The Checkweighing Guide
Building an Effective Programme
Introduction: What is a Checkweigher?

A checkweigher is a high-precision measuring instrument designed to check the weight of individual products in motion.

1. What is the Difference Between a Static Scale and a Dynamic Checkweigher?

1.2 Components of a Checkweigher

A checkweigher is usually part of a typical quality control system, ensuring that every product leaving a production line is the right weight and corresponds to packaging requirements. Checkweighers are key to ensuring manufacturers deliver quality products that ensure customer satisfaction. Selling products with incorrect weights causes problems for manufacturers: underweight products can result in companies being fined or subject to other penalties, whilst overweight products generate unnecessary and expensive product giveaway.

Checkweighers can be used in many industries as part of an effective quality assurance system. Relevant sectors include:

- Food
- Pharmaceuticals
- Cosmetics
- Beverages
- Transport/logistics
- Chemicals
- Automotive
- Metal manufacture and fabrication industries

In an increasingly competitive marketplace, checkweighers are essential in fulfilling ever-changing customer needs and in complying with local Weights & Measures standards, as well as global standards.
1.2 Components of a Checkweigher

There are several different checkweigher designs in common use, with components varying greatly depending on: how they are used, items being weighed, and their surrounding environment. A typical checkweighing system comprises:

- An infeed section
- A weighing section
- An outfeed section with sorting/rejecting device
- A weighing terminal as user interface

1.1 What is the Difference between a Static Scale and a Dynamic Checkweigher?

The main differences between static scales and dynamic checkweighers are:

1. Static scales measure the weight of products that stand still, whereas...
   Dynamic checkweighers weigh products in motion.

2. Static scales are used for manual weighing of products or for sample spot-checking, whereas...
   Dynamic checkweighers automatically check 100% of the products produced.

3. In order to check product weights, static scale weighing is required. This is a manual operation requiring product weighing, recording the result, and then product removal for the next weighing procedure, whereas...
   Dynamic checkweighing is entirely automatic, without manual intervention or a dedicated operator: products are weighed as they pass along a production line, with off-weight products rejected from the production line by automated removal devices such as pneumatic pusher arms or air-jets (sometimes known as ‘air-blasts’).

In a production line, static scales are used to sample a certain percentage of product weights, whilst dynamic checkweighers automatically sample 100% of all weights.

Both static scales and dynamic checkweighers are to be found in most production environments, with static scales commonly:

- Determining target weights for dynamic checkweighers
- Performing sample tests for net weight and tare weight reports that satisfy Weights & Measures compliance requirements and Weights & Measures package tare weight verification reports

The choice of checkweighing system used on a production line is usually dictated by application requirements and processes, financial and economic factors, plus the need for brand protection.
Checkweighing – Enhancing Compliance and Productivity

Checkweighers can help to achieve compliance with regulations and can also ensure increased productivity through waste reduction, tighter tolerances and better product consistency. This all adds up to enhanced efficiency and improved profitability for those companies that employ checkweighers.

2.1 Typical Uses

Checkweighers are used for a variety of applications some of which include:

- Checking for under and/or overweight packages
- Ensuring compliance with net contents laws for pre-packaged goods
- Checking for missing components in a package including instructions, lids, leaflets or products
- Verifying count by weight by checking for a missing carton, bottle, bag or can in a case
- Checking package mixes against weight limits to keep the solid to liquid ratio within established standards
- Reducing product giveaway by using checkweigher values to determine filler adjustments
- Classifying products into weight zones for grading or portioning
- Ensuring product compliance with customer, association or agency specifications
- Pure ‘net weighing’ with tare/gross systems
- Weighing before and after a process to check process performance
- Fulfilling reporting standards in line with USDA, FDA, OIML, FPVO and others
- Measuring and reporting production line efficiency

By definition, a checkweigher is a system that weighs items as they pass through a production line, then classifies the items by preset weight zones, and sorts (or rejects) items based on those classifications. Checkweighers weigh 100 % of the items on a production line and provide a 100 % overview of production data, such as production counts, batch tracking, total weights, good weights and rejected weights.
2.2 Reasons, Advantages and Benefits

Avoid Costly Fines and Tarnished Brand with 100 % Weight Inspection

One of the main reasons for using a checkweigher is to ensure compliance with government regulations and industry standards. 100 % weight inspection should be an integral part of a coordinated quality and process control programme – and use of a checkweigher also means that information previously collected manually can now be automatically collected in a fraction of the time.

Example: Consider a line with a throughput of 100 packages per minute. If you sample 15 packages every hour, what percentage of the total production is that sample? In 60 minutes, 60 x 100 = 6000 packages pass through the line. 15 packages represent only 15/6000 = 0.25 %. With a sample size that small, there is a little statistical significance to the results, because over 99.75 % of packages are not inspected. A checkweigher automatically weighs 100 % of all packages on the line and can react immediately if it senses a problem.

Protection of the Customer and Consumer

To ensure customer and end-consumer satisfaction, manufacturers have an obligation to ensure consistent product quality by minimising the risk of producing under-filled products or supplying products with missing parts. Failure to achieve these aims can create potential animosity between the retailer or customer and the manufacturer, and can result in the potential breakdown of customer relationships plus loss of future business opportunities.

Net content laws and regulations differ from country to country; for example, in the US the National Institute of Standards and Technology’s (NIST) Handbook 133 on pre-packaged goods defines the specific net contents laws on packages for processors, wholesalers and retailers. It states that the average weight of the product cannot be less than the label weight. It also states that no individual package can exceed the “Maximum Allowable Variation (MAV)” which is the amount of allowed underweight for a certain labelled weight.

As another example, the OIML2 R87 (International Organisation of Legal Metrology) standard is used by most European nations and many other countries around the world. The standard defines the tolerable deficiencies in actual content for pre-packaged products, whilst national Weights & Measures authorities regulate and enforce the local net content laws applicable in different countries. Official action resulting from package checking can take the form of spoken recommendations, instructions, warnings, or legal action.

Protection of Brand and Reputation

Powerful and positive product branding gives customers a strong assurance of safety and quality. Branding is frequently responsible for driving consumer repeat purchases, and so is an important tool in maximising sales and justifying premium product pricing by manufacturers and retailers.

For these reasons, a company’s responsibility is not only related to protection of the end consumer but also to the brand and reputation of the company. Product brands are important assets that need to be managed carefully and protected from adverse publicity. Underweight product acquired by consumers can have a negative impact on an organisation, resulting in damage to the brand and potentially costly recalls.

In the event of a company being investigated as a result of a customer complaint, documentation will provide invaluable evidence of the correct operation of the checkweighing programme.

Counting and Statistical Functions

Checkweighers provide real-time monitoring of production processes, including yield statistics and SPC (Statistical Process Control) trending. This can be used for process improvements and operating efficiencies (Figure 2.1).

Examples of checkweigher statistical functions and production line efficiency functions include:

- Analysing production by weight zone or classification
- Using 3 or more zones to gain detailed fill weight information
- Monitoring overall production efficiency through total count and total weight (Figure 2.2)
- Monitoring overall production rate efficiency (packages per minute)
- Monitoring mean value (average) to alert operators or fillers of an out-of-tolerance condition or trend

![Figure 2.1: Real-time monitoring of production processes](image-url)
Checkweighing – Enhancing Compliance and Productivity

- Maintaining records of settings for management and regulatory agencies
- Analysing filler head performance for both single and multi-head fillers
- Printing or accumulating individual production weights or totals for a day, shift, hour, batch or collecting and printing a production run
- Monitoring short, long-term or individual weights and filler performance through statistics
- Providing SPC charts for manual feedback and process adjustments
- Providing closed loop control and automatic process adjustments
- Linking packaging line data to upstream control and information systems
- Interfacing with business systems, Programmable Logic Controllers (PLC) and SCADA systems, to link the checkweigher to the production process (including controlling the checkweigher by a remote device)
- Reducing quality control labour
- Providing an important information source for Quality Control departments

Making Better Use of Limited Resources

An accurate checkweigher will ensure tighter production tolerances that will yield less waste and enable more final products to be produced from the same amount of inventory. Raw materials can be very expensive, and a checkweigher should be an integral part of an overall programme to make the most of existing resources.

### Package and Production Information

<table>
<thead>
<tr>
<th></th>
<th>Savings Yielded (By a 1 Gram Overfill Reduction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labelled Package Weight = 450 grams</td>
<td>0.1 ct Savings per Package</td>
</tr>
<tr>
<td>Material Cost = 0.1 ct per gram</td>
<td>20 ct Savings per Minute</td>
</tr>
<tr>
<td>Line Rate = 200ppm Line Utilisation = 65 % Shift = 8 hours</td>
<td>€12 Savings per Hour</td>
</tr>
<tr>
<td>Shifts per Day = 2</td>
<td>€124 Savings per Day</td>
</tr>
<tr>
<td>Production Days per Year = 230</td>
<td>€28,704 Savings per Year</td>
</tr>
</tbody>
</table>

The reduction of 1 gram overfill as shown in this example would free enough raw materials to produce an additional 60,000 products.

Figure 2.3: Shows a simple calculation that demonstrates savings which can be made by reducing overfill by 1 gram

Keep Fillers in Tune with Active Checkweigher Feedback

Feedback to filler is one of the strongest reasons to invest in a checkweigher. It enables active monitoring of filler performance, plus it minimises unwanted overfills and underfills by keeping filler heads and processes properly adjusted. Checkweighers can communicate directly with the filler control; alternatively, they can network to existing factory floor automation systems. The overall result is complete and seamless feedback control.

Fewer False Rejects, Less Rework and Reduced Scrap

Processes that incorporate an accurate and well-maintained checkweigher also find fewer products in their reject bins. Tighter tolerances lead to improved overall process quality, reducing the amount of scrapped product and those requiring re-work. False rejects are also minimised, because checkweigher accuracies are more precise as zone settings become more refined.

Labour-Saving Operation

Use of static scales to spot-check products is common to many operations; however, use of in-line checkweighing eliminates potential sampling errors and also removes often excessive labour costs required for static scale spot-checking.
Increased Overall Equipment Effectiveness

Overall Equipment Effectiveness (OEE) is enhanced through improvement of any or all of OEE’s three metrics: availability, performance, and quality. 100 % monitoring of items provides valuable indications of:

- Process variations which can which lead to unexpected downtime events (availability)
- Reduced line capacity (performance) caused by out-of-tune upstream devices
- Tighter production tolerances arising from checkweighing (reducing overfills and underfills), resulting in a higher yield of satisfactory products (quality)

Inspection of Product Integrity and Package Quality

Checkweighers are also used for additional inspection purposes, above and beyond those described above, in fact checkweighers are, increasingly, becoming quality assurance devices, whilst also integrating other automated inspection processes. Together, these can check factors such as:

- Open flaps on a carton or case
- Missing caps
- Bar code labels and tamper evident seals
- Package orientation and skew detection
- Printed information on the package, such as batch number, expiry or ‘Best Before’ date
- Contaminants such as metal, stone or glass
- Traceability and serialisation

Integration of other inspection devices (such as cameras, scanners, marking systems, sensors, metal detectors and X-ray devices) makes checkweighers a high-performance product inspection solution. The main benefit of combining other inspection devices is the consolidation of multiple-user interfaces into one, so as to simplify operator training and reduce time taken for package set-up and line changeovers.

Further consolidation of various inspection technologies within a single product-handling platform can be optimised to save valuable production space.

In addition, rejected products can be quarantined in one area for convenient and error-free management of non-conforming products.

2.3 References

Links to various sources of information are included below for reference:

Protection of the Customer and Consumer


Where Can a Checkweigher Be Used?

3.1 What Kind of Items do Checkweighers Typically Weigh?

A checkweigher can be used to weigh almost any production line items. These can range in weight from below one gram up to several hundred kilogrammes. Typical examples of checkweighed items (and reasons for checkweighing them) include:

- Raw or unwrapped food products prior to packaging
- Pre-packed food products such as cans, glasses, wrapped products and trays
- Boxes, cartons or tubs of products (weighed so as to determine if papers, components, instructions or other items are missing)
- Weight-based counting of contents of bottles, bags, packaged parts, such as cases of batteries, nappies or drink bottles in a case
- Checking volume or density of a mixture, such as bread and yoghurt
- Weighing items of different weights for future reference or for billing (such as a warehouse or delivery service)
- Blister packs of products such as tablets and capsules

3.2 What are Typical Checkweigher Applications in the Production Process?

Within industry, checkweighers are often used for product integrity checking, and to determine whether products meet manufacturing/quality tolerances. For instance, in metal casting, checkweighing is often used to determine whether the casting has an air void.
1. Checkweighers can be used before products enter the packaging line. For example, checkweighers can weigh raw dough prior to freezing and packaging. In this application, the checkweigher also sends a feedback signal to the divider; this maintains product consistency and reduces product giveaway.

2. Checkweighers can also be used in the primary packaging process. For example, checkweighers can checkweigh tubes of personal care products before they are placed in the cartoner; this helps keep a filler in tune and prevents any non-conforming product from reaching the next stage of the process. Checkweighing in the primary packaging process also eliminates re-work and minimises costly waste – which can occur when non-conforming product is combined with other components or packaging materials.

3. The secondary packaging process occurs when various components are combined into a common package. For example, checkweighing can be used when checking ready-to-serve meal kits to ensure that all components have been included in the package. Another example of checkweighing during the secondary packaging process is when a checkweigher is placed at the outfeed of the cartoner to ensure that the inserter has placed dosage instructions into the carton.

4. A caseweigher is another type of checkweigher, and it is normally located after the case packer on the production line. Caseweighers determine whether the case contains the correct number of packages, and ensures that no short cases are shipped. In addition, caseweighers may also transmit the case weight data to a manifest system for shipping purposes. Caseweigher-type checkweighers are also used for large bulk bags of products, such as 25 kg bags of dry dog food, bags of flour or sacks of chemicals for net weight control.

Figure 3.1: Typical 'Checkweighing Points' along the packaging line
Defining Your Needs

There are many different types of checkweighing systems, each of which is specific to a particular application. At one end of the scale, there are low-cost, quick-to-order basic checkweighers available for simple tasks; at the other end of the scale, there are highly sophisticated checkweighing combination systems which undertake critical processes while also controlling significant sections of a production line.

4.1 What are the characteristics of the product to be handled by the checkweigher?

4.2 What are the environmental conditions that the checkweigher would be facing?

Most checkweighers are custom designs – in other words, they are configured to the specific needs of the customer, and will be fitted with particular mechanical options and software features. A good and reputable checkweighing system supplier will help to assess and supply the best solution for individual requirements.

Purchasers should be familiar with the options available, so that they can determine which checkweigher configuration will best meet their operational needs.

Different Checkweighing Platforms

When deciding which checkweighing solution is right for a particular product and production line, the customer should start by taking a look at current processes within their manufacturing operation. With specific reference to:

• The weight, shape and size of products
• The production environment
• Legal or brand requirements.

To start the assessment process, three simple questions need to be answered:

1. What types of products will be handled by the checkweigher?
2. In what kind of environment will the checkweigher be installed?
3. Apart from weighing, are there any other product inspection requirements that need to be fulfilled?
4.1 What are the Characteristics of the Product to be Handled by the Checkweigher?

