetration is not 100% prevented, although it cannot penetrate in quantities that are sufficient enough to prevent the equipment from working properly. The casing has splash water protection on all sides, thereby preventing any harmful effects.
- **IP65** – Protection against dust penetration. Any water hitting the casing from any angle will not have any harmful effects.
- **IP66** – Protection against dust penetration. Any powerful jets of water hitting the casing from any angle will not have any harmful effects.
- **IP67** – Protection against dust penetration. Protection against submersion in water up to 1 m. Water must not be able to penetrate the casing when it is submerged in water under certain pressure and time conditions (up to a submersion depth of 1 m).
- **IP69k** – DIN 40050-9 extends the scope of protection to include coverage for high-pressure cleaners and high-temperature cleaning processes. These casings must offer protection against dust penetration (IP6X) and against both high-pressure and steam jet cleaning. The test is performed using a spray nozzle supplied with 80 °C hot water at 80 - 100 bar pressure (8 - 10 MPa) and a flow rate of 14 - 16 l/min. The nozzle is held at a distance of 10 - 15 cm from the device being tested for a total of 30 seconds at an angle of 0°, 30°, 60° and 90° (Fig. 1). The test equipment is fitted to a rotary table that completes one full revolution every 12 seconds (5 rpm).

![Fig. 1: IP69k test](image)
2.2 Extreme conditions require special measures: Potentially hazardous areas (Category I/II, A/B) ATEX Zone 2 or 22

Checkweighers also live a dangerous life.

<table>
<thead>
<tr>
<th>Designation</th>
<th>Description</th>
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<tbody>
<tr>
<td>Class I</td>
<td>Combustible gases and vapours, Groups A, B, C, D</td>
</tr>
<tr>
<td>Class II</td>
<td>Combustible dusts, Groups E, F, G</td>
</tr>
<tr>
<td>Class III</td>
<td>Flammable fibres and airborne particles</td>
</tr>
<tr>
<td>Category I</td>
<td>Class II or III typically present</td>
</tr>
<tr>
<td>Category II</td>
<td>Class I, II or III present in the event of an error</td>
</tr>
<tr>
<td>Not classified</td>
<td>Potentially hazardous properties far enough away from a hazard area that the area can be classed as secure</td>
</tr>
</tbody>
</table>

Fig. 2: Hazard class descriptions

Checkweighers are also operated in potentially explosive areas. However, they must then be secured accordingly using the methods described. Explosion-protected checkweighers and special components are available for this.

If you would like more detailed information on explosion protection when using checkweighers, there is a white paper available at www.mt.com/garvens-atex

3 Different yet precise

Weighing cells use different technologies.

When it comes to precise weighing of products, attention generally focuses on the weighing cell, or load cell, which sits at the heart of any checkweigher. The wide range of requirements encountered in practical applications have led to various solutions being developed and certain technologies gaining ground over others. It should therefore come as little surprise that the various suppliers of checkweighers have their own, individually specified weighing ranges, including the type of weighing cell and signal processing. As a general rule, however, it is fair to say that the process for selecting a specific kind of weighing cell should be based on the precision required for the respective application, as well as the ambient conditions and product handling parameters at the place of installation. Reputable manufacturers will therefore always start by analysing the specific manufacturing situation in each case, then specifying the required precision and ultimately selecting the optimum weighing cell technology. This once again serves to underline the importance of clearly defining the future task as the basis for an efficient checkweigher solution.

But why are these key elements of precision, ambient conditions and product handling parameters so important? Practical experience has shown that the accuracy of a checkweigher solution is directly related to the conveyor speed, as well as the stability and properties of the products being weighed. Up to a certain point, accuracy increases as the line’s conveyor speed and throughput are both reduced. The greater the stability of the product during weighing, the greater the accuracy. While most manufacturers of checkweighers can provide systems with adequate accuracy for the intended application, cases are still encountered in which even high-precision checkweighers reach their limits in terms of product size, weight, throughput and system environments. Yet despite this, intensive development work (performed in particular by international manufacturers) is enabling weighing technology to keep pace with ever stricter market requirements.
Special software now allows the characteristic interference profile of modern checkweighers to be identified and removed from the equation. Each checkweigher possesses a unique interference profile during operation (Fig. 3), which is generated by influences from the ambient environment and the system’s own design features. Modern weighing cells are capable of detecting and “learning” new interference patterns while running. They then independently initiate the necessary settings to attain and secure the greatest possible accuracy – all without any user input.

The information which the checkweigher continuously receives throughout the weighing process (for example due to an increase in conveyor speed) provides the basis for this. Software-based filter algorithms then filter out these new forms of interference and thereby ensure the necessary accuracy.

Various weighing technologies have been developed over the years in an attempt to cater to the strict and very diverse requirements of checkweighing. As is the case with other technical equipment, practical testing in the field has shown that not all systems are equally well received by the market. For checkweighers, the most popular weighing cells today use the principle of wire strain gauge technology and electromagnetic force restoration (EMFR technology). Although other technologies are also in use, their deployments are typically restricted to very specific fields, so they will not be addressed in great detail in this White Paper.

3.1 Load cells with wire strain gauge technology

Load cells with wire strain gauges employ a principle that has proven highly effective.

Their two main components, the bending springs on the load-bearing surface and a strain-sensitive measuring transducer, are the key to their performance.

When an object is placed on the weighing platform, its weight causes the system to bend (Fig. 4). The proportional deformation of sensors caused by this (strain-sensitive measurement transducers) forms the basis for the measurement. This deformation can be measured in the form of a minor change in voltage. As the change in voltage – that occurs at the voltage output as soon as a load is placed on or removed from the weighing conveyor – is linear throughout the entire weighing range of the strain gauge cell, the control system can use the voltage determined to calculate the actual weight. This calculation is performed in a predetermined way, as it is based on the system calibration.

How does a ‘strain gauge’ load cell determine weight?

The strain gauge is a thin film resistor whose resistance changes when a load is applied. A strain gauge load cell employs four strain gauges and fixed resistors, which are connected as a Wheatstone bridge. The load cell sends a low voltage to the strain gauges. When the load cell is balanced, each strain gauge has the same resistance (Fig. 5).
When a force is applied to the load cell, the resistance changes unevenly via the Wheatstone bridge and thereby generates a change in output voltage. In an ideal scenario, these changes are linear relative to the load placed on the load cell and the change in voltage can be quickly converted into a weight (Fig. 6)

**Note:** Strain gauge load cells are often equipped with external mechanical overload stops to prevent damage caused by excessive loads.

### Strain gauge technology at a glance

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
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<tbody>
<tr>
<td>Diversity</td>
<td>Large selection of strain gauge load cells</td>
</tr>
<tr>
<td>Integration</td>
<td>Easy mechanical integration for a whole range of applications</td>
</tr>
<tr>
<td>Design/Construction</td>
<td>Much smaller units are possible relative to other technologies</td>
</tr>
<tr>
<td>Costs</td>
<td>Lower procurement costs in comparison with other technologies</td>
</tr>
<tr>
<td>Error tolerance</td>
<td>More software functionalities for neutralising interference profiles</td>
</tr>
<tr>
<td>Resolution</td>
<td>Limited measurement divisions when processing very low weights</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Limited measurement accuracy due to mechanical components</td>
</tr>
<tr>
<td>Response time</td>
<td>Slower measurement procedures, which can have a knock-on effect on throughput depending on the load and resolution</td>
</tr>
<tr>
<td>Performance</td>
<td>Limited scope for increasing production throughput</td>
</tr>
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### 3.2 Weighing cells with EMFR technology

**The introduction of microprocessors injected new life into developments in the field of weighing technology.** These microprocessors formed the basis for electro-magnetic force restoration technology - a technology which excels through its consistently high accuracy and impressive performance. EMFR weighing cells are intelligent sensors that can control and compensate a large number of functions with direct influence on weighing performance, such as the sample rate and temperature fluctuations, as well as filter and interference reduction. This is all made possible through use of highly developed software filter techniques.

**Particularly when used with EMFR weighing cells, these filter algorithms allow multiple product weight measurements to be taken in a fraction of a second as the respective product passes over the checkweigher.** Alongside this, modern EMFR weighing cells also have access to intelligent software tools that are capable of 'learning' and thereby neutralising the individual interference profile of the checkweigher. They are also equipped with a high-precision temperature sensor and temperature compensation software that together allow any potentially detrimental effects caused by temperature changes to be eliminated. The best manufacturers are committed to further development of these software tools for the various processes with a view to increasing both accuracy and throughput, while maintaining consistently high quality.
How does an EMFR weighing cell determine weight?

When a load is placed on the weighing cell, the magnetic coil inside the cell (Fig. 7), which is held in position above a permanent magnet by its electromagnetic field, is displaced. When the magnetic coil is moved, a position sensor in the weighing cell measures the deviation from null (home position) and the current controller now adapts the current intensity i.e. increases the current through the coil so that a force is generated that moves the coil back into its home position. The current intensity is proportional to the force – which allows for determining the weight of the load by measuring the current.

In summary, increasing the current generates an upwards force within the magnetic field in line with the "right-hand rule" of electromagnetism. The weighing cell increases the current through the wire of the coil until the corresponding upwards force is reached and the coil therefore returns to its home position. Weighing cells with electromagnetic force restoration are therefore sensors which measure an increase in current, which can then be used to calculate a weight.