If packaging is subject to the kinds of variations and actions described above, a reputable checkweigher supplier should offer options that will:
- Mechanically stabilise the product whilst it is motion on the production line
- Maintain or create the correct pitch between items for trouble-free, accurate weighing.
- Reject ‘bad’ products in a reliable way

A choice of the most common options is described below.

Transfer and Package Stabilising

The transfer of products from the production line to the checkweigher, and then back onto the production line, is extremely important. This is because any unnecessary movement of the product during the weighing process will affect the accuracy of the final results.

Vibration caused by hard or uneven transfers between systems will also have a negative effect on the weighing accuracy.

There are as many possible transfer solutions as there are products and applications. Below are a few common transfer solutions for ‘difficult’ products:

Possible Solutions for Stabilising Packages That are Moving Along the Production Line

Sidegrip Belts

Sidegrip belts are conveyors that support a package by contacting its sides. They are used for packages which are difficult to transfer with conventional conveyors. They can also be used to space packages, and to maintain package stability. Where a conventional conveyor has pulleys with horizontal axes, sidegrip belts have vertical axes. Sidegrips should be adjustable for different package widths or diameters, without the need for tools.

The characteristics of a product, such as its general size and weight, determine the general size of the checkweigher in terms of belt width and length, as well as determining the weighing range of the load cell. Product characteristics also have a significant influence on the overall accuracy of the checkweigher. Factors which affect accuracy include product weight and size, as well as height, shape and footprint.

Some checkweighers are specifically designed for certain types of packages, such as cans, bags, cartons and cases. Some checkweighers are built for unstable products such as tall bottles which could be top-heavy, which have a small footprint on the conveyor or which have an unfavourable height-to-width ratio.

The ideal product for a checkweigher is one which is tightly enclosed in a uniform packaging, and will not jostle or sway, shake or vibrate as it passes along the checkweigher.

In reality, though, products, package shapes and contents deviate considerably from this ideal. For example, liquid contents may move around within a package, making the package unstable; this can cause scattering of the measured weight values (i.e. a given set of measurement data. This is seen as a higher standard deviation.

All these factors make product-handling a major challenge when trying to establish accurate checkweighing that can also be performed at the right speed, in accordance with production-line demands.
**Mechanical Transfer Unit**
Consisting of a top belt conveyor and (depending on design) one or two bottom belt conveyors, a Mechanical Transfer Unit provides guidance from the top while the sides of the product remain accessible. A Mechanical Transfer Unit is often used weighing systems in the pharmaceutical industry with an additional function (such as laser marking or ink-jet printing product sides e.g. pharmaceutical cartons) to ensure correct alignment of the product as it travels. Adjustments for package height should be done in seconds, without the need for tools.

![Mechanical Transfer Unit](image)

**Guide Rails**
Usually made from metal or sometimes plastic-lined metal, lateral guide rails can direct and stabilise items which are higher than they are wide. Placed alongside the belt or chain conveyor before and after the weighing platform, guide rails help to maintain product stability; however, items should not come into contact with the guide rails whilst being weighed. Adjustment of guide rails is needed for different product widths and heights. Adjustments should be quick, and without the need for tools.

![Guide Rails](image)

**Nose Roller or Small Roller Diameter**
The transition area from one conveyor to the next can cause products with a small footprint to sway or even topple. In some cases, the gap between conveyors can be bridged with a narrow dead-plate (also known as a ‘glide plate’ or ‘transition plate’). In other cases, a recommended solution is to use either an additional roller with a particularly small diameter in the gap, or to use a conveyor built with small-diameter deflection rollers.

![Nose roller or small roller diameter](image)

**Package Spacing**
For proper weighing, only one item at a time can be on the weighing section i.e. weighing conveyor when the checkweigher is measuring the weight.

In order to create or maintain an appropriate package ‘pitch’ (distance between leading edges of adjacent packages), spacing conveyors can be used to speed up products and create a larger gap between items, as shown in Figure 4.7. In this case, the spacing conveyor will run at a faster speed than the production line.

![Insufficient pitch](image)

![Sufficient pitch](image)

If items are randomly approaching the checkweigher without any consistent spacing, as shown in Figure 4.8, it may be necessary for the packages to be timed, using a timing conveyor, which creates a uniform spacing between items.

This method requires packages that are rigid, with regular geometry.

Typically, the timing conveyor will slow the packages to create end-to-end spacing (where the pitch equals the length of the item). Timing prepares items for the spacing conveyor.
Defining Your Needs

Spacing Conveyor
Conveyors can create or increase a gap between products by running at a different speed. The second conveyor runs faster than the first.

Timing Conveyor (Back-up Conveyor)
Sometimes an existing conveyor line can serve as ‘the first’ (slower) conveyor, so that no timing conveyor is needed at all; in other scenarios, a pair of conveyors is needed with the ‘first’ (the timing conveyor) mainly used for collecting products arriving at irregular distances. The ‘first’ conveyor then hands them over to the second (faster) conveyor – which creates the regular gaps.

Starwheel and Sidegrips
Suitable for products with a round or oval cross-section, a starwheel has a series of pockets that match the shape of the package, and times the packages for downstream operations, including weighing. The starwheel then transfers them (with the desired gap between products) to a conveyor belt equipped with sidegrip conveyors. The gap achieved depends on the starwheel or number of pockets, diameter and rotation speed. A starwheel often precedes an infeed timing screw (see above) to help ensure proper product infeed into the screw thread.

Infeed Timing Screw
Suitable for products with a round or oval cross-section, this screw has a pitch which increases over the length of the screw. Products enter the screw one by one, close together at the screw beginning (infeed) where the pitch is small. Products are then displaced further apart as the screw pitch increases. Exiting the screw at the other end, the products have an identical gap between them, so that they are ready for accurate weighing.

The ‘Golden Rule of Spacing’ can be applied to determine product spacing, conveyor speed and line throughput.

The Golden Rule:
Conveyor Speed = Packages Per Minute x Pitch
100 PPM x 400 mm pitch
= 40,000 mm/min./1000 = 40 m/min

‘Pitch’ is defined as the distance between two items, measured from the leading edge of one item to the leading edge of the next item (or from center to center) in millimetres.

Package Rejecting
The main goal in most checkweighing applications is to ensure that no unsatisfactory products remain on the production line.

The best method of rejecting a product is dictated by product characteristics, application requirements and remedial action which may be required.

A ‘reject’ signal is sent from the checkweigher controller to a rejecting or sorting device on the checkweigher – or the signal may be sent further downstream. Rejecting or sorting devices can be an integral part of the checkweigher or they can be supplied separately.

Timers and photo-eyes (light barriers) in the electronic control unit ensure that the correct item will be rejected. Several methods are used to reject items – and whilst some sorting/rejecting devices are electrically triggered, most are pneumatically activated.
Air Jet
An air jet rejector consists of an air hose which forces air through a nozzle at high pressure. The resulting air jet blows items off the conveyor. A simple air jet is often the best solution for self-contained light packages up to 500 grams. To work successfully air jet rejectors require instantaneous air-flow, correct package density, and even distribution of material inside the package. High-performance air jets can be employed to remove larger products such as pillow-style product bags. If the product is fragile or in an open container, then gentler rejection methods are recommended.

Swing Gate
An air cylinder piston moves the gate (a plate hinged at one side) sideways i.e. the gate pivots on a vertical axis and directs items to the side. A variation on this design is the ‘central’ swing gate which can divert and guide products between multiple lanes by directing items to the left or right. Swing gates can be used as a soft rejecting or sorting tool. Miniaturised swing gates for small products are sometimes referred to as ‘flippers’, and whilst they can cope with much higher product throughput, they usually act less gently than the larger gates.

Lift Gate, Designed as Slide or Conveyor
Lift gates, either designed as a slide or as a conveyor, are rejecting devices which mechanically slant upwards to reject items. Lift gates are useful for items which are difficult to direct away from the direction of travel, though there are limitations on item height and throughput.

Drop-down Conveyor
Drop-down conveyors are rejecting devices which mechanically slant downwards to reject items. They are useful for items which are difficult to direct away from the direction of travel – however, there are limitations on item height and throughput.
4.2 What are the Environmental Conditions That the Checkweigher Would be Facing?

For all checkweighers, the surrounding environment has an influence on weighing accuracy and efficiency. It can be difficult to know exactly what type of checkweigher is needed for a particular environment, so the optimum solution is to consult with the checkweigher supplier for guidance. Some checkweigher systems are better equipped than others, for reliable operation in extreme environments.

There are several environmental characteristics which affect the efficiency of a checkweigher:

- Temperature fluctuation or extreme temperatures
- Debris and dust
- Vibration
- Air currents
- Electrical noise
- Caustic product or environment
- Moisture or condensation
- Harsh wash-down environment
- Hazardous location/highly-explosive atmospheres

Before selling a checkweigher to a customer, a reliable and competent checkweigher supplier will give highest consideration as to how these environmental characteristics will determine the attributes of the particular checkweigher being sold. The following parameters need to be taken into account:

**Temperature**

Excessive temperatures and temperature gradients can affect weighing performance. For example, the application may be in a refrigerated or heated area. If might be weighing frozen, refrigerated or heated items, and the ambient temperature may vary by 10 or more degrees during the day.

Whilst electro-magnetic force restoration (EMFR) load cells are temperature-stabilised, strain gauge load cells can be affected by changes in temperatures or gradients, and will interpret that change as an inaccurate weight. Large changes in plant temperature are rare, and, with automatic re-zeroing of the checkweigher, seldom impact the weighing performance.

Large temperature fluctuations or extreme temperatures can cause condensation. In such cases, it is necessary to protect controls, junction boxes, motors and load cells against condensation by using insulation and sealing materials. Extremely hot or cold products may also call for the use of special belt materials.

Positive venting, internal cooling and heating methods can also reduce condensation in electrical enclosures.

**Debris and dust**

Where debris and dust are in the immediate vicinity of the checkweigher, it is advisable to shield the weighing section from foreign matter or to keep a reasonably clean production area around the checkweigher.

Debris and dust falling on and around the weighing section can off-set the ‘zero’ setting on the checkweigher. If debris continually builds up on conveyors or platforms, then the checkweigher will continually need to be rezeroed.

**Vibration**

Any vibration exposes the checkweigher to ‘noise’ or unwanted signals. As a general rule, any vibration that you can see or feel can deteriorate weighing performance. These vibrations are low frequency and hard to filter, or high energy. The cause of this interference could be a hopper, a nearby press or even another conveyor in contact with the checkweigher. High-performance checkweighers can automatically filter out some extraneous noise by means of particular software; however, for optimal performance, a checkweigher should be completely isolated from extraneous vibrations.

**Air currents**

Air currents, from all directions, can also affect checkweigher indications. It is especially important to avoid draughts around highly sensitive checkweighers, such as those commonly used in the pharmaceutical industry. Even if air movement is kept to a minimum, a draught shield may still be helpful. With a highly sensitive checkweigher, even passing a hand over the weighing section (without touching it) can cause a weight fluctuation.
Defining Your Needs

Electrical Noise

Electrical noise, such as Electro-Static Discharge (ESD), Electro-Magnetic Interference (EMI) and Radio Frequency Interference (RFI) can interfere with checkweigher indications. RFI can be caused by pagers, cell phones and walkie-talkies, as well as by other devices or plant using radio signals. If not properly shielded, variable frequency drives, and other components within the checkweigher enclosure, can also have an adverse effect on sensitive weighing and data-processing circuits.

The build-up of static electricity on a checkweigher can result in apparent and rapid weight build-up which cannot be filtered from readings – and static build-up can be caused by the machinery itself or by items crossing the weighing section. Anti-static draught shields should be used for very sensitive applications, since even a draught shield or guard can cause static build-up.

Caustic Product or Environment

If product (or the operating area cleaning regime) contains corrosive elements such as chlorinated chemicals or salt, the checkweigher will need to be designed and built to stand up to harsh washdown conditions.

Caustic environment can degrade a load cell and other components. Some load cells are made of aluminium – and whilst they work well and cost less than stainless steel load cells, they are not designed for contact with water or other corrosives.

Checkweighers are generally available in many materials, and stainless steel checkweigher components will stand up to harsh environments or frequent contact with water. Other materials can be coated with a resistant paint, but these will not stand up to harsh wash-down environments.

Moisture or Condensation

If there is moisture or excessive condensation on or around the items to be weighed – or if surfaces are to be regularly washed down with water – the checkweigher will need adequate and appropriate protection (in accordance with EN 60529, Ingress Protection for electrical ensloures) against solid and water ingress.

Mild steel and aluminium will corrode, even with protective coatings such as paint, powder coat, or electrolytic surfaces.

If moisture collects only at the product area, then stainless steel and waterproof components around the product area may be sufficient.

Some load cells are not suited to handling high moisture or condensation, and strain gauge load cells that are not hermetically sealed can be compromised by external contaminants.

For washdown conditions, load cells should be made of caustic-resistant materials, hermetically sealed, and have an IP rating sufficient for the type of water jets the device will see.

Harsh Wash-down Environment – Water Ingress Protection

There are two common methods to identify the protection of electrical devices against dust and water penetration.

The NEMA (National Electrical Manufacturers Association) ratings identify the protection capabilities for dust and water ingress, and also the ability to resist corrosion.

The IP (Ingress Protection, EN 60529) ratings are used exclusively for dust and water ingress. IP ratings do not qualify the device’s corrosion resistance.

Both NEMA and IP ratings are for electrical devices only, as defined in the scope of the referenced standards.

Beside the above-mentioned effects of moisture or excessive condensation, cleaning with pressurised water (such as a water jet from a hose or even a power cleaner) can adversely affect motor and gearhead gaskets, the load cell and other components. To ensure trouble-free function despite strict cleaning regimes, the checkweigher manufacturer should offer adequate ingress protection (in accordance with the IP Code, International Protection Marking) to a degree that matches the checkweigher application and your production line hygiene requirements.

The following terms describe the environmental protection required by the checkweigher controls and enclosures. Additional information and extended descriptions can be obtained via the Internet.

Common Classifications Include:

- **IP 2X** – Protection against approach by fingers. Cannot be penetrated by a solid object which is 0.79 inch (12 mm) or more in diameter.
- **IP 30** – Prevents ingress of objects >2.5 mm (tools, thick wires, etc.).
- **IP 54** – Ingress of dust is not entirely prevented, but dust will not enter in sufficient quantity to interfere with the satisfactory operation of the equipment. Water splashing against the enclosure from any direction will have no harmful effect.
- **IP 65** – No ingress of dust. Protected from water jets. Water projected by a nozzle against enclosure from any direction will have no harmful effect.
- **IP 66** – No ingress of dust. Protected from powerful water jets. Water projected in powerful jets against the enclosure from any direction shall have no harmful effect.
- **IP 67** – No ingress of dust. Protected against immersion up to 1 m. Ingress of water in a harmful quantity will not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1 m of submersion).
- **IP 69k** – Standard DIN 40050-9 extends the protection for high-pressure, high-temperature wash-down applications. Such enclosures must not only be dust-tight (IP6X), but must also be able to withstand high pressure and steam-cleaning. The test specifies a spray nozzle that is fed with 80 °C water at 8 – 10 MPa (80 – 100 bar) at a flow rate of 14 – 16 l/min. The nozzle is held 10 – 15 cm away from the tested device at angles of 0°, 30°, 60° and 90° for 30 seconds each (see Figure 4.17). The test device sits on a turntable that rotates once every 12 seconds (5 rpm).
Hazardous Locations/Highly-Explosive Atmospheres

A Hazardous Location is any space indoors or outdoors that contains explosive gas, vapour, dust or airborne particles which, when mixed with air, can reach dangerously explosive concentrations.