### EMFR technology at a glance

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>Very small measurement divisions are possible</td>
</tr>
<tr>
<td>Response time</td>
<td>Extremely fast measurement reactions are possible</td>
</tr>
<tr>
<td>Precision</td>
<td>Very precise, even when using the smallest divisions</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Consistently high accuracy throughout the service life thanks to microprocessor technology</td>
</tr>
<tr>
<td>Error tolerance</td>
<td>More software functionalities for neutralising interference profiles</td>
</tr>
<tr>
<td>Performance</td>
<td>Good options for adapting to performance increases in the production process</td>
</tr>
<tr>
<td>Design/construction</td>
<td>Sometimes larger design than other technologies due to constructive requirements</td>
</tr>
<tr>
<td>Integration</td>
<td>Sometimes larger design than other technologies due to constructive requirements</td>
</tr>
<tr>
<td>Costs</td>
<td>Higher procurement costs in comparison with other technologies</td>
</tr>
</tbody>
</table>

### 3.3 Diversity in weighing technology

Alongside the weighing technologies employing wire strain gauges (strain gauge technology) and electromagnetic force restoration (EMFR technology), both of which are currently in use worldwide across all industrial sectors, there have also always been other approaches to development which offer solutions for their specific niche. To get an accurate picture of the full bandwidth of systems available, these technologies should also be addressed.

**The 'vibrating wires' process:** This measurement principle is based on the natural frequency of a tensioned measurement wire being altered through application of a tensile force. When the tension of the wire changes due to the weight of a product, the frequency of the wire forced to resonate within a magnetic field by applying a current also changes. This change in frequency can then be converted to calculate the respective weight. Twin vibrating wires are generally favoured today, as they offer better accuracy than single-wire checkweigher systems.

### 4 Diverse yet highly individual

Intelligent weighing cell technology provides precise solutions.

One question that customers ask more than almost any other is: which technology is best? So what is the answer? "Well, there really is no 'one for all' solution." However, a more appropriate response to this question is that it really depends on your specific requirements. The key is for customers to receive a solution tailored precisely to their actual needs. This is also the area that allows customers to quickly determine how good their supplier really is. Every
system ultimately has its pros and cons. One area where most customers struggle is finding a realistic assessment of the long-term effects that these might have on their production operations. In a relationship built on partnership, however, this should not be the customer’s responsibility. The experts can offer valuable assistance here.

**The key issues revolve around manufacturing specifications, budget expectations and future developments.** The goal should be to determine the necessary resolution of a balance, any legal stipulations, any environmental influences and customer expectations regarding throughput. At the same time, however, it is also important to take into account the decision-maker’s willingness to invest. A more affordable solution may well cater to current needs quite effectively, although it can often fail to take future requirements into account – which in turn represents another key issue when trying to identify the right system. Future developments, such as a projected increase in manufacturing speed or a planned investment in a more powerful packing system that will of course also have an effect on a checkweigher in the production line, are not incorporated.

**Take a peek behind the scenes** Manufacturers of checkweighers offer very different product portfolios. Not all manufacturers employ the technologies that have proven most effective in the market. Indeed, several manufacturers have chosen to adopt just one system, which will obviously limit the scope of their solution expertise. The problem here is that not all customers are aware of these issues at the start. As such, it makes sense to dig a little deeper and find out more about the experience and expertise of potential suppliers. Typical questions include asking for evidence that the common strain gauge and EMFR technologies are being employed, whether the systems using these technologies are approved and whether any guarantee can be provided that the systems will be further developed and improved in future. It is not uncommon for checkweighers currently in use by customers to require retrofit work and extensions due to product switchovers. Only those suppliers that employ state-of-the-art technology can cater to these requirements.

5 **Measured precisely, yet still different**

It is important to take a close look at the results of weighing processes.

When checkweighers are unreliable, this not only has a negative impact on production, but also on employees. Incorrect rejection of ‘good’ products and having to constantly pay attention to maintaining weighing accuracy can cause staff to quickly lose motivation. The success of a modern checkweighing programme ultimately depends on achieving consistent accuracy when weighing, the ability to make flexible settings when switching over “articles” (product setups) and reliable rejection of out-of-tolerance products.

To gain a better understanding of the fundamentals required for consistent accuracy, it makes sense to take a closer look at the basic design of a checkweigher.

As already highlighted, the ultimate design of a checkweigher system and its components depends on the nature of the application, the articles to be weighed and the environment in which the weighing is performed. The basic elements of a checkweigher are the infeed conveyor, the weighing conveyor and the accompany weighing cell, the outlet conveyor with sorting device and the weighing terminal with user interface for displaying and further processing the data captured.

5.1 Practical applications differentiate between
static scales and checkweighers

Static scales/balances are generally used to determine the target weights for checkweighers, taking random samples of net weights and taring. Measured values which need to be documented as per the requirements of the verification authorities.

Static scales require manual loading. This means that a member of staff must place the respective product onto the scales, read off the weight, record the results and then remove the product ready for the next one to be weighed. When performed like this, the weighing process is not tied to any specific cycle and does not interrupt any production process. Random samples are therefore typically tested using static scales.

Checkweighers, on the other hand, check 100% of all products produced. Checkweighing is an automated process, which normally runs without the need for any manual intervention or a specific operator. The main difference between static weighing and dynamic weighing using checkweighers lies in the fact that static weighing determines the weight of products at standstill, whereas checkweighing weighs the products while they are in motion. In comparison with checkweighers, the weighing results for a single product determined using a high-quality static scale normally display a higher degree of repeatability and far lower standard deviation.

5.2 Weighing timing (including evaluation point) – weighing time – response time

Dynamic weight determination is closely tied to product size, as well as the length and speed of the weighing conveyor. As already highlighted, a product is weighed while moving across the weighing conveyor. To get a precise value, a whole range of measured values (electronic signals) are recorded within a defined path (distance). These values are then used for the final weight determination. In modern production systems, which are capable of producing up to 1000 products per minute, it is therefore important to record a sufficient number of values within a short time frame in order to comply with all the requirements of the desired monitoring function.

Practical experience has shown that the time needed to record a sufficient number of signals and accurately determine the precise weight of a product is in the millisecond range. The end of this time period, the so-called measuring time, is reached as soon as the product passes through a light barrier. At this moment, the weighing timing/evaluation point is marked. A result is then calculated within milliseconds from the values determined up to that point. This is the weight value.

In continuous production operations, the results determined are documented and then further processed using software. However, the process goes even further than this, as the latest software filters are also capable of neutralising the typical interference profile of the respective checkweigher while performing the calculations (= weighing time), which in turn provides precise weighing results. Obviously, it is no longer possible to display the individual values captured within this split second. In circumstances such as these, the importance of a manufacturer's experience and expertise really becomes apparent. Precise measurement results can only be determined when the length and speed of the weighing conveyor are properly coordinated with the planned production throughput and when measurement/software developments are capable of handling these speeds.

5.3 A few words on statistical data analysis

It is important to remember that precision is subject to the laws of statistics. Modern checkweighing systems already offer very high precision. However, there are certain physical laws which cannot be altered and will therefore always have an influence on weighing processes. During checkweighing, for example, deviations still occur even when the conditions remain exactly the same. These deviations can be defined using recognised laws of mathematics (e.g. the law of standard deviation). This then leads to probable weight deviations within a production run of identical products.

However, since they follow the aforementioned laws and can be calculated, these statistical deviations can be taken into account constructively during the weighing process. The example of a filling system can help illustrate this theory in practice.
Production operations are often full of small sources of interference. On their path through a production line, products are subjected to a large number of random influences, such as wind turbulence, voltage peaks, moisture, changes in product density and the effects of mechanical equipment used during the filling process. These random events make it impossible to achieve absolutely identical fill levels at all times. The weights of all the products deviate slightly from one another and, as long as the events influencing the filling process are genuinely random and occur with the same probability, the weights will follow the law of standard deviation, which is often also referred to as normal or Gaussian distribution (see Fig. 9).

In order to classify normal distribution, it is first necessary to explain two further terms used in statistics. These are the mean or average value, typically designated by the symbol μ, and the standard deviation, typically designated by the symbol σ (sigma).

Mean value: the mean or average value is the sum of all values divided by the number of values. In our example (Fig. 10), we have 5 bags with the following weights in kg: 8, 9, 10, 18, 20. The mean value is therefore 13 kg.

Standard deviation: the standard deviation of an observation series describes the spread of weight values and mean values in deviation from an observation series with normal distribution. In the field of measuring technology, it is important to know how many measuring points lie within a certain tolerance range or spread. This spread of normal distribution is described by the standard deviation.

In the case of ‘statistical normal distribution’:

- 68% of all measured values are within ±1 standard deviation from the mean
- 95% of all measured values are within ±2 standard deviations from the mean
- 99.7% of all measured values are within ±3 standard deviations from the mean

This distribution is also referred to as the ‘68-95-99.7’ rule and states that almost all values lie within ±3 standard deviations from the mean in the case of normal distribution. The standard deviation is therefore also applied to determine weighing accuracy, as the weighing accuracy corresponds to 3 times the standard deviation from a statistical perspective.

Note: to compare the performance of various checkweigher manufacturers, the weighing accuracy must be specified using the same parameters (e.g. ±3 standard deviations). Manufacturers sometimes specify accuracy as just ±1 standard deviation.
The curves shown in Fig. 11 have the same mean value, yet different standard deviations. The standard deviation of the red curve is greater than the green curve.

Let us compare these lines on both sides with the average shown in Fig. 9, designated as $\mu-\sigma$ and $\mu+\sigma$. As already explained, these lines describe the boundaries, between which 68% of all weights have an average of ±1 standard deviation. These lines change with alternating standard deviation, although the percentages between them remain constant.