Any industry can contain Hazardous Classified Areas – and if an organisation has such an area within their operational environment, they must adhere to certain requirements (depending on the classification of hazards, and the authority having jurisdiction) to prevent a fire or explosion.

The decision as to which specific checkweigher to use in a Hazard Classified Area can only be taken after the checkweigher supplier has undertaken a fundamental analysis of the requirements of the individual production facility. In the US, the employer’s licensed Professional Engineer, must state the requirements for the location, in terms of its Class, Group, Division, and Temperature.

The employer’s Professional Engineer must then verify the construction of the equipment as suitable for use in that environment.

There are several methods of protection, the most basic being to keep away from the classified area all equipment which could cause a fire or explosion. Other protection methods include using only intrinsically safe equipment, explosion-proof enclosures or ‘purge’ systems.

Purging an enclosure consists of maintaining positive-pressure air-flow through it to remove any hazardous (flammable) substances from the environment.

Mitigating Risk from Explosion

| A.   | Eliminate the source of the dust or vapor |
| B.   | Move the machine outside the hazardous location |
| C.   | Eliminate the source of ignition |
| D.   | Manage the ignition to limit propagation |

If the checkweigher will be running in a classified area, the environment will need to be protected with at least one of the above methods. Qualified checkweighers and components are available for installation in such environments.

<table>
<thead>
<tr>
<th>ATEX Nomination</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>Flammable gases or 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 II</td>
<td>Ignitable fibres and flyings</td>
</tr>
<tr>
<td>Division I</td>
<td>Class, II, or III normally present</td>
</tr>
<tr>
<td>Division II</td>
<td>Class I, II or III present on a failure</td>
</tr>
<tr>
<td>Unclassified</td>
<td>Hazardous properties far away enough from a classified area to be determined safe</td>
</tr>
</tbody>
</table>

Figure 4.18: Hazardous area classifications

Mechanical Abuse
One of the most common causes of poor checkweigher accuracy is mechanical abuse. Any employees working with and around checkweighers can unknowingly damage the checkweigher, with common examples including:

- Stepping on a weighing platform
- Placing too much torque on a load cell by over-tightening a bolt
- Twisting a weighing conveyor body and cleaning the checkweigher inappropriately

How You Can Protect the Checkweigher from Its Surroundings
There are different actions that can be taken to protect the checkweigher from surrounding hazards:

- Keep the work area clean
- Shield the weighing section from falling debris
- Make sure no other mechanical systems are in physical contact with the checkweigher
- Bolt the checkweigher firmly to sound ground
- Isolate the checkweigher from any machinery that produces vibrations
- Isolate the checkweigher from wind or air currents, or install shields if necessary
- Earth all shields and components touching the checkweigher
- De-ionise the product
- Shield the checkweigher from electromagnetic interference
- Provide a “clean” power source, and protect lines from voltage peaks
- Choose a checkweigher construction compatible with the manufacturing environment
- Use a load cell that is suitable for the environment
- For all personnel who come into contact with checkweighers, make sure they are issued with system-based training. In this context, ‘personnel’ includes operators, mechanics, maintenance and cleaning crews and manufacturing engineers
- Conduct routine and preventative maintenance
- Define a Service & Maintenance Plan
- Clean the checkweigher in accordance with the instructions provided by the supplier
A competent checkweigher supplier should be able to offer compact, operator-friendly combination solutions when:

- A second (and even a third) method of inspecting products is required for quality assurance purposes
- Production-line space is precious
- The best possible protection of your brand reputation is as important as minimising total cost of ownership (TCO)

In order to minimise complexity and space (and to integrate components on a line), the following combinations can be specified:

- Combined checkweighing and metal detection systems
- Combined checkweighing and X-ray systems
- Combined checkweighing and vision inspection systems

Figure 5.1
These systems are easy to install (which saves time and money), and they are usually less expensive than buying separate systems and then integrating them together. In addition, a combination system reduces operator errors and speeds up production changeover, thanks to quick and easy, semi-automatic product set-up on a single-user interface for both technologies. In addition, combination systems require less operator training, whilst also reducing maintenance and cleaning costs. A state-of-the-art checkweigher is the optimum starting point for a combination system because it possesses several useful capabilities:

- Packages are timed, spaced, and oriented in a uniform and repeatable manner – providing a convenient platform for integration of other inspection devices such as open-flap detectors, vision systems and tamper evident sealing
- The checkweigher is well suited for management of rejected products, providing a suitable basis for centralised isolation and tracking of non-conforming products.

When Does a Combination System Make More Sense?

Experience has shown that working in co-operation with a central supplier, who already works collectively with other technology suppliers and has knowledge of combining components, is the most advantageous solution. This especially applies when optical verification, marking and checkweighing are required in an automatic in-line serialisation system. It is not only a legal requirement, but the continually rising demand for quality and traceability in pharmaceutical and medicinal products have also led to a need for modern system solutions in the areas of quality assurance, serialisation and Track & Trace. It is advisable to choose a key supplier that has already established successful partnerships with other suppliers and has experience in combining technologies in a complete serialisation system comprising marking, visual verification, checkweighing and tamper evident sealing.

As an example, ensuring that products are not contaminated by a foreign body and meet the prescribed weight on the label is one of the main challenges faced by food producers. A checkweigher combined with an x-ray system or metal detector is an efficient tool that can offer a return on investment in little time. Again, discussing combination solutions with a key supplier who has decades of expertise in integrating and perfecting multiple technology solutions into a production environment is advisable.

The advantages of a complete solution include its simple integration into the production line and the knowledge that all the components will work together smoothly.

Complete solution suppliers also offer a single point of contact for both service and support. The decision to opt for a complete solution supplier offers the following advantages:

- One point of contact for all systems concerned.
- A single just-in-time supplier of ordered components, rather than several equipment suppliers.
- Compatibility of components.

Combinations systems also off a number of benefits:

- Combination systems are more compact, saving precious space in production lines.
- Combination systems allow easier line integration, and have fewer moving parts, thereby reducing maintenance time and cost.
- Reduction of user interfaces minimizes operation errors and makes product changeover faster and more efficient, reducing downtime.

An experienced supplier should be able to demonstrate established expertise and competence in devising and perfecting such combination solutions. They should also be able to demonstrate that such systems are entirely flexible in terms of configurability – so as to ensure a 100 % match with manufacturer requirements.
6.1 Metrological Regulations and Other Guidelines

Checkweigher suppliers should be able to advise on legal requirements necessary for the specific country in which manufacturing takes place. They will also advise on checkweighing requirements for individual products within specific industries. A reliable supplier should guarantee that a given checkweighing solution meets current legal stipulations and prepares the manufacturer for future changes in legislation.

Checkweigher set-up, system design and choice of load cell technology are governed by metrological regulations and guidelines, in combination with operating goals and requirements. In most countries, there are regulations covering:

- Weights
- Measures
- Packaging requirements
- Net content
- Maximum permitted variation value for a package being produced

In Europe, the Measuring Instruments Directive (MID) can have a significant impact on checkweigher purchasing decisions, when in doubt it is advisable to contact the appropriate authority with regard to Weights and Measures regulations, tolerances or packaging requirements.

6.2 Weights and Measures Guidelines

Weights and Measures guidelines refer – among others – to the accuracy of the checkweigher and its ‘resolution’. The checkweigher’s resolution is expressed as ‘the smallest increment of weight change that can be displayed by the indicator’.
For legal purposes, the checkweigher’s resolution is determined during the set-up procedure. The resolution is also dependent on the type of load cell chosen and the use to which that load cell is put. The resultant value can be much lower than the actual resolution which is physically achieved by the load cell – and this is because the allowable increment value displayed on the indicator can be restricted by Weights and Measures guidelines.

Note: There is no correlation between the resolution displayed by the indicator and the actual accuracy of a dynamic checkweigher, unless both are programmed to be the same value. Some jurisdictions may allow the displayed increment value to be smaller than the actual approved accuracy of the device.

6.3 Measuring Instruments Directive (MID)

The Measuring Instruments Directive was announced by the DIRECTIVE 2004/22/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL and came into effect on 30th October, 2006. It is valid for all EU member and EFTA (European Free Trade Association) countries, as well as applying to Liechtenstein, Iceland, Norway and Switzerland.

The only checkweighers requiring assessment in accordance with the MID are those which weigh products to be commercially sold on to customers and end consumers, based on the weighing results.

Checkweighers which only carry out a completeness check do not have to be assessed, since they are only used for counting and not for the weighing of individual products. Therefore, checkweighers used in mail order from catalogue senders do not have to be assessed.

The Measurement Instruments Directive describes in detail the processes and responsibilities for 10 types of measuring instruments (including checkweighers) during their production and commissioning.

Prior to introduction of the MID, national legal verification authorities were responsible for determining and confirming whether checkweighers complied with national error limits for initial legal verification. Under the MID, the supplier is now responsible for determining and confirming that the checkweigher complies with these error limits (known as ‘conformity assessment’) under production conditions. Once the conformity assessment has been successfully completed, the CE declaration can be provided.

MID can be regarded as the visible ‘tip of a European iceberg’, based on the OIML (Organisation Internationale de Métrologie Légale) guidelines (Figure 6.1).

The OIML guidelines, in combination with local regulations and laws, continue to regulate error and tolerance levels. However, the MID does not change these tolerances and does not create a disadvantage for the end customer.

The MID:

- Regulates all production processes which are metrologically significant from development through to market introduction (including placing systems within production environments)
- Regulates the exact production and performance requirements that must be fulfilled by the checkweigher supplier
- Defines how the checkweigher must be marked or labelled
- Sets out all procedures and documentation requirements needed to issue a Conformity Declaration Certificate

Post-commissioning legal verification inspections from local government authorities are not affected by MID, and they will still take place; The MID only replaces the initial legal verification.

For a checkweigher owner, it may seem that the MID conformity assessment is the same as an initial legal verification, since both govern the process for which the measuring instrument is used. However, the MID covers much more than just placing the checkweigher into its operational environment: it governs and regulates the supplier’s complete production process and QM system.

This increased official monitoring, especially in the production chain, ensures that the supplier only delivers measuring instruments produced to an extremely high and consistent standard. Therefore this extra monitoring in the manufacturing process can be regarded as advantageous to all checkweigher customers.

The MID does not regulate a checkweigher after it has been put into use – and once the MID process has been fully completed, all weighing results are governed by normal operational tolerances. It is the responsibility of the checkweigher owner to regularly check the accuracy of the device by testing random samples in accordance with local Weights and Measures standards.

If the checkweigher ceases to conform to standard operational tolerances, it needs to be repaired, serviced or taken out of use. This process is already in use in most countries and is not associated with the MID.
6.4 MID Associated Terms

**Legal Verification**
A legal verification is carried out by the local government authority, which tests whether the checkweigher adheres to local regulations and whether its measurements are within predefined tolerances. The process is simply a check to see whether a checkweigher actually displays and records the correct weight. This is then certified, documented and made clearly visible on the instrument.

**Conformity Assessment Procedure**
The initial legal verification has been replaced with the final conformity assessment procedure. This describes in detail the required procedures, processes and services, up to and including the commissioning of the checkweigher.

Conformity assessment specifies and determines that the checkweigher conforms to the MID, the OIML guidelines and its error tolerances, as well as holding an EU-type examination certificate.

6.5 What Impact Does MID Have on Periodic Legal Verification?
The MID has no impact on periodic legal verification. This process is still carried out by the local legal verification authority, without any influence by the MID. Furthermore, the checkweigher supplier is not allowed to carry out the periodic legal verification.

As in the past, checkweigher owners are responsible for contacting their local legal verification authority when a periodic legal verification is due. For the majority of checkweighers, this process must be performed every one to two years. Each country has its own regulations.

6.6 What are the Advantages of the MID for Checkweigher Owners?
Application of the MID means that checkweigher owners only have one partner to contact when they wish to commission the checkweigher and place the checkweigher in its operational environment. Preparation of legal verification, assessment of conformity, and answering questions are performed by one competent checkweighing supplier.

The most important advantage to the customer is that they receive a qualified and certified EU production and quality guarantee. The MID regulates all checkweigher supplier production processes and QM systems – and the only the measuring instruments which can be brought onto the market and put into use are those produced using processes and QM systems approved by an MID notified body.

6.7 On-Site Preparation
Checkweigher owners must also prepare for the initial legal verification – and to aid this procedure, checkweigher users can:

- Stop the production line for static testing
- Make provisions for static testing when setting the dates for delivery, installation and conformity assessment
- Make available an original sample of each product to be weighed. It is helpful if a table listing these products can be placed adjacent to the checkweigher being assessed. In addition to the physical samples, a tabulated printout must be provided, listing the exact name, weight, throughput rate and maximum line speed for each product.

For dynamic testing at very high speeds it is sometimes necessary for products to be placed on the line using upstream equipment, which may prove difficult to accomplish if not properly organised prior to the commencement of the testing process.

The exact testing requirements must be discussed with any potential checkweigher supplier in advance.

6.8 Other Guidelines, Agreements and Initiatives
As well as consideration of a range of legal requirements, there are various industry-specific guidelines (or initiatives and agreements) worth bearing in mind when determining the electronic and mechanical design of a checkweigher. These guidelines are likely to lead to decisions for or against a certain design detail or special software function.

Below are guideline examples from food and pharma industries – though manufacturers may be subject to additional special requirements from business partners such as large retailer chains.

**BRC – British Retail Consortium and BRC Global Standards**
Formed in 1992, the British Retail Consortium (BRC) is one of the UK’s leading trade associations representing a range of retailers, from small, independently owned shops to large retailers and department stores.

In 1998, the BRC produced the first edition of the BRC Food Technical Standard and Protocol for food suppliers. This has been widely adopted throughout the UK and around the world.

The British Retail Consortium is well known for its global standards and literature, covering:
- Food safety
- Consumer products
- Packaging and packaging materials
- Storage and distribution
**FDA 21 CFR, part 11**

FDA 21 CFR, part 11 provides ‘control objectives’ for establishing the trustworthiness and reliability of electronic records and electronic signatures. These control objectives can be classified as ‘technical’ controls and ‘procedural’ controls.

FDA 21 CFR, part 11, applies only to the United States of America; however, similar standards exist in Europe and elsewhere.

**FPVO and Equivalents Such As MAV (Maximum Allowance Variation) in the USA and The Weights and Measures (Packaged Goods) Regulations 2006 in the UK**

The German Fertigpackungsverordnung (FPVO) is legislation covering pre-packaged goods to protect consumers against underweight products, or products with ‘insufficient net content’. These are products (even allowing some tolerance for weight variation) with net contents that are below the label weight.

Furthermore, the FPVO aims at protecting consumers against deceptive package designs (e.g. oversized outer packaging with small amounts of product inside, double-wall cosmetic cream jars with a too small inner container, etc.)

**GFSI – Global Food Safety Initiative**

A major factor driving the growth of official food safety management schemes has been the Global Food Safety Initiative (GFSI) – a non-profit organisation started in 2000 by senior food industry figures to help restore consumer confidence in the food industry.

One of the aims of GFSI was to harmonise the fundamental food safety requirements of schemes, and so avoid multiple audits – and nowadays, GFSI-recognised schemes are acknowledged globally and utilised by thousands of companies.

GFSI also facilitates collaboration in the food industry to promote greater food safety and uphold consumer trust.

**HACCP (Hazard Analysis and Critical Control Point)**

HACCP is a process control system that identifies what hazards might occur in food production, and where they might occur. By identification of the hazards through HACCP, the hazards can be eliminated or reduced, and monitored at the critical control points.

**IFS (International Featured Standards) Food**

Applying to food-processing companies that pack loose food products, IFS Food is a GFSI-recognised standard for auditing food safety, as well as assessing the quality of food manufacturers’ processes and products.

IFS Food applies when products are “processed” or when there is a risk of product contamination during primary packing. The IFS Food Standard is important for all food manufacturers, especially those producing private labels, because it contains many requirements related to specifications’ compliance.

IFS Food supports production and marketing efforts for brand safety and quality – and its version 6 has been developed with full and active involvement of certification bodies, retailers, industry, plus food service companies from all over the world.

Food manufacturers have an ever-increasing responsibility to take all precautions to ensure that their products are safe, free from contamination and are unlikely to harm the end consumer in any way. (http://www.ifs-certification.com/index.php/en/ifs-certified-companies-en/ifs-standards/ifs-food)
Connectivity and Software

Whatever its application, a checkweighing system is crucial to the daily operation of the production facilities that use it. It’s important to select the right system, so that it will have a direct and positive input on both revenue and operational productivity. A checkweigher is not simply a modern and manufacturing version of the historical balance or scale; it can be a multi-purpose software-enabled tool for production control and monitoring. In addition, it can communicate vital information to a manufacturing facility’s data acquisition systems.

7.1 Supporting Compliance Needs

Well-chosen software and data collection options for a checkweigher enable a manufacturing operation to comply with Hazard Analysis and Critical Control Points (HACCP) requirements – plus they allow a business to conform to the broader needs of external safety regulations and standards. Collecting data from Critical Control Points (CCPs) in the production process can support compliance with basic standards and external codes of practice such as BRC and IFS.

A reputable checkweigher supplier should offer a comprehensive range of software and connectivity solutions, ranging from simple peer-to-peer connectivity to sophisticated security, networking and statistical analysis packages.

This enables the supplier to configure a tailor-made software package which best suits the individual manufacturer’s needs, whilst also being fully integrated with factory management systems. Recording of performance data, events, settings and test routines significantly enhances opportunities to make informed management decisions and carry out in-depth due diligence procedures.

7.2 Making the Manufacturing Processes Transparent

Efficient transfer of weighing process data to higher-level systems can help make manufacturing processes more transparent – and increased transparency can reduce operating costs, whilst making it easier to comply with certification standards or legal regulations. What’s more, weighing and communication solutions are more likely to meet defined objectives and produce measurably improved Returns On Investment (ROI).
7.3 Determining Data Integration Objectives

Before selecting a weight data communication system, an assessment of data integration objectives must be made. A checkweighing system supplier should be able to provide proper support by answering the following questions:

- What is the target hardware (PLC, PC, SCADA)?
- What data are needed (individual weights, statistics, batch reports, line control signals, machine-state information, Weihenstephan protocol)?
- Is the communication unidirectional or bi-directional?
- What is the preferred form for the communication (Ethernet TCP/IP, Serial, OPC (dA or uA), Fieldbus (Profinet, Ethernet IP, Modbus)?

Several of these questions are strategic in nature, covering matters such as the type of information required, by whom, and for what purpose. Once these questions have been answered, the manufacturer and the checkweighing system supplier can explore possible solutions with the goal of enhancing performance; this increases the likelihood that the final process integration will provide quick and measurable Return On Investment.

7.4 Data Management With Effective Software Tools

Production plant managers and quality managers usually welcome PC software tools that collect data from checkweighers and other inspection equipment. For these reasons, the checkweigher system and its software should be able to:

- Provide statistical reports
- Include archiving capabilities
- Communicate bi-directionally with a user’s host computer
- Manage equipment from a remote location

Such data management software should provide seamless integration of product inspection devices, so as to make processes more streamlined, more accessible and more efficient.

Where practical, the data management software should also allow users to control the entire product inspection management process from a single point or from multiple remote locations, eliminating the need for time-consuming production line patrols.

7.5 A Common Language Throughout the Production Facility: PackML (ISA TR88.00.02)

Beginning their work in 2002, the Organization for Machine Automation and Control (OMAC) started to develop a machine language (known as PackML) that would provide a consistent and common means of communication between all forms of packaging equipment and line controls.

The intention was to ensure that every packaging machine reported its operational status in the same way, independent of machine type.

Initial use of PackML began with checkweighing, but its advantages were clear, and so it migrated to other inspection forms. PackML is now the standard for machine state communications across the majority of today’s product inspection equipment.

PackML uses three categories of information: States, Modes, and PackTags.

States are the most fundamental conditions seen in a production line, such as executing, stopped, suspended, stalled. They give the line-control PLC (and other line equipment) information about the condition of the checkweigher or other product inspection equipment.

Modes are common forms of operational activity, such as jog, calibrate.

PackTags provide the accounting tools needed to perform efficiency calculations that are critical to production-line improvements. Packtags can be direct inputs for the user’s OEE calculations.

7.6 Intuitive User Interfaces

Even the best checkweigher software tools cannot perform efficiently without an intuitive user interface. Suppliers need to ensure that the user interface features simple navigation, supports daily work methods and avoids operating errors.

A well-designed user interface will help to establish a checkweigher’s invaluable presence in a production line, raising its status to that of a helpful partner and eliminating any perceptions of it being a complex, difficult-to-understand system.

Only with an appropriate user interface can the extensive software functions of a checkweigher be used in a measurably useful manner – and one of its main contributions to the production process will be to help generate more manufacturing uptime.

Figure 7.1: Real-time monitoring of production processes

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What Are Your Objectives? A Questionnaire

As well as being detectors of off-weight or otherwise non-conforming products, modern checkweighers can act as constant protectors of product integrity and brand quality.

8.1 Questionnaire

To help you achieve your goals, a checkweigher manufacturer needs as much, and precise, background information as possible – above all, about the products (mostly packages) to be weighed, the ambient conditions of the site, and production line integration details.

What Are Your “Checkweighing Objectives”?

- Reduce giveaway
- Counting
- Monitoring upstream processes
- Weights & Measures approval required
- Eliminate underweights
- Fill process optimisation
- Verification

Other __________________________________________________________

Does a Space and Time Saving Combination Solution Make Sense?

Several manufacturers can offer user-friendly, compact two-in-one solutions when another aspect of quality assurance, beside checkweighing, is to ensure that products are free from metal foreign bodies or plastic/glass/bone/other high-density particles. Or to ensure the perfect look of the product and correct position of – for example – labels and bottle caps. In such cases a checkweigher can be combined with a metal detector, an X-ray inspection system or a visual inspection system.

For more complex inspections, separate metal detectors, x-ray, and vision inspection systems are available.

Checkweighing should be combined with:

- Metal detection
- X-ray inspection
- Visual inspection
Type of Production Line

☑ Single-product (single-article)
☐ Various products (articles) alternated, each over a longer period of time
☐ Various products (articles) alternated, each for a short interval only i.e. frequent line setup changeovers

Products (articles): How many different products (articles)?

<table>
<thead>
<tr>
<th>Product (Article)</th>
<th>Description/name</th>
<th>Length in run direction (mm) or diameter</th>
<th>Width (mm)</th>
<th>Height (mm)</th>
<th>Weight (g)</th>
<th>Throughput (pcs/minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Product (Article) and Packaging Characteristics:

☐ Open
☐ Semi-solid/soft
☐ Liquid
☐ Box
☐ Can (tin)
☒ Block-bottom bag
☐ Closed
☐ Frozen
☐ Unpackaged
☐ Flat bag/pouch
☐ Bottle or jar
☐ Carton

Other __________________________________________________________

Containers:
Tare (weight value)______________________________________________
Tare fluctuations from _____ to _____
Container handling stability during movement
☐ high ☐ low
Preferred conveyor belt/transfer device

Accuracy:
Deviations in product weight

Desired accuracy

Standard deviation
**Mechanical Interface(s):**

*Upstream machines/equipment:*

- Throughput (pcs/min) __________________________
- Product centre spacing __________________________
- Clocking (stepwise motion) __________________________

*Downstream machines/equipment:*

- Throughput (pcs/min) __________________________
- Product centre spacing __________________________
- Clocking (stepwise motion) __________________________

**Optional Fill process Optimisation by Use of Feedback Controlling:**

- Filling machine control system – For example, external ‘more/less’ controlling is performed by pulse width modulation, or control voltage increase/decrease, or other method

- Weight of over/underweight products – Filling machine variance

- Counted over/underweight products when filler is reacting to a correction – No. of products (qty.) and individual product weights

**Ambient Conditions:**

*Place of installation:*

- Ground floor
- On a pedestal

*Environment:*

- Floor vibrations
- Dusty atmosphere
- High humidity
- Wet environment
- EX zone (ATEX)
- HACCP

*Cleaning conditions:*

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

*What happens/shall happen in the event of:*

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

*Other notes:__________________________
Notes
9 Selecting the Right Partner – Service as it Should Be

9.1 Life Support

Once a manufacturer has identified the need to purchase a checkweighing system, it is important that:

- The equipment is correctly installed
- Operating personnel are correctly trained
- Performance verification is carried out in a professional manner

In addition, ‘Useful Life Support’ (i.e. provision of relevant support throughout the working life of the checkweigher) is just as important as installation support and the assistance provided during the initial commissioning process.

A checkweigher manufacturer should ensure that the user is constantly satisfied with the performance of the checkweigher; furthermore, they should be there to guide the user through the entire useful life of the system.

Figure 9.1: The useful life support by a good manufacturer/supplier
9.2 Installation

A well-executed and carefully carried out installation phase is the foundation of worry-free and efficient use of the checkweigher throughout its working life. Therefore, a competent supplier should strongly support its customers throughout the installation process by ensuring that the checkweigher:

- Adheres to HACCP-based requirements and associated standards
- Complies with quality management system audits and relevant legislation applicable to the country in which the equipment is installed
- Supports proof of due diligence and helps optimise the filling process
- Operates as intended when at factory default settings aligned to the customer's product
- Is adjusted properly so that product weight is measured correctly within specification parameters
- Is installed correctly with reference to system peripheral devices and reject systems
- Can be used properly and effectively by operators, so that they can enjoy maximum benefit from the features that the checkweigher offers

Line Integration

Checkweighers are in most cases not stand-alone devices; they are usually integrated into a production line alongside other devices, such as metal detectors and x-ray machines. For these reasons, therefore, production-line integration should be considered as part of the installation process. Matters to consider include:

- Placing equipment in a logical sequence so that downstream equipment can run first; this should prevent back-up
- Stopping upstream equipment first; this should allow the line to be clear of product
- Recognising and acting on current machine status (such as ‘ready to run’, ‘machine running’, ‘machine stopped’, ‘machine fault’, etc.). Awareness of these different status conditions allows for comprehensive control of the production line
- Signals that can be used to start and stop the equipment from a remote location

The intended installation location and environment could have an adverse effect on the operational performance of a checkweighing system. For this reason, installation instructions should be consulted both before installation and during installation.

This will ensure that the best possible performance is obtained from the system and will minimise the risk of adverse environmental influences during operation.

Instructions provided by the system supplier will contain more information than this guide can provide. However, general principles can be applied to most checkweighing systems, and gaining a basic understanding of these principles will help at the equipment selection stage.

9.3 System Commissioning

Before operational use:

- The installed checkweighing system should be commissioned to ensure that the installation complies with the manufacturer’s recommendations
- The system operates as intended
- All relevant personnel are trained in its safe and proper use

The following points should be taken into consideration during system commissioning, especially when using a checkweighing system.

Conveyor Systems

The conveyors should be switched on and the following should be checked:

- The belt speed matches the displayed value
- Conveyors are running smoothly
- Conveyor belts are centred
- Conveyor belt does not rub against other conveyors
- The rejection unit functions correctly
- The rejection unit is inhibited if the security device is activated
- All light barriers function correctly
- There are no vibrations on the load cell

Loading and Transport

The weighing section should always be secured when transporting a checkweigher to a new location. The checkweigher is a highly sensitive weighing device and any damage (often not visible) can influence the weighing results.

Equipment Access

The checkweigher should be accompanied by clear documentation and drawings that illustrate the principal electrical and mechanical interfaces, as well as the main access locations for maintenance and operation. The checkweigher should also be accessible from all sides for ease of inspection and cleaning.

Vibration and Mechanical Shock

Checkweigher systems should not be installed in areas that are subjected to (or near to) vibration and mechanical shock. Where this cannot be avoided, every effort should be made to minimise the effects that vibration or mechanical shock can create.

Electromagnetic Interference

Wherever possible, systems should not be installed near any devices which may emit electromagnetic interference, such as radio transmitters.

Hazardous Location Use

If the checkweigher is installed in a potentially explosive environment or atmosphere, it is important to ensure that only system components with special zone-compliant ‘Ex’ protection have been used in the construction process.
Accuracy

During commissioning, it is vital to ensure that the checkweigher fulfills specified accuracy requirements. Tests of load cell accuracy, linearity, repeatability and re-zeroing should always be included in this process, and should be carried out by the checkweigher supplier before delivery. Repeatability test and re-zeroing should also be carried out on-site in the production environment.

9.4 Training

Well-trained and competent operators are essential to keep production processes running with maximum efficiency. In-depth knowledge of the specific checkweighing system is also important – and together, these factors can ensure that work is carried out quickly, efficiently and safely, with essential equipment enjoying a long and useful life.

A competent checkweigher supplier should offer training to help ensure work safety, whilst also making best possible use of the checkweighing system. Ideally, operator training should be held at the production facility, so that attendees can learn how regulations are applicable to their specific day-to-day working activities.

A competent checkweigher supplier should help to ensure that all users receive appropriate equipment familiarisation instructions, in order to ensure productive work procedures. At the very least, operators should be trained to a basic level in terms of operation, care and maintenance of the checkweigher.

Minimum operator training requirements before starting production should cover:

- Product set-up
- Product changeover
- Immediate action to be taken in the event of false product rejections or unplanned stops

Operator training will help production-line personnel, and the company, enjoy all the benefits that a checkweigher can offer. After having participated in checkweighing training, users should be able to:

- Obtain the best results from the checkweigher system, based on knowledge of factors such as testing procedures and documentation
- Gain an understanding of checkweigher operating safety instructions
- Learn how to use the checkweigher in a safe manner
- Identify possible hazards and how to avoid them
- Explain warning signs used on the equipment
- Properly clean and maintain the checkweigher
- Receive and understand overall information regarding the correct handling of product inspection solutions as part of the production process

9.5 Performance Verification

Users of checkweighing systems should be aware that it is their responsibility to ensure consistent performance of the checkweigher system through its useful life. A competent checkweigher supplier can assist the checkweigher owner to achieve these aims.