**Standard deviation calculation:** the standard deviation is calculated using the following formula. The individual calculation steps are described.

$$S = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2}$$

Whereby $(x1, x2, ..., xn)$ are the weights of the samples and $\bar{x}$ is the average of the samples. $S$ stands for the standard deviation of the samples (dispersion of the random sample) and provides an appropriate picture of the overall spread. The overall average ($\bar{x}$) of $x$ is deducted from each value $x$ and this result is then multiplied by itself (squared). All of these square values are added together. The result is then divided by $(n-1)$, whereby ‘$n$’ stands for the number of weights taken. The square root is then taken of the final number, which provides the standard deviation of all weights being investigated.

**5.4 Accuracy is a question of resolution and legal guidelines**

Wherever manufacturing operations must comply with legal regulations due to a public interest, this is often referred to as legal metrology. This means that the checkweighers used must comply with the stipulations of the German Calibration Ordinance and/or EU measurement and calibration legislation – which obviously also includes the weighing cells. Weighing cells intended for deployment in applications of this type must possess legally defined characteristics with regard to measurement deviations and repeatability. The German Calibration Ordinance, for example, stipulates the maximum permissible error limits and the corresponding conditions in four different scale classes. The higher the resolution of a scale, the more accurate it must be. There is therefore a strict correlation between the resolution of the weighing cell (= number of display units offered by the scale) and the maximum permitted errors.

Measuring equipment can generally only be calibrated when its design allows this. The manufacturer must apply for this approval procedure, which is then performed by an institute such as the ‘Physikalisch-Technischen Bundesanstalt’ metrology institute in Germany. Tests are performed here to determine whether the properties, design and accuracy class all comply with the respective calibration regulations. The ‘calibratability’ is then finally documented when the type approval is issued. This confirms the necessary metrological and device-specific requirements.

Metrological guidelines are based on the resolution of the respective checkweigher or the number of divisions recognised by the checkweigher. The ‘division’ is defined as the ‘smallest weight change increment that can be shown by the display’ here. When performing a calibration, the resolution is set during checkweigher configuration and depends both on the type of weighing cell and the application. This value can be far lower than the actual resolution that the weighing cell can achieve.

**For example:** a checkweigher with a resolution of 10,000 display “steps” and a maximum permitted load of 500 g can display the weight of a product in 0.05 g increments. A checkweigher with a resolution of 10 000 “steps” and a maximum permitted load of 5 000 g can display the weight of a product in 0.5 g increments. In both cases, the
checkweigher can offer a higher resolution thanks to the technology it employs, but the permitted interval to be displayed is stipulated by the official verification guidelines (Weights and Measures legislation).

**This specified resolution is therefore dependent on the respective application and the calibration regulations formulated for this.** If the production specifications change, this can easily lead to a situation in which the checkweigher's configuration also needs to be changed. Manufacturers of checkweighers whose technological expertise and experience generally allows them to achieve high resolutions enjoy a clear advantage here. In these cases, a change in the configuration can therefore be made using the existing weighing equipment, since the resolution offered already contains enough leeway.

**Attention must also be paid to the rated load of the weighing cell here.** Weighing cells can only ever be loaded up to a specific weight. Any additional load above this level will cause damage to the cell. These weight limits are classed as the rated load. In practice, the weighing cell is connected to the so-called weighing conveyor, which transports the respective product during the weighing process. For reasons of stability, this conveyor is typically made of metal and therefore has a significant dead weight. When calculating the maximum permitted weight for a weighing cell, the weight of the actual conveyor belt (preload) must therefore be subtracted from the weighing cell's rated load. For example, if the weighing conveyor weighs 5 kg and the rated load of the weighing cell is 10 kg, the maximum weight of products that can be checked is 5 kg. Not every manufacturer is today capable of achieving a high rated load in their equipment, which indirectly supports the stability of the products being transported through use of a compact weighing conveyor and, above all, permits high product weights.

6 **Precise procedures can still produce inaccurate results**

There are many causes of weighing inaccuracies.

The accuracy of a checkweigher is closely linked to the influences of the production environment and the characteristics of the product to be manufactured. These two aspects should always be given top priority when planning an equipment investment together with a manufacturer. Only then can the design of the measuring instrument be tailored precisely to the respective operational requirements. In the real world, however, the orders they receive force many companies to move their checkweighers to different locations or use them to weigh other products with significantly different weights and properties. This can also change the influences acting on the weighing equipment in some cases. In critical cases, it cannot only lead to inaccurate weighing results, but also cause damage to the measuring instrument and drastically reduce its service life.

**The highly sensitive weighing cells are particularly susceptible to changes.** Moving them to a different location can easily cause changes to ambient conditions.

These changes can involve:

- **Temperature fluctuations and humidity:** weighing equipment which has not been specifically designed to handle temperature and humidity fluctuations is placed at risk when confronted with conditions of this nature. The effect: fluctuating temperatures can lead to inaccurate measurement results due to material changes. Any foreign particles or liquids penetrating the equipment, such as condensate, can damage the weighing cell.