Generally, it is recommended that ongoing Performance Verification should be carried out by an authorised engineer on a bi-annual basis (or at periods agreed with the user) to verify that the equipment remains within specified tolerances. It is important to test for both the presence of accurate weighing as well as to test for the correct rejection of deviating weights.

Any checkweighing system should be periodically verified in order to demonstrate due diligence, and to ensure that:

- It continues to operate in accordance with the specified accuracy standard
- It continues to reliably reject off-weight products
- All additional warning/signalling devices are effective (e.g. alarm conditions, reject confirmation)
- Installed failsafe systems are functioning correctly

Performance verifications should be carried out by the checkweigher supplier’s service technicians as part of a regular service programme. A service technician will always have the tools and equipment required to carry out this task, which allows them to make adjustments where necessary.

On-site Preparation to Help the Customer Undertake Successful Periodic Legal Verification

Checkweigher owners must, depending on jurisdiction, prepare for regular legal verification which is usually required once a year. To help with this process:

- The production line must be stopped for static testing. Provision for this should be made when setting the dates for delivery, installation and conformity assessment.
- An original sample of each product to be weighed must be made available. It is helpful if a table listing all products can be placed adjacent to the checkweigher being assessed. In addition, physical product samples should be supplied, alongside, a tabulated printout that includes the exact name, weight, throughput rate and maximum line speed for each product.
- For dynamic testing at very high speeds, it is sometimes necessary for products to be placed on the line using upstream equipment. This may prove difficult to accomplish if not properly organised before commencement of the testing process.

A competent checkweigher supplier should be able to accompany a customer through the process of legal verification. They should help checkweigher owners to achieve conformity to test requirements, as well as helping with periodic check-ups for potential problems such as signs of wear.
Service and Maintenance

The checkweigher manufacturer should be an excellent partner in a product manufacturer’s daily business activities, as well as providing on-going support in helping a manufacturer achieve long-term strategic productivity goals.

Relevant and timely checkweigher manufacturer support is particularly important in relation to servicing and preventive maintenance. For example, there may be advantageous service contracts (such as a machine check-ups at regular intervals) that a competent checkweigher supplier can supply, in order to meet the product manufacturer’s unique service profile.

10.1 Serviceability and Maintenance

A complete review of all potential service contracts, wear and spare part kits, and machine warranties should be made before making a decision to acquire any checkweigher.

Some warranties provide much more comprehensive coverage than others, and additional matters of equal importance can include:

- The presence of a service centre near the checkweigher purchaser’s place of business
- An active network of service technicians based in the locality

All the above factors can save money in the long run and can increase the useful life of a checkweighing system.

The latest checkweigher systems have been designed for easier maintenance – and these days, parts last longer and can be changed more easily. For simple maintenance, it can be beneficial to use:

- Quick-disconnect electrical connections
- Tool-free or quick-change parts
- Spare part kits including belts, chains, bearings and sprockets

It is worth bearing in mind that:

- New parts must be ordered and delivered quickly, so as to minimise downtime
- Parts supply and service processes must be clearly stated
- Spare parts should be kept on-site to avoid downtime if there is a delay in spares deliveries
10.2 Validation and FAT Procedures

Regulated industries such as pharmaceuticals require that checkweighers should be part of a validated process. Special documentation and (potentially) FDA 21 CFR part 11 checkweigher supporting functions should be borne in mind when considering validation.

When choosing a competent checkweigher supplier, it is essential that they can provide necessary documentation, software features and full support.

The qualification and validation process should provide:
- Pre-approval documents
- Design Qualification (DQ)
- Installation Qualification (IQ)
- Operational Qualification (OQ)
- Performance Qualification (PQ)
- Certificates (CE etc.)
- Maintenance Qualification

It is advisable for the checkweigher to undergo a Factory Acceptance Test (FAT) to ensure operational (i.e. specification) compliance. A key element in this process is the rigorous testing of the new checkweigher prior to crating and shipment.

The Factory Acceptance Test will ensure that the checkweigher is delivered with a design (containing construction and electronic details) matching the application; the test will also ensure that the checkweigher is in a condition that meets the performance requirements i.e. accuracy and throughput that has been specified.

10.3 Documentation Beyond the Operation Manual Can Earn You Money

It is worth asking the checkweigher manufacturer for supplementary instructions, such as bespoke machinespecific cleaning instructions, which provide more in-depth explanations and detailed illustrations.

These instructions would enable the user to ensure that cleaning routines were thorough and time-saving – whilst also avoiding incorrect cleaning treatments.

Further examples of extra documentation are special short-form operating instructions detailing only with relevant actions, such as how to re-start the checkweigher after a shift change.

This kind of highly specific information can be found quickly and easily, minimising the unnecessary looking-up of instructions or excessive and irrelevant amounts of reading for the production line operator.

In addition, a Functional Design Specification (FDS) can be required for both validation purposes and technical production-line integration purposes – and checkweigher manufacturers should be able to provide such customer-specific documentations.

Start-up Documentation Set

In addition to the usual user manual containing operating instructions, some checkweigher manufacturers can supply customers with helpful documentation which accelerates routine operations and makes them easier to carry out. For example, a start-up documentation set can comprise some (or all) of the following:

- A checklist form in which the service technician/service engineer ticks the check-boxes to indicate the jobs/activities they undertook when installing and commissioning the machine. Having completed the form, the service technician should then sign it
- A short instruction sheet detailing the tasks that the new operator must carry out, or check, after a change of shifts
- A short instruction sheet detailing cleaning instructions (different versions of this description may exist for different protection classes i.e. ‘IP equipment degrees)

Various other instructions may exist for other activities, such as manual adjustment of special conveyor systems or starwheels, according to changes in product size. For ease of use, all these documents should be properly illustrated with easy-to-understand pictograms or photos that accompany the instructions or descriptions.

Equipment Qualification Documents

Equipment qualification documents support the process of routine machinery ‘health checks’ at regular intervals. An experienced checkweigher manufacturer can provide easy-to-use forms – or even software tools – that help ensure equipment will be maintained in optimum operating condition.

Regular equipment qualification can demonstrate gradual losses in machine performance (i.e. accuracy or maximum attainable throughput) at an early stage, so that remedial action can be taken.
Enhancing the Equipment Efficiency and Sustaining Performance

A modern checkweigher is capable of more than simply weighing and reliably sorting non-conforming products whose weights do not accord with predetermined specifications; the software features and options available from the checkweigher supplier can provide far more control over production processes, making the most of valuable resources by increasing productivity reducing waste, and improving the overall efficiency (OEE) of the production line.

11 Enhancing the Equipment Efficiency and Sustaining Performance

11.1 Reporting
11.2 Data Communication
11.3 Process Control
11.4 Spotting Invisible Losses by Determining the Overall Equipment Effectiveness (OEE)
11.5 Calculating OEE as the Basis for Improvement
11.6 Improving the ‘Availability’ and ‘Performance’ Components of OEE Through Proper Maintenance
11.7 Keeping Score and Sharing Results
11.8 OEE Software
11.9 Make OEE Part of the Investment Decision Making Process

These additional processes are not essential for a basic checkweighing programme, but should be considered for more demanding and complicated application requirements.

11.1 Reporting

The reporting needs of the product, process, and the other stakeholders within the organisation can be greatly improved by using a checkweigher. For example, if there is already a sophisticated data acquisition solution within the facility, the checkweigher can send weights out to a remote computer via a serial or Ethernet TCP/IP port.

This method is probably the easiest way to generate reports customised to the needs of the facility; however, the checkweigher should be an integrated part of a production process, providing valuable real-time feedback to upstream devices. Consequently, an interface to a Programmable Logic Controller (PLC) or Supervisory Control and Data Acquisition (SCADA) program may be required.

Further add-on software programs are often available, and these are specifically designed to collect information from the checkweigher. Such programs generate production analysis and documentation (i.e. statistics), including graphical reports by batch, hour, shift, day and week (or even year) to fit standard operational procedures.

This software enables production data to be centrally monitored and recorded for security and compliance; it also measures quality, and ensures that processes are under control. The software should be compliant with the legal regulations of most countries, including uniformity tests for pharmacopoeia.

In general, most software programs enable connection of multiple checkweighers to a single program within the facility network. Frequently, a checkweigher installation will require all types of connections to drive real-time control optimisation, whilst also delivering the ‘as inspected’ historical data. It is important that the checkweigher can perform both tasks automatically and simultaneously.
Some checkweighers have reporting and statistics capabilities which can be viewed on-screen, stored on a USB stick or printed on internal and external printers. The print-outs are a simple and inexpensive way to collect weight records and statistics. However, print-outs do not have the dynamic capabilities of data stored in a computer.

The controller can print out for specific reasons, such as:
- At regular time intervals
- At certain times each day
- After a given number of items are weighed
- When the product setup is changed
- Upon request.

For most statistics-generating software provided by the checkweigher supplier, different versions will be available, depending on factors such as individual needs, the country of operation, and requirements for a certain sector of industry.

### 11.2 Data Communication

The checkweigher manufacturer should be able to supply a satisfactory data communication solution i.e. a data communication interface with additional control programs.

#### Fieldbus Networks

Fieldbus networks such as DeviceNet, ControlNet, Ethernet/IP, Profinet, and others have become increasingly standard in manufacturing and packaging industries – and some checkweigher suppliers have designed PLC interfaces to common PLC formats, for seamless integration into production lines.

The checkweigher supplier should be asked what level of integration they provide for PLC support, and an interface guide should be available, detailing the exact level of integration that can be achieved from the interface.

The level of integration should range from basic weight readings to the sophisticated upload and download of data and commands. Together, these should be able to provide a high degree of automation.

Once the checkweigher is integrated within a fieldbus network, the checkweigher can be controlled through any of the following:
- The PLC directly
- A DCS (Distributed Control System)
- A Supervisory Control And Data Acquisition (SCADA) system. SCADA systems are very beneficial for process integration control because they provide a single factory-floor point of control for all machines which may be controlled by a fieldbus network.

#### OPC

As an open connectivity standard, OPC (OLE for Process Control) is also becoming increasingly important as a standard methodology for connecting applications. OPC is a technology designed to bridge many Windows®-based applications and process control hardware, and its open standard permits a consistent method of accessing field data from devices on the factory floor.

The access method remains the same, regardless of the type and source of data, so checkweigher owners are free to choose software and hardware that meet their primary production needs, without having to consider the availability of proprietary drivers.

In addition, owners of OPC-compliant checkweighers can potentially interface systems to SCADA systems or other control devices more quickly, so as to reduce deployment time and costs. As with fieldbus interfaces, the checkweigher supplier should be able to provide an OPC server interface guide which will provide details of interface structure and capabilities.

### 11.3 Process Control

#### Filler (filling machine) Accuracy

The filler (filling machine) is key to effective fill weight control, and the weight distribution of filled items provides the best measure of filler performance. The lower the variation of the filler, the better its performance and the less product will be given away.

Another form of process control is feedback, and this can track the performance of filler heads. It can even control the filler to obtain optimal fill weights. If manual control over the fillers is desired, the checkweigher can simply provide a report on each head, triggering an alarm if a filler head is out of tolerance.

If the target weight of a filler (filling machine) is set two standard deviations off the fill weight (greater than the labelled weight), 95% of the filled items will weigh more than, or the same as, the labelled weight.

If the filler (filling machine) has a smaller standard deviation, as described by the dashed-line weight distribution in Figure 11.1, the target weight can be much closer to the labelled weight, compared to a less precise filler (filling machine).

The filler (filling machine) will optimise the weight variation when:
- The filler is suited to the product
- The filler is in first-class condition
- A uniform product flow is entering the filler (filling machine)

---

**Figure 11.1: Filler (filling machine) accuracy**

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Feedback

Feedback control from a checkweigher can minimise product weight errors and product giveaway introduced by filler drift. (Figure 11.2). The drift may be caused by slow changes in the environment – or it may be caused by product characteristics (e.g. product density drift).

Note: Where a checkweigher provides feedback to a filler (filling machine), its accuracy compensates for the product changes, but does not improve filler performance.

Step 3 (Figure 11.5) shows that the time delay is equal to the time taken to weigh packages which had left the filler (filling machine) before the checkweigher signalled a change.

In Step 4 (Figure 11.6), the downward filler drift is corrected by feedback.

Minimising False Rejects Caused by Gradual and Consistent Changes in Product Weight

‘Floating Zones’ or ‘Gliding Limits’ software (also referred to as ‘Mean Value Tracking’) adjusts the target value and zone limits of a checkweigher to compensate for gradual and consistent changes in product weight. The software detects trends, based on short and long-term means.

A common application for this software is weighing paper or cellulose products such as nappies, where it is important to verify the right number of individual items within a larger package. Ambient temperature and humidity fluctuations will increase or reduce the moisture content and the weight of the paper, and these changes will occur gradually.

Figure 11.2: Filler drift

The checkweigher and filler (filling machine) are in constant communication, ensuring that if a weight drift is detected, it can be rectified before it has a negative influence on production.

Step 1 (Figure 11.3) shows a downward filler (filling machine) drift detected by the checkweigher. If this trend continues, the fill weight variation will increase and items may be filled underweight.

With checkweigher feedback, a signal is sent to the filler (filling machine) to adjust the fill, as in Step 2 (Figure 11.4). There is a time delay, during which the checkweigher will not instruct the filler (filling machine) to make adjustments.

As the distance between the filler (filling machine) and the checkweigher increases, more packages will be located between the filler and checkweigher during any particular time-period.

If there is an increase in the number of packages that are placed in the checkweigher queue, the time delay for feedback to the filler (filling machine) will also increase. Ideally, the checkweigher should be located right next to the filler (filling machine) for the most immediate response to changes in fill weight.

Figure 11.3: Checkweigher feedback process to filler – Step 1

Figure 11.4: Checkweigher feedback process to filler – Step 2

Figure 11.5: Checkweigher feedback process to filler – Step 3

Figure 11.6: Checkweigher feedback process to filler – Step 4
11.4 Spotting Invisible Losses by Determining the Overall Equipment Effectiveness (OEE)

After successful implementation of an effective checkweighing programme (including all necessary actions for improving performance), production processes must be constantly monitored to sustain these performance levels – and, where possible, production processes must take further action to improve them.

Some manufacturers, for whom OEE represents best practice, require assessment of Overall Equipment Effectiveness (OEE), which is an effective method of measuring and quantifying the performance of a production line.

It is sometimes difficult to quantify the exact reasons for production losses. However, OEE makes all losses clearly visible, showing which machines and/or processes are responsible for such losses. OEE also measures how much the losses are – and all this data helps manufacturers to take necessary remedial actions.

Usually, a checkweigher is not the cause of unexpected production losses; however, it is often the final item of production-line equipment used for undertaking a last check of products prior to their despatch. This makes a checkweigher ideal for capturing valuable data which can be used to calculate OEE.

Using OEE to monitor production processes will show where production losses are occurring and why they are occurring – but it does not show the root cause of these losses. OEE delivers a value based purely on machine and process production data, and does not take the human factor into account in its calculations.

In its simplest definition, OEE is defined as:

\[
\frac{\text{Actual Good Output}}{\text{Maximum Capable Output}} \times 100 = \% \%
\]

There are three primary factors which need to be taken into consideration when calculating how well a production line is performing. These are:

- Availability
- Performance
- Quality

When considered together, these factors form the basis for measuring OEE.

Improving any of these three factors will result in an improvement in OEE.

11.5 Calculating OEE as the Basis for Improvement

OEE is calculated by measuring actual results for Availability, Performance and Quality, and then comparing them against planned or predetermined standards for each factor. The resulting percentages are multiplied together to determine the Overall Equipment Effectiveness.

‘If you have an OEE of 85 % or greater your production line can be considered to be world-class.’

Availability

Availability is the actual operating uptime, when shown as a percentage of planned production time. 100 % availability means the production line has been running without any unplanned and recorded stops.

Performance

Performance is the actual throughput, shown as a percentage of the maximum or specified throughput. Performance is a measurement of a production line’s ability to run at its maximum specified throughput, and 100 % performance means that the process has been consistently running at its designated maximum throughput.

Quality

Quality is the amount of good products shown as a percentage of all products produced. 100 % quality means there have been no rejected or reworked products.

Calculation Example:

\[
90 \% \text{ Availability} \times 95 \% \text{ Performance} \times 99.9 \% \text{ Quality} = \text{a world-class OEE of 85} \%.
\]
The advantage of OEE lies in the three factors which can be analysed and acted upon individually. Figure 11.8 provides an overview of how to calculate OEE.

### OEE Calculation Example

<table>
<thead>
<tr>
<th>Availability</th>
<th>A</th>
<th>Planned Production Time (480 Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Actual Production Time (360 Minutes)</td>
<td>Unexpected Halts in Production</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance</th>
<th>C</th>
<th>Specified Throughput (10 pcs. per Min. = 360 Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Actual Throughput (2880 pcs.)</td>
<td>Lack of or Poor Maintenance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quality</th>
<th>E</th>
<th>Total Products produced (2880 pcs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Good Products – 2736 pcs.</td>
<td>Underfills, Overfills, Re-work</td>
</tr>
</tbody>
</table>

- Availability = $\frac{B}{A} = \frac{360}{480} = 75\%$
- Availability = $\frac{D}{C} = \frac{2880}{3600} = 80\%$
- Availability = $\frac{F}{E} = \frac{2736}{2880} = 95\%$

OEE = $75\% \times 80\% \times 95\% = 57\%$

**Figure 11.8: OEE calculation example**

### OEE Data Collection and Assessment Form

Date: __________________________

Assessment for (machine/ work cell/ production line) __________________________

(A) Planned Production Time ____________ (min.)

(B) Actual Production Time ____________ (min.)

B/A = ____________% Availability

(C) Specified Throughput ____________ (pcs. per min.)

(D) Actual Throughput ____________ (pcs. per min.)

D/C = ____________% Performance

(F) Total Products Produced ____________ (pcs.)

(F) Good Products ____________ (pcs.)

F/E = ____________% Quality

OEE = ____________%

If you have an OEE of 85% or greater your production line can be considered to be world class.
11.6 Improving the ‘Availability’ and ‘Performance’ Components of OEE Through Proper Maintenance

Some companies follow ad hoc or routine maintenance procedures without considering the impact of proper planned maintenance on the Availability and Performance components of OEE.

The primary focus of an effective maintenance plan should be more extensive run cycles and not faster recovery from unplanned downtime. Proper maintenance leads to more extensive run cycles, as well as even faster recovery after unexpected downtime.

Maintenance should never be neglected; all checkweighers require regular maintenance so that they can keep functioning at their specified ideal run rate. If internal resources are not available for carrying out regular maintenance programmes, the equipment supplier should be able to take on this critically important function.

Operators should be thoroughly trained – and in some organisations, the Maintenance team can perform this task, once they are trained by the equipment supplier. If this resource is not available, the equipment supplier can provide customised training programmes based upon specific application requirements.

Well trained, conscientious and proactive operators can substantially improve OEE by firstly recognising potential downtime problems before they occur – and then by applying corrective actions to address those potential problems.

Training should not be a short-term process; all new operators should undergo extensive training on both the checkweigher and its associated processes, so as to result in major improvements to OEE.

It is also important to remember that proper maintenance can have an impact on quality. Correct maintenance enables machines to perform to their original design specifications; in turn, this enables the maintaining of tighter production tolerances, which leads to a more uniform and higher-quality product.

Improving OEE should be regarded as a continuous process and not a one-time project or activity. Small gains can lead to significant OEE improvements over time, but only if continuously observed and monitored. Gains in more than one factor lead to even greater gains in OEE, with the resulting cost savings and increased profits.

11.7 Keeping Score and Sharing Results

It is important that OEE information is shared with production personnel. Highly skilled and conscientious operators who understand how check weighers work (and how they can be used to obtain the best all-round results) can make an enormous contribution to finding solutions for check weighing problems. For these reasons, such operators should be involved and motivated at all times.

Experts strongly recommend installing a simple monitoring system such as an LED display in key areas of the facility, so that manufacturing personnel can see production-line OEE in real time. Lack of visible awareness of OEE masks the impact, gains or reductions that OEE can have on sustaining production-line performance.

Once the basic factors for calculating OEE are understood, tools can be developed to collect the information and undertake the calculations.

It is recommended that OEE calculations should start by monitoring a single checkweigher, as follows:

- Take measurements i.e. collect data, identify individual problems and develop solutions
- Measure again to see if there has been improvement; continue this exercise on an on-going basis
- Extend this process by measuring a work cell or a complete production line; follow the same process
11.8 OEE Software

When implementing an OEE programme, consideration should be given to using professional software solutions that will help considerably to increase and sustain a high OEE value. Many companies provide software and solutions for managing OEE.

A good OEE software package helps to create a paperless shop floor. Without such a software package, facility operators and supervisors can spend an enormous amount of administrative time recording, analysing and reporting downtime reasons on paper, then explaining these paper-based reports to management.

An OEE system automatically captures and reports downtime and efficiency. This eliminates time lost in non-value-added reporting activities, plus it allows personnel to focus on more valuable tasks.

In addition, everyone within the manufacturing facility, from the production line to the boardroom, is better informed, on a more frequent basis – and with less effort than paper reporting.

More important, a good OEE software package can:

- Identify the opportunities and actions required to cut production losses and increase capacity
- Portray the real cost of all downtime, idle time, yield-loss, rework, and scrap process losses
- Deliver accurate analytical data to drive successful Lean Manufacturing and Six Sigma initiatives
- Provide a substantial competitive advantage for the manufacturing business in the overall supply chain

11.9 Make OEE Part of the Investment Decision Making Process

OEE can also be employed to avoid making inappropriate purchases by improving the performance of current machinery and plant resources. When investment in new machinery is necessary, equipment should be provided by equipment suppliers who understand OEE.

When drawing up supplier contracts, it is essential to specify output-driven performance measures for new processing machinery. OEE measures can be used to make sure that new equipment performance satisfies the original reasons for acquiring that new equipment in the first place.
Setting Limits

Once the checkweigher has been installed and commissioned, and its functionality has been verified, it can be used on the production line. For each type of product being weighed, there will need to be upper and lower zone limits, and this chapter explains in detail those zone limits, as well as their role as an essential part of any checkweighing programme.

12.1 Setting Limits

Zone limits are also known as ‘classification limits’; these are the weight values automatically set by the checkweigher or manually entered by the operator, and they establish the cut-off point between consecutive weight zones.

Zone limits are a filter to allow only acceptable weight packages to continue through the flow of production. The exact setting of the zone limits depends on packaging regulations, plus individual objectives and control process.

If the checkweigher accuracy is ±1 gram, there is a chance that a package may either be accepted or rejected if its weight is within a gram of the zone limit. Therefore, the zone limits should be set at a point where there is no chance that an unacceptably underweight or overweight package can be accepted by the checkweigher.

A ‘weight zone’ is the interval between the zone limits, and most checkweighers have 3 or 5 weight zones. Some checkweigher manufacturers refer to 2 zone or 4 zone limits, but this has the same meaning.

On a 3 zone (2 zone limits) checkweigher, the centre zone between the upper and lower zone limits indicates the range of weights which are acceptable. On a 5 zone (4 zone limits) checkweigher, the centre zone is usually the ‘accept’ zone and the weight zones on either side are ‘warning’ weight zones to alert the operator if items are of a marginally acceptable weight.

The two outside zones on a 3 or 5 zone checkweigher are for unacceptable weight items.

Figure 12.1: A five zone Checkweigher
12.2 How to Determine the Optimum Zone Limit Settings

Zone limits are set in accordance with the acceptable weight variation of the items being weighed, and are dependent on the accuracy of the checkweigher. Setting zone limits depends on the objectives which have been set for the checkweighing programme, as well as on the variability of upstream devices and packaging materials that are employed.

It is important to understand that the tighter the zone limits, the more likely it is that acceptable items will be classified incorrectly. However, tighter zone limits also drive improved metrics, which leads to better process control. This will ultimately create products with reduced variability and more consistent quality.

There is often a misunderstanding about the combination of tolerance levels, standard deviation, and accuracy. This may result in many producers setting limits artificially higher than necessary just to be safe, but there is absolutely no need to do this.

Note: Under normal circumstances, all modern checkweighers are pre-programmed with the allowable weight variance tables contained in the OIML guidelines and NIST Handbook.

The accuracy of the checkweigher is critical at the weight zone limits. Consider a 110 g item which is passed over the checkweigher, as described in Figure 12.2. The graph shows the checkweigher’s normal distribution curve for a 110 g item; it also shows that 95% of the time, a 110 g item will be classified by the checkweigher as falling between 109.8 g and 110.2 g.

99.7% of the time, the items will be measured between 109.7 g and 110.3 g. The indecision or accuracy is that at 110.0 g it is as likely that the item will be classified in Zone 3, as in Zone 2. The checkweigher measurements will vary a small amount with the repeated measurement of a single weight. The checkweigher variance is independent of the variation of the actual weight, from one item to the next.

For example, in Figure 12.2, the checkweigher variance is depicted as a frequency histogram of measurements of a 110 gram item. The actual weight may vary acceptably from 100 to 130 grams, but the checkweigher measurements will vary only up to 0.6 grams for any given item.

The appropriate table can be selected in accordance with the installation location. When entering the nominal weight of a product to be weighed, the checkweigher will automatically calculate the legal zone limits and display them on screen for acceptance. This automatic calculation also takes into account the checkweigher accuracy.

If the automatic setting is accepted, then the calculated zone limits will allow the checkweigher to classify and sort products correctly in accordance with these guidelines and regulations.

There are circumstances in which it is desirable to manually set the zone limits. These include:

• When local packaging regulations are not based on the OIML guidelines or NIST Handbook
• When requirements for weight variance are stricter than local laws and packaging guidelines
• When internal company guidelines demand a more consistent quality

12.3 Filling Applications

Determining zone limits can be achieved as follows:

1. Define the target weight (Figure 12.3)
2. Select the goal for percent rejects, based on production costs and the checkweigher zone limits
3. Calculate the target weight based on filler variance and percent rejects

It is important to establish the maximum acceptable variations above and below the target weight (Figure 12.4), and the satisfactory definition of these variations depends on national laws in the respective country. For example:

• NIST Handbook 1334 identifies the maximum allowable variations for items sold by net weight in the USA (“Checking the Net Contents of Packaged Goods”)
• FPVO (Fertigpackungsverordnung) provides for similar allowances in Germany – and for Europe refer to OIML R67
In Germany, the regulations which govern the minimum allowable weight variation are based on the OIML guidelines, and state that the weight of a product with a labelled weight of 100 g is allowed to be up to 4.5 g (T1 – in this case 95.5 g) underweight, but must never fall below 9 g (T2 – in this case 91 g).

In addition, it is allowable that a maximum of 2 % of the total production may have a weight between 95.5 g (T1) and 91 g (T2). However, the ‘mean’ (or average) weight of the total production is not allowed to fall below the labelled weight of 100 g.

Note: If manual limits are set, it is strongly recommended that a copy of local packaging regulations is available and referred to, in order to ensure compliance with regulatory standards. It is also advisable to contact a local government representative or a service technician for help or for additional details, if necessary.

Many modern checkweighers which have statistical reporting functions allow the user to additionally set ‘statistical limits’ that can be identical with the set weight zone limits — or different, depending on what the statistical reports shall be based upon.

Within the checkweigher ‘Zone of Indecision’, the measured weight can vary slightly from the actual weight (see ‘Checkweigher Accuracy’ in the next chapter, paragraph 13.9).

Because of this variation, it is recommended that the acceptable weight zone limit should be tightened by the accuracy of the checkweigher (i.e. by 2 or 3 standard deviations from the maximum and minimum weight variations).

This will ensure that all products which have an actual weight equal to (or within 2 or 3 standard deviations from) the zone limit are correctly classified. The zone limits can be adjusted accordingly, as in Figure 12.5. The reject zones are depicted as the shaded areas.

If the zone limits are tightened by two standard deviations of the checkweigher accuracy from the maximum and minimum acceptable weights, then at least 95 % of the accepted items will be classified correctly. A more conservative adjustment of three standard deviations of the checkweigher accuracy will ensure that 99.7 % of the items are classified correctly.

Example: Reliably reject all products with an actual weight of 95.5 g or less. The checkweigher accuracy is ± 0.3 g at ± 3 σ (when this checkweigher is used, the accuracy of a product with an actual weight of 95.5 g could have a weighing result anywhere between 95.2 g and 95.8 g).

With reference to the table in Figure 12.6, when zone limits are adjusted by 2 or 3 standard deviations, these can affect checkweigher accuracy, to the extent that the actual weight can be measured as equal to (or below) the targeted reject weight.
Figure 12.6: Impact of adjusting zone limits

This shows the relationship between zone limits and checkweigher accuracy, and demonstrates that a tightening of the zone limit by 3 $\sigma$ ensures that all products with an actual weight of 95.5 g or less will be reliably rejected.

When filling products that are subject to net content regulations, the target weight must be set at some point above the labelled weight of the package. The checkweigher will help to regulate how much product that will be given away by rejecting underweight packages. This will allow for a lower target weight.

However, the checkweigher may only be as good as the preceding processes. If there is little control over the variation in the tare weight of the container, the checkweigher following the filler will provide an accurate gross weight (not a fill weight). The fill weight can therefore fall outside the limits that have been set.

A tare-gross system weighs empty containers and then weighs full containers, and can be used to account for container weight variation. The same is true for any application – and the greater the weight variation of individual components, the more difficult it will be to check the weight of an individual component, regardless of the accuracy of the checkweigher.
12.4 Applications for Counting or Looking for Missing Pieces

If a package count or a search for missing items is being undertaken, the first consideration should be the mean weight distribution of the lightest item. The total (collective) mean weight distribution should be compared with the weight distribution, plus and minus the smallest or lightest item.

This process may not be as crucial if there are extra pieces, as opposed to a missing piece – in which case, the zone limit should be set at the points where it can be certain that the count is correct.

Figure 12.7 shows the lower zone limit in comparison with the weight distribution curves of both the target package and a package which is missing an item.

Figure 12.8 shows what will happen if the individual piece weight is less than the total product weight variation.

The zones can be narrowed by the accuracy of the checkweigher. As illustrated in Figure 12.7 and Figure 12.8, the lower the uncontrollable weight variation of items (compared with the weight of each item), the more effectively a checkweigher will detect a missing item correctly.

In Figure 12.8, the distribution is so great that the checkweigher will reject ‘good’ items in order to reject the items which are missing pieces, regardless of checkweigher accuracy. In this case, a tare-gross system may help with high container weight variance.