- **Dust and dirt:** increased dust and dirt levels can lead to deposits on the weighing platform or the weighing conveyor. The effect: weight deviations and frequently having to reset the weighing equipment compromise the production process. Measures for screening/shielding the weighing area and keeping the affected production area clean can help here.
Vibrations: the sources of foreign vibrations, which can cause negative effects, are varied. They range from opening and closing of containers stored in the vicinity, all the way up to transport conveyors located directly next to one another. The effect: distorted measurement results. Decoupling the checkweigher and regularly monitoring the environment can help here.

Air streams: highly sensitive checkweighers, which are required to deliver accuracy down to fractions of a gram, do not like draughts. Draughts of air, often with seemingly banal causes, therefore frequently cause issues with weighing equipment. An open door or window is already enough to make a difference. And even a quick hand movement in the direct vicinity of the weighing platform can cause problems. The effect: results are easily distorted. Paying attention to the production area and having a thorough look around can help prevent issues of this nature.

Electrical noise: electrical devices and machines are capable of generating frequency disturbances, electromagnetic discharges and other general interference. The effect: the data and weighing processes of sensitive checkweighers can be compromised and then no longer work correctly. Screening/shielding measures and conscious handling of electrical or electronic devices in the direct vicinity of measuring instruments can help here.

Corrosive substances: there is a serious risk of hazards whenever checkweighers are moved to a new location with an ambient environment containing corrosive substances. The effect: components can be damaged or even destroyed. Measures to prevent the risk of damage in cases such as this should always be discussed with the manufacturer.

Whenever checkweighers suffer damage or deliver inaccurate results, this is often the result of unintentional or incorrect operations. Unfortunately, issues involving staff resting their body on parts of the weighing equipment, walking on the weighing conveyor or overtightening screws continue to occur. Incorrect operator actions such as these can easily cause damage. However, other activities can also lead to undesired results. Damage can, for example, often be caused when weighing products which are significantly heavier or larger than the products for which the weighing equipment was originally designed – often due to a product switchover. In cases such as these, the motor, pivot bearing or weighing cell are subjected to greater stress than intended and therefore wear more quickly.

Products are almost always less than ideal when it comes to checkweighing. If you ask a checkweigher manufacturer what is the ideal product, they are likely to say that it should have a solid shape, be surrounded by evenly shaped packaging and not move, vibrate or fall over when passing over the checkweigher. However, the reality often looks quite different. Market observations have shown that the trend is to increasingly use...
large-volume packaging, despite the fact that products are actually getting smaller and smaller. Indeed, new technologies are not only making production lines operate faster, but also allowing more diverse product designs. However, creative packaging designs often go against the requirements of optimum weighing processes. Small footprints typically cause products to have high dead weights and also lead to vibrations which can impair the results of the weighing process. As such, product handling expertise is now more in demand than ever and requires both experience and diverse solution knowledge from the manufacturer.

**Industrial enterprises have considered many ways of eliminating interference and negative effects during the checkweighing process.** Many different approaches have been tried in order to neutralise the aforementioned factors, which affect the weighing process due to product characteristics and the production environment.

- **Intelligent use of software:** Thanks to modern microprocessor technology, a whole range of weighing cells can now ‘learn’ the individual interference pattern of specific checkweighers when processing articles. These devices are, for example, capable of controlling and compensating for scanning speeds, temperature fluctuations, filters and interference suppression measures. Complicated filter algorithms employed here facilitate sustainably precise checkweighing.

- **Cleverly planned use of software:** the use of double weighing cells can, for example, make sense as a way of achieving consistently accurate measurement results. In set-ups like these, the first weighing cell calculates the interference, while the second cell measures the weight. The interference is then compensated by combining data from the two cells. Even in cases like this, however, the application in question still determines which solution should be used or combined with another.

### 6.1 Keep your eye on the entire checkweigher system

When the goal is to obtain precise measured values, focus obviously first turns to the weighing cell. Yet anyone seeking to guarantee precise results in the long term must also take into account the environment in which the weighing cell is used. The less stable the product contents, the more time is required to determine the correct weight after the respective product crosses the weighing platform. Products that are tall, but have a small footprint are very unstable and can cause an inaccurate weight to be displayed due to ‘wobbling’. The optimum solution here is to use intelligent guide rails, which guarantee stability during the feed process and thereby ensure that the product stands freely but remains stable on the weighing conveyor. Appropriate solutions help ensure that the transition from the feed conveyor to the weighing conveyor does not trigger any fluctuations or unwanted movements. These technical design measures require sophisticated material and design expertise on the part of manufacturers.

For example, the weighing conveyor and weighing cell must be matched to one another in such a way that any lateral forces and bending moments are largely prevented. This can potentially be achieved by aligning the effective line of measured force as precisely as possible with the axis of the weighing conveyor. In modern weighing cells, the weighing conveyor sits directly on the cell. Recognised manufacturers are engaged in continuous research in this field to find better solutions that can guarantee long-term precision down to the finest detail.