An alternative is to consider evaluating the production processes of the individual product components, or to add an X-ray machine to the checkweighing system in order to detect broken or missing items.
Load Cell Technology

Every checkweigher supplier has their own uniquely designed weighing technology, including their own individually designed type of load cell and their own particular method of signal processing.

13.1 The Right Type of Load Cell

Selection of the right type of load cell arises from the accuracy specifications required for the application; load cell choice also depends on environmental and product-handling parameters.

So before selecting the preferred load cell technology, it is important to determine what level of dynamic weighing solution accuracy is required. This is directly linked to the speed, stability and properties of products being weighed – and up to a certain point, accuracy increases as conveyor speeds and line throughput decrease.

The more stable the item is during weighing, the greater the accuracy will be – and most checkweigher suppliers will be able to offer a system that can meet the accuracy requirements demanded by the application. The highest-precision checkweighers may, however, be limited by product size, weight, throughput and the system environment.

There are many different weighing technologies, but the two most common load cells used in checkweighers are strain gauge load cells and EMFR load cells – which are load cells that operate on the principle of electro-magnetic force restoration.

13.2 Strain Gauge Load Cell

The strain gauge load cell has two major components:

1. A flexible strip on a load-bearing surface (which acts as a ‘carrier’ for the strain sensor), and
2. The strain sensor

Load cells are often provided with external mechanical overload stops to prevent damage to the load cell if the load exceeds the weighing capacity. When there is a load on the weighing platform, the strain gauge load cell measures the strain (Figure 13.1) or proportional compression or elongation (yield) of the sensor material within the load cell.

The strain is measured as a small voltage output, and the output varies in a linear manner along the weight capacity of the cell, as load is added or removed from the weighing conveyor.
The controller translates the voltage to a meaningful weight, based on the system calibration.

In practical applications, there are a number of influencing factors which can cause the output to deteriorate and lead to inaccuracies in the resulting weight readings. These influencing factors include:

- Temperature gradients – strain gauges are sensors, and will sense any change in their condition. When temperatures are constant, the load cell is stable and there is no adverse effect. If the temperature changes rapidly, the strain gauges sense the temperature change, and the result is an alteration in the output, which the controller will interpret as a change in weight. The two most common examples of rapid temperature changes are when the load cell is subjected to high-temperature water or steam during a cleaning process or where the area is not environmentally controlled. Under these latter circumstances, the temperature in the morning may be a comfortable 20°C, though by noon it could easily have risen to a measurably hot 35°C.

- Load cell material – all strain gauge load cells are constructed from a base metal that has certain spring characteristics. Ideally, the load cell is a perfect spring; therefore it is both repeatable and linear. However, in most cases, the base material is not a perfect spring and may show slight differences in the actual load that is sensed when comparing the output values. These values will be, firstly, the load increases from zero to full capacity and, secondly, as it returns from full capacity back to zero.

- EMI and RFI influences – changes in the output of a strain gauge load cell are measured in millivolts by the checkweigher controller, and the distance between the load cell and the controller can be anything from just a few centimetres to many metres. Devices which emit strong electromagnetic and radio frequency interference (EMI/RFI) such as walkie-talkies, large motors, or medium-to high-voltage distribution panels, can cause a change in the load cell signal – and this may well result in an erroneous weight reading. While these factors do present potential inaccuracies for the weighing system, it is important to understand that a quality checkweigher manufacturer can provide sound installation strategies and precision components, both of which reduce the effects of these influences. Factors which affect checkweigher accuracies are discussed in more detail below.

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**How Does a Strain Gauge Load Cell Measure Weight?**

A strain gauge is a thin film resistor whose resistance changes as the film flexes under load. A strain gauge load cell contains four strain gauges and fixed resistors connected in the same way as a Wheatstone Bridge – which is an electrical circuit used to measure an unknown electrical resistance. A Wheatstone Bridge operates by balancing two legs of a bridge circuit, one leg of which includes the unknown component.

The load cell passes a small voltage across the gauges. When the load cell is balanced, each of the gauges has the same resistance (Figure 13.2).

When a force is applied to the load cell, the resistance is displaced unevenly across the bridge, creating a change in the voltage output. Ideally, the changes occur in a linear manner along the capacity of the load cell. The voltage change can be readily converted to a weight output (Figure 13.3).

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**Figure 13.1: Unbalanced load cell (force applied)**

**Figure 13.2: Balanced load cell (no force applied)**

**Figure 13.3: Unbalanced load cell (force applied) weight variation**
13.3 Electromagnetic Force Restoration (EMFR)

A load cell is an intelligent sensor which measures the increased current and converts it to a weight. EMFR load cells can be more accurate and can measure at a faster rate when compared with a strain gauge load cell. However, a wider range of strain gauge load cells is available – and in some applications, they may be better suited to installation due to their smaller size and simplified mechanical construction.

EMFR load cells gain their significant advantage by using the latest enhancements in weighing technology to improve performance and provide sustained accuracy. EMFR load cells are intelligent sensors which control and compensate for a variety of functions that can directly influence the weighing performance, such as:

- Sampling rate
- Temperature compensation
- Filtering and noise reduction

EMFR load cells are equipped with a high-performance digital signal processor, which allows for the use of advanced software filtering techniques. These filter algorithms make it possible to sample (or take more readings of) the weight of the package as it passes across the checkweigher.

So, the more often the weight can be measured, the more accurate the final weight should be.

The EMFR load cell also incorporates a precision temperature sensor and temperature compensation library which, together, eliminate the effect that changes in temperature may have on the load cell’s performance.

As described in the previous section, strain gauge load cells require some time to stabilise after cleaning and sanitising with hot water. An EMFR load cell will allow production to start immediately after cleaning, without any negative impact on accuracy.

EMFR load cells also have the capability to ‘learn’ the unique noise pattern of the checkweigher as it is processing packages – and each checkweigher will exhibit a unique noise profile while it is running (Figure 13.4).

The EMFR load cell will automatically determine the best filtering algorithm to use, based on information it processes whilst the checkweigher is weighing. If something changes during the course of production (such as increasing the line speed to increase throughput, or if a conveyor bearing begins to wear and no longer rotates freely), the noise profile of the checkweigher will also change.

The EMFR load cell will detect and ‘learn’ the new noise pattern, and will make the required adjustments to ensure that the greatest possible accuracy is achieved and sustained – all without any operator intervention. In the case of the worn bearing, the operator or service technician will be alerted to the fact that the bearing is wearing, and so they will be able to take remedial action before the bearing fails. This type of functionality is impossible with traditional strain gauge load cells.

It’s worth remembering, however, that there are some drawbacks when using EMFR load cells. For example, they are larger in size than strain gauge load cells and require more complex mechanical integration for their use in a checkweigher.

In addition, the initial investment in an EMFR-based checkweigher is more expensive, especially when compared to a checkweigher supplied with a strain gauge load cell. However, the difference in initial costs becomes insignificant when weighed against the savings that improved accuracy will deliver over the life of the checkweigher.
How Does an EMFR load cell Measure Weight?
A rod (resting within a magnetic field) within the load cell deflects when a load is applied (Figure 13.5). When the rod is displaced, a sensor tells the load cell to apply a force to restore the rod to its resting position. This requires the load cell to increase the current through its coil.

When the current is increased, an upward force is generated within the magnetic field, according to the electro-dynamic ‘right-hand rule’. The load cell increases the current through the wire until the upward force matches the load, and the rod is realigned. The change of the current intensity ‘describes’ the weight.

13.5 Reject Mechanism Design
Reject systems are an important part of checkweighing systems, because they ensure that underweight and overweight products are effectively and reliably rejected from the production line. A correctly specified system should be foolproof and capable of rejecting all underweight and overweight products under all circumstances. See Chapter 4 for further details.

13.4 Weights and Measures Approval
Weights and Measures approval has an impact on choosing the correct load cell for the checkweigher – and when selecting a checkweighing system, the following factors should be considered:

- Whether Weights & Measures approval is required
- The maximum weight of the products to be weighed
- The level of accuracy required

Every checkweigher supplier requires this information during the process of configuration, system design and definition of the correct load cell technology. This information will also have a direct impact on the resolution of the weighing indicator. For more metrological information, see Chapter 6.
Checkweighing and Statistical Process Control (SPC)

14.1 Principles of Checkweighing and SPC

Legal standards state that the average weight of packages comprising a ‘lot’ or ‘batch’ should be equal to or greater than the labelled weight. Legal standards also state that no single package should weigh significantly less or more than the labelled weight.

To meet these legal requirements, and maintain an efficient packaging operation, the checkweigher operator and supervisor must understand the principles of checkweighing and Statistical Process Control (SPC). This knowledge enables companies to reduce problems resulting from underweight and overweight products.
14.2 Statistical Data Analysis

Products travelling along a production line are subjected to several hundred random events, such as air currents, voltage peaks, humidity, changing product density and the effects of mechanical devices involved in the filling process.

Because of these random events, the same fill weight cannot be achieved on every occasion; each weight will vary slightly from one package to another, and as long as events affecting the filling are actually random and equally likely to occur, the weights will follow the laws of standard distribution. These laws are also referred to as the ‘normal distribution’ (see Figure 14.1).

The Mean (or Average) is the sum of all values, divided by the total number of values. Consider five bags, with the following weights in kg: 8, 9, 10, 18, and 20 (as shown in Figure 14.2).

\[ \text{Mean weight} = \frac{8 + 9 + 10 + 18 + 20}{5} = 13 \text{ kg} \]

To avoid underweight products, the target weight for the process is usually set slightly above the labelled weight. If the mean weight is (or above) the target, there is a good chance that the company will produce a legally compliant product, but this is not guaranteed.

The variation of those weights must also be considered. Assume, in Figure 14.2 that the labelled weight on a bag is 10 kg and that the target weight is 11 kg. According to a mean weight of 13 kg, production is above the target and legal requirement, but examining the individual weights indicates that two bags are underweight, that one is correct and that two are grossly overweight.

In this example the mean value is compliant, but it does not accurately inform the user of process health or compliance. A second value is required to determine how far each bag weight is from the mean: this will also define the spread of the data.

Mean

The Mean (or Average) is the sum of all values, divided by the total number of values. Consider five bags, with the following weights in kg: 8, 9, 10, 18, and 20 (as shown in Figure 14.2).

In a ‘Normal Statistical Distribution’, 68 % of values are within 1 standard deviation away from the mean (μ) of the total production population; 95 % of the values are within ±2 standard deviations and 99.7 % lie within ±3 standard deviations.

This is known as the ‘68-95-99.7’ rule. The rule states that, for a normal distribution, nearly all values lie within ±3 standard deviations of the mean. To define and understand a normal distribution, two statistical terms need to be understood:

- The Average or Mean, denoted \( \mu \) (pronounced ‘mu’)
- Standard Deviation, denoted \( \sigma \) (pronounced ‘sigma’).

Note: The Mean can also be denoted as \( \bar{x} \) (x-bar), and is often used as a technical term when describing the mean of a set of values. Traditionally, this is used when differentiating the mean of a sample (x-bar) versus the mean of the entire population (μ).

Standard Deviation

The standard deviation of the population describes the spread of the weighing results from the mean of a normally distributed population. In Figure 14.3, the two different curves have the same mean, but different standard deviations. The blue curve has a greater standard deviation than the green curve.
Checkweighing and Statistical Process Control (SPC)

Compare the lines on either side of the mean in Figure 13.5, labelled $\mu-1\sigma$ and $\mu+1\sigma$. As previously described, these lines represent boundaries between which 68% of all weight data fall between the mean, minus one standard deviation – and the mean, plus one standard deviation.

These lines will move as the standard deviation changes, but the percentages between them remain constant. Returning to the bag example from Figure 14.2, the standard deviation is 5.6 kg and the mean is 13 kg. Using the definition in Figure 14.1, it is known that 68% of all bags fall between 7.4 kg and 18.6 kg. However, this result is not satisfactory, as it is only 68% of the bags.

To find the standard deviation of the data in the previous sample, use the formula and follow the steps as shown below.

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

$x_1, x_2, ..., x_n$ are the weights from the sample.

$\bar{x}$ is the mean of the sample.

$S$ represents the standard deviation of the sample and is an adequate representation of $\sigma$.

**Follow these steps:**

1. For each value $x$, subtract the overall mean $\bar{x}$ from $x$, then multiply that result by itself (also known as determining the square of that value).
2. Add up all those squared values.
3. Divide that result by $(n-1)$ where ‘$n$’ is the total number of weights taken in the sample.
4. Determine the square root of the overall result which yields the standard deviation for the sample population.

**Step 1:**
The mean weight is $(8 + 9 + 10 + 18 + 20)/5 = 13$ kg

**Step 2:**
Find the deviation of each number from the mean

- $8 - 13 = -5$
- $9 - 13 = -4$
- $10 - 13 = -3$
- $18 - 13 = +5$
- $20 - 13 = +7$

**Step 3:**
Square each of the deviations, which amplifies large deviations and makes negative values positive.

- $(-5)^2 = 25$
- $(-4)^2 = 16$
- $(-3)^2 = 9$
- $(+5)^2 = 25$
- $(+7)^2 = 49$

**Step 4:**
Sum up all of these squared deviations and divide the result by the quantity of samples minus one (spread of the sample data)

$$\frac{25 + 16 + 9 + 25 + 49}{5 - 1} = 31$$

**Step 5:**
Take the non-negative square root of the quotient (converting squared units back to regular units)

$$\sqrt{31} = 5.567$$

**So the standard deviation of the set is 5.6**

Note: Microsoft Excel® has a statistical function ‘STDEV’ which you can use to quickly calculate the standard deviation for a set of weights.

Returning to the bag example, what would the range be at ±2 standard deviations – or 95% of the production yield? Since one standard deviation ($1\sigma$) is equal to 5.6 kg, then $2\sigma$ equals 11.2 kg. The range of weights (based on the 13 kg mean value) would be 1.8 kg to 24.2 kg.

In Figure 14.3 the blue curve represents this series of results. What if the existing filler was replaced with a newer version that allowed for finer adjustments which yielded the following sample weights: 13, 12, 14, 12, 14 kg?

The new mean, based on these samples, is still 13 kg – but the standard deviation is now 1 kg. At two standard deviations (or 95% of the anticipated yield), the range is now a very tight 11 kg to 15 kg. This improvement is represented by the green curve in Figure 14.3.

In the production process, the standard deviation of the product weight is largely determined by the characteristics of the filler. One goal of checkweighing and SPC is to determine the mean and standard deviation values, so that the filling process can be controlled by raising the mean in such a way that the required percentage of the bell curve (the shape which is determined by the standard deviation) is above the legal limit.

Definition: ‘Standard deviation’ is the spread of data around the mean of a normally distributed population or sample.

14.3 Defining Accuracy

When measuring the overall accuracy of a checkweigher, the two most important factors are linearity and repeatability. In addition, the word ‘accuracy’ is interpreted differently for static weighing and dynamic weighing. Consequently, checkweigher accuracy statements can be extremely confusing.

Depending on the supplier, any one of the statements in Figure 14.4 could be correct. All six of the statements represent a checkweigher which has an accuracy of 0.5 grams at 1 sigma (1 standard deviation). When considering various quotes, it is important to translate the accuracies quoted into a common standard. Alternatively, a potential supplier should be asked to state the accuracy in a specific format.
Static Accuracy

Accuracy is simply the ability of the scale to measure a known weight value correctly – for example, placing a 100 gram weight onto the scale and seeing if it weighs exactly 100 grams.