**Understandably, customers often ask which is the best solution again at this point.** Only experienced and well-versed manufacturers can answer this question. This is because the key for customers is to receive a solution tailored precisely to their actual requirements. Set against this background, the importance of analysing the actual situation and the associated requirements cannot be stressed enough. Reputable manufacturers will listen to customers carefully here and address all available parameters – also incorporating future developments – to create a sound basis for reaching a decision. Customers should also make sure that they allow enough time for this phase, as the effects on production are profound.
6.2 How is the precision of a checkweigher tested?

Repeated test measurements are the easiest way to determine the accuracy of weighing equipment. This process involves a representative product being taken from the production line and weighed with an extremely precise static balance. The balance used here must meet certain conditions. It needs to have been recently calibrated, tested and offer a resolution at least five times higher than the checkweigher. The measured values should be documented.

In the next step, the selected product is then guided over the checkweigher at production speed. In our example, 100 weighing results are recorded.

**Fig. 13** Testing with 100 passes and 68 results between 449.5 g and 450.5 g for an accuracy of ±0.5 g at ±1 or 3 g at 6σ.

Note: only 30 results are typically required when performing maintenance work, whereas a conformity assessment requires 60 results. Every result should also be documented during the weighing process here.

In an ideal scenario, the weights will all fall within a normal distribution. This data can then be used to calculate the mean weight and the standard deviation. The accuracy of a checkweigher can be defined as ±1, ±2 or ±3 standard deviations (σ) from the mean value. In the above example, 68 of the 100 passes produced weighing results between 449.5 g and 450.5 g. This corresponds to an accuracy of ±0.5 g at ±1σ or 3 g at 6σ.

7 All-rounders and empty promises

Weighing technology requires expertise and experience.

**Strong specialist partners are therefore needed, not self-proclaimed ‘all-rounders’.** Make the most of your partner’s knowledge and experience, as these form the basis for your success. Strong partners are those that put themselves in their customer’s position and use their knowledge to secure the best solutions. Reputable suppliers will always adopt a customer-specific approach to finding the right solution for a specific task. This means that they will only put together the optimum checkweigher system for the customer following in-depth analysis. As is so often the case, it is the many little things that bring about the desired results and highlight the expertise of a specific manufacturer. Reputable manufacturers will always be open in their approach and happy for customers to be actively involved. And customers should not be afraid to ask tough questions. For example, does the manufacturer offer solutions that go beyond the legal requirements and therefore provide scope to incorporate future developments? Does the manufacturer offer a high degree of protection (IP 69k) as standard, thereby providing excellent protection from external influences even in basic models? Please also make sure that your supplier has the necessary knowledge and experience of working with recognised weighing technologies. Does the manufacturer have the necessary approvals? Any company capable of offering just a single technological solution will always struggle to find the optimum approach.

7.1 Product diversity and service pay off

**The option to use the checkweigher for further test procedures massively expands its range of deployments.** High quality systems have long since been able to detect defective barcodes, foreign objects in boxes or open packages. Additional product inspections performed in connection with the checkweigher can give a production company’s profitability a welcome boost – but require a great deal of knowledge and continuous development work. When your partner has global operations with local offices and collaborates with well-known manufacturers, this clearly offers a genuine advantage. Do not be afraid to ask questions and reassure yourself that the supplier in question can guarantee on-site servicing of your production equipment (wherever it may be located).

Note: developments within modern production operations across the globe have shown that it is now difficult to market an efficient and economically viable checkweigher system as a standard product. Customers are increasingly demanding individual solutions, so the bar has been raised for all manufacturers.
8 Precise and complying with all applicable legislation

MID – The initial calibration performed by the supplier

The settings made on the checkweigher, the system design and the weighing cell technology selected are all determined by metrological legislation and guidelines. Most countries have legal regulations for weights, dimensions, packaging requirements, net contents and the maximum permitted variance of the articles produced. In Europe, the decision to purchase a checkweigher is often largely influenced by the Measuring Instruments Directive (MID).

The official verification plays a key role in selecting the right weighing cell within a dynamic weighing system. The fundamental questions which need to be answered here are: Is the official verification by the Weights and Measures authorities necessary or not? What is the maximum weight of the articles to be weighed? What level of accuracy is required? The answers to these questions have a direct influence on the resolution of the weight display. When performing an official verification, the resolution is set during checkweigher configuration and depends both on the type of weighing cell and the application. As already mentioned, this value can be far lower than the actual resolution that the weighing cell can achieve.

The installation of a checkweigher must comply with the legal regulations of the respective country. The Measuring Instruments Directive (MID) must be observed when installing a checkweigher. This Directive applies to all countries in the EU, the EFTA, as well as Liechtenstein, Iceland, Norway and Switzerland. Its contents describe the processes and responsibilities involved in manufacturing and commissioning equipment such as checkweighers. Before the MID, the responsibility for verification lay with the national authorities. Since 30 October 2006, a conformity assessment procedure is in place, and responsibility for carrying this out lies with the scale manufacturers.

With a so-called MID conformity assessment, authorised manufacturers confirm that their checkweighers comply with the respective national provisions and tolerances. The results are certified (MID declaration of conformity), documented and indicated by a test seal applied to the weighing equipment. The original products to be weighed must be made available for on-site testing in companies during installation. Important note: the checkweigher owner i.e. the company is responsible for requesting and arranging all subsequent re-verification processes with the verification authorities.

The advantages of the MID process are impressive. Owners of checkweighers only need to get in contact with one office for commissioning i.e. initial operation of their equipment. Calibration preparations, conformity assessments and answers to questions are all provided by a single specialist manufacturer. Yet the greatest advantages for customers are the warranty associated with qualified and certified production in line with EU Directives and a guarantee of quality. The MID governs all production processes and QM systems for manufacturers of checkweighers. Only those measuring instruments that have been manufactured using a production process and QM system approved by a registered MID office may be marketed and commissioned.

9 Well conceived and prepared

The right information makes planning easier.

Manufacturers can only reach a fundamental decision to use a specific weighing technology after a thorough analysis of the requirements in their customer’s production operations. This is not always easy, as many operations and actions are often considered obvious and established – meaning that they are rarely brought up in meetings or discussed. As a customer, the best thing you can do is to define and confirm the parameters that are important to you before requesting a quote or meeting from your supplier. You then lay the foundations for successful planning yourself. To help you in this regard, we have compiled a checklist of the most important points to be considered.
What are your objectives?

- Less overfilling
- No underfilling
- Counting
- Feedback control
- Monitoring
- Verification
- Calibration approval

Type of production line

- Single-article
- Various articles alternated

Articles: How many different articles? __________

<table>
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<tr>
<th>Art.</th>
<th>Description / name</th>
<th>Length or diam. in run direction</th>
<th>Width</th>
<th>Height</th>
<th>Weight</th>
<th>Throughput (pcs/minute)</th>
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Characteristics:

- Open
- Closed
- Semi-solid/soft
- Frozen
- Liquid
- Unpackaged
- Box
- Bag/pouch
- Can (tin)
- Bottle/jar
- Flat bag
- Carton
- Other: __________________________

Containers:

- Tare __________
- Tare fluctuations from ______ to ______
- Stability during movement: high, low
- Preferred conveyor belt/transfer device: __________________________

Accuracy:

- Deviations in product weight ______________
- Desired accuracy ______________
- Standard deviation ______________

Filling machine control system – Filling machine variance: __________________________

Weighed over/underweight – Filling machine variance: __________________________

Counted over/underweight products – Individual unit weight: __________________________

Mechanical interface(s):

Upstream machines/equipment: __________________________

- Throughput (pcs/min) __________
- Product centre spacing __________
- Clocking __________
- Product length __________

Downstream machines/equipment: __________________________

- Throughput (pcs/min) __________
- Product centre spacing __________
- Clocking __________

Place of installation:

- Ground floor
- __ floor
- On a pedestal

Environment:

- Floor vibrations
- Strong air currents
- Dusty atmosphere
- Extreme temperatures
- High humidity
- EX zone (ATEX)
- Wet environment
- HACCP
- Other: __________________________

Cleaning conditions:

- Spray water (IP54)
- Jet water (IP65)
- High-pressure cleaner (IP69k)
- Special detergents
- Other: __________________________

What happens in the event of

- Malfunction/failure
- Emergency stop
- Starting up the checkweigher/packaging machine

Other notes: __________________________
Checkweigher software compendium

The checkweigher software compendium describes software functions and options that facilitate easy navigation and optimisation of checkweigher systems. It provides a comprehensive overview of the features offered by the checkweigher models in the X series. The compendium can also help producers, for example by showing them how to reduce their set-up times when switching over production lines. Solutions for improved fill level monitoring, perfect product transport and the greatest possible data security are also included.

www.mt.com/garvens-software

Guide to weighing technology

Creating an effective checkweigher programme

The Garvens “Principles of Checkweighing” guide is a very useful reference document. It offers insights into all aspects of checkweighing, starting from the basic principles and stretching all the way up to implementation of a comprehensive checkweighing programme.

This 70-page FREE guide also provides manufacturers with useful information for setting up this type of weighing programme and is required reading for anyone that works with checkweighing systems.

www.mt.com/cwguide

Calculator

Return of investment calculation for inline checkweighers

This calculator can help you work out how much you could save by minimising overfilling and waste. It also includes an example calculation.

www.mt.com/garvens-roi

Manual or 'inline' weighing?

A comparison of manual weighing and dynamic checkweighing:

This calculator can help you reach a decision as to whether it would make more sense for you to replace a static scale with a dynamic scale (checkweigher).

www.mt.com/garvens-dynamic

Online library

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