The difference between the actual weight and the indicated weight is referred to as the ‘error’. The smaller the error, the better the accuracy of the system.

Linearity

Linearity is the capability of the checkweigher to follow the linear inter-relationship between the load applied and the displayed weight value. An example would be to use a series of test weights from 1 gram to 100 grams, in 1 gram increments. The fewer displayed weight value deviations that occur, the better the linearity of the system.

Mean Error

The mean error describes the average difference between the indicated and actual weight of a package.

Repeatability

Repeatability is also sometimes referred to as ‘precision’. This is the checkweigher’s ability to weigh consistently over time. Using the same 100 gram weight, if it was placed on and off the checkweigher 100 times, how many times would a value of 100 grams be obtained, versus another value in dynamic operation mode?

Plotting accuracy and precision is very similar to target practice: the closer you are to the centre of the target, the more accurate are the results. Each ‘hit’ on the following diagrams symbolises one weighing of a particular item – and the following test scenario uses four checkweighers, with an item then weighed five times on each checkweigher. The centre of the target symbolises the static weight of the item measured on a calibrated static scale.

Figure 14.5 shows a checkweigher whose results are very inaccurate and not repeatable. The results are not grouped together or near the centre of the target. Generally, if a result such as this occurs, a part of the process has failed and requires immediate attention.

Figure 14.6 shows a checkweigher whose results are accurate but not repeatable. The results are grouped loosely around the target and would yield a performance curve that would be characterised by a very low mean error and a high standard deviation.

While the middle of the target can be hit, the aim is not sufficiently accurate to hit the centre of the target. When results such as these are obtained, slight adjustments to the checkweigher may be able to create a tighter grouping around the centre of the target.
Figure 14.7 shows a checkweigher whose results are repeatable but not accurate. The results are closely grouped but off-centre. This would yield a very low and favourable standard deviation; however, the mean error would be very high. While this type of performance is not desirable, it can be easily corrected using the dynamic correction factor of the checkweigher.

Figure 14.7: Repeatable, but not accurate – low standard deviation, high mean error

Figure 14.8 shows a checkweigher whose results are accurate and repeatable. All results are closely grouped around the centre of the target, and would yield both a low standard deviation plus a low mean error over the entire production run.

Figure 14.8: Accurate and repeatable – low standard deviation, low mean error

14.4 Checkweigher Accuracy

Checkweigher accuracy is defined as the sum of the standard deviation and the mean error of the weighing results of a single item, run across the checkweigher several times.

Checkweighers can easily avoid or compensate for high mean errors. So how can checkweigher accuracy be determined? Typically, checkweighers cannot weigh items as accurately as a comparable static scale. When determining the accuracy of a checkweigher, the standard deviation must be calculated first.

The term ‘accuracy’ is actually a measure of the indecision of the checkweigher. In the next example, a single 110 g product is weighed 100 times on a checkweigher. The test is carried out in-motion, with the product passing from the infeed conveyor across to the weigh conveyor and then on to the outfeed conveyor.

The 100 pass test yields a series of weight readings which vary from 109.7 to 110.3 grams, as shown in Figure 14.9. It is important to note that, in this example, the product had an actual weight of exactly 110 g, as determined by a separate calibrated static scale.

Figure 14.9: 99.7 % of results between 109.7 and 110.3g

The resulting test data yields a checkweigher that has an accuracy of ±0.3 g @ ±3σ or 0.6 g @ 6σ.

This test reveals two additional and important factors:

1. An item with an actual weight of 110 g could be shown to have a weight of between 109.7 and 110.3 grams.
2. An item shown in the checkweigher data as having a weight of 110 g could actually weigh between 109.7 and 110.3 grams.

This is also known as the ‘Zone of Indecision’, and it is important to take the Zone of Indecision into account when setting limits.

Definition of Zone of Indecision: range from -3 SD to + 3 SD = 6 SD

Unlike a static scale, many dynamic forces act upon a checkweigher. These forces arise from a wide range of environmental, package and application variables. As a result of these forces, checkweigher accuracy does not equal the achievable accuracy of high-precision balances. Consider the environment around a checkweigher: packages are continuously moving on and off the weighing conveyor, as fast as several hundred per minute.

By way of example, consider the process by which a person weighs themselves on a bathroom scale at home. The person steps on the scale and lets the weight settle until it displays a stable reading. If the person ran around the room and crossed the scale while moving, one would expect the weight readings to vary.

Checkweigher load cells have very short settle times, but because the package never stops moving, the load cell never fully settles in order to capture a single static weight reading.

To ensure a checkweigher can deliver readings of increased accuracy, it may be necessary to compromise on the sturdiness or flexibility of the machine, and its ability to handle a variety of applications.

A higher-accuracy system may cost more money, but it will save much more product and profits in the long term by reducing product giveaway, scrap and rework costs. A checkweigher with lower accuracy may cost more in the long term.
Testing Checkweigher Accuracy

The easiest way to measure the accuracy of a checkweigher is to perform a multi-pass accuracy test. The test simply requires taking a representative package off the production line and weighing that package on a static scale. The scale needs to be recently calibrated and checked, and should have a resolution at least five times higher than the checkweigher. The static weight indicated must be recorded.

Next, run the same package over the checkweigher at the specified production speed. In this example, 100 weighing results were taken; however, on many systems, the calculation can be performed with as little as 30 results.

During servicing, it is normal to use 30 results, whereas 60 results are typically used during conformity assessment. As each weighing process is performed, the results must be recorded – and, ideally, a normal distribution of weights is established.

Using this data, calculate the mean and standard deviation. Checkweigher accuracy can be defined at ±1, ±2 or ±3 standard deviations (sigma) from the mean. The mean error equals the absolute value of the difference between the actual weight of an item and the mean weight calculated by the checkweigher.

![Figure 14.10: 100 pass test with 68 results between 449.5g and 450.5g for an accuracy of ±0.5g @ ±1σ](image)

In the example above, out of a 100 pass test, 68 of the weighing results are contained between 449.5 and 450.5 grams. This would equate into an accuracy of ±0.5 grams @ ±1σ or 3 grams @ 6σ.

Defining Minimum Required Accuracy

To ensure that the checkweigher will be as efficient and useful as possible, a minimum accuracy is required for the system to work effectively. The theoretical best possible accuracy that could be delivered by the checkweigher may not be suitable for the application.

Consideration will need to be given to the product-handling requirements that the checkweigher must deal with, together with the environment in which the checkweigher will be running.

For example, a 'laboratory'-quality checkweigher may not stand up well in a harsh industrial environment or food-processing plant. It will therefore be necessary to consider the environment and package application (as well as accuracy) when investing in a checkweigher.

There are two basic types of checkweigher applications – ‘net weight control’ and ‘completeness check’. Net weight control refers to the content of prepackaged products; completeness control means monitoring that there are all pieces or components in a package.

14.5 Checkweighing: Part of an Overall Quality System

Checkweighing is not an absolute guarantee of quality, but it is a very effective tool when used in conjunction with a well-designed quality control programme; the checkweigher simply reports on processes upstream.

With appropriate maintenance and periodic testing, a checkweighing system can ensure that no off-weight or incomplete packages reach the end consumer. To ensure that a checkweigher is running at its full potential, it should be included in preventive maintenance and cleaning programmes.

It is important that checkweigher supplier offers preventive maintenance programmes (including performance verification testing) to keep the systems performing correctly at all times.

A perfectly good checkweigher may allow off-weight packages to continue along the line when the zone limits are set improperly. Quality personnel (and others responsible for the operational use of the checkweigher) need to be able to calculate acceptable weight and zone limits for each product and production line.

Feedback, Inspection and Tracking

Increasingly, checkweighers are becoming both an input device and a feedback mechanism for overall Statistical Process Control (SPC). Based on the product weight, checkweighers can count, calculate statistics and automatically send feedback to other systems in the line.

Checkweighers can be equipped with other inspection tools, including open flap detectors, cap detectors and metal detectors. As an inspection tool, the checkweigher can document process performance for ISO, customer, agency and internal requirements.

Checkweighers can present information on-screen, through an internal printer or in an output signal for a printer or a PC-based data gathering system. The controls can be integrated with a Programmable Logic Control (PLC) and provide an interface between the checkweigher and a Supervisory Control And Data Acquisition (SCADA) system.

Modern checkweighers are highly effective for quality control and tracking, so it is advisable to research all the functions of current checkweighers (or checkweighers to be acquired in the future) in order to establish the benefits and value they can provide.
**Filling**

In filling applications, the greater the accuracy, the less product will be given away; this applies to both the filler and the checkweigher. In filling operations, the aim is to achieve the greatest possible checkweigher accuracy for the environment and application.

Equally important is the ‘tare’ (container) weight variability. However, it is the filler that actually controls the fill weight distribution. The most effective way to decrease product giveaway or percentile rejects is to decrease the standard deviation of the filler. A smaller variance in filling allows the target weight to be set closer to the labelled weight (see Figure 14.11).

![Figure 14.11: Filler accuracy](image)

Decreasing the filler’s standard deviation reduces product giveaway. The standard deviation of the filler can be reduced by:

- Using a filler suited to the product
- Maintaining the filler to an optimum condition
- Providing a uniform product flow to the filler

Please refer to Chapter 11 ‘Enhancing the Efficiency…’ and how feedback control works.

**Counting**

When checking for missing items or counting the items per package by weight, the total standard deviation of the package (including all its components) must be calculated. The total standard deviation (SDtotal) multiplied by three (3 x SDtotal) must be less than the weight of the smallest component to be verified by weight.

If the package weight variation is bigger than the smallest missing component you can not find it anymore, the checkweigher will not be able to determine, by weight, whether the component is actually in the package. When the total variability of the package is greater than the smallest component weight to be checked, then a checkweigher may not work in the application. Reasons for variation are tolerances in the container or packaging material weight and individual component tolerances.

A tare-gross checkweighing system may be used if the greatest variation is caused by the container.

If the total variance of the package is less than the component weight, then the checkweigher accuracy must be better than the weight of the smallest component, minus the total package weight variance, i.e. ≤ 0.8 x [Wcomp. – (3 x SDtotal)], where Wcomp. is the weight of the smallest component, SDtotal is the standard deviation of the package and all its components, and 0.8 is a safety factor.

The checkweigher accuracy (Acw) can be defined at ±1, ±2 or ±3 standard deviations with the same formula: Acw ≤ 0.8 x [Wcomp. – (3 x SDtotal)]

Note: If the accuracy is calculated at 1 standard deviation, only 68 % of items with weights equalling the reject point will be classified correctly. The same accuracy value at 3 standard deviations will ensure 99.7 % of the same items are classified correctly.

Example: The minimum required accuracy to find a component by weight: first find SDtotal which is the sum standard deviation of each component, including the packaging.  

(3 x SDtotal) + Acw ≤ Wcomp.  
Acw ≤ Wcomp. – (3 x SDtotal)  
Acw ≤ 0.8 x [Wcomp. – (3 x SDtotal)]

8 tablets, each weighing 2 g, should be packed into a box.

![Figure 14.12: 8 Tablets example](image)

The weight of the packaging is 32 g. The total weight of the box including all components is 48 g.
5 boxes with the following weights in grams (48, 47, 48, 48, 47), result in a standard deviation of 0.547 (SDtotal). Multiplying the SDtotal by 3 gives the result 1.64, which is less than the weight of the smallest component (2 g).

If the result was higher than 2 g, it cannot be determined by weight whether or not the component is actually in the package. \( Acw \leq 0.8 \times \left[ 2 \text{g} - (3 \times 0.547) \right] \). Based on the above formula, the accuracy of the checkweigher (Acw) must be better than +/- 0.287 g.

Note: Some checkweighers, which perform completeness checks, can display the amount/quantity of products instead of just the weight, both on-screen and in statistical reports. Using the product at Figure 14.12 as an example, the display would show ‘8 Tablets’.

### 14.6 The Environment

The accuracy of all checkweighers is affected by environment, and some checkweigher systems are better equipped to work in extreme environments than others. Figure 14.13 illustrates major environmental factors that can affect checkweigher accuracy.

- Any vibration introduces ‘noise’ or unwanted signals to the checkweigher. The cause could be a hopper, a nearby press – or even another conveyor in contact with the checkweigher.
- Performance checkweighers can automatically filter out some extraneous noise – though for optimal performance, a checkweigher should be isolated from extraneous vibrations.
- Air currents can affect checkweigher indications. It is especially important to avoid draughts around highly sensitive checkweighers such as those commonly used in the pharmaceutical industry. Even if air movement is kept to a minimum, a draught shield may still be helpful. If a checkweigher is highly sensitive, simply passing a hand over the weighing section without touching it may cause a weight fluctuation.
- Electrical noise such as Electro-Static Discharge (ESD), Electro-Magnetic Interference (EMI) or Radio Frequency Interference (RFI) can interfere with checkweigher indications. RFI can be caused by pagers, cell phones and walkie-talkies, as well as by other machines. If not properly shielded, variable frequency drives (and other components within the checkweigher enclosure) can also have an adverse effect on sensitive weighing and data processing circuits.
- The build-up of static electricity on a checkweigher will result in apparent weight build-up very quickly, and cannot be filtered from the readings. Static build-up can be caused by the machinery or items crossing the weighing section, so that anti-static draught shields should be used for very sensitive applications, since even a draught shield or guard can cause static build-up. Furthermore, all components should be earthed.
- A caustic environment can degrade a load cell and other components.
- Checkweighers are available in many materials; stainless steel components will stand up to harsh environments or frequent contact with water. Other materials can be coated with a resistant paint, but these will not stand up to harsh wash-down environments.
- Some load cells are made of aluminium. These work well and cost less than stainless steel load cells, but they are not designed for contact with water or other corrosives.
- One of the most common causes of poor accuracy is mechanical abuse, and any employees working with and around checkweighers can unknowingly damage the checkweigher. Common examples of mechanical abuse include: Stepping on a weighing platform, Placing too much torque on a load cell by tightening a bolt, Twisting a weighing conveyor body, Cleaning the checkweigher inappropriately.
Glossary

The following is a glossary of common terms used in this guide and in the checkweighing industry.

Accuracy
Accuracy refers to the linearity and repeatability of a system. For checkweighers, it can be defined as the sum of the standard deviation and the mean error of the system.

Belt Speed
See conveyor speed.

BRC (British Retail Consortium)
BRC Global Standards is a leading safety and quality certification programme, used by over 21,000 certificated suppliers in 123 countries, with certification issued through a worldwide network of accredited certification bodies.

The Standards guarantee the standardisation of quality, safety and operational criteria, and ensure that manufacturers both fulfil their legal obligations and provide protection for end consumers. BRC Global Standards are now often a fundamental requirement of leading retailers.

Checkweigher
A checkweigher is a mechanism which:
1. Weighs items as they continuously move along a production line
2. Classifies the items into preset weight zones (typically defined as overweight, acceptable and underweight)
3. Sorts items and/or rejects items of unacceptable weight

Controller
A controller is a checkweigher’s electronic console. When triggered by the weigh light barrier, the controller weighs and classifies each item and rejects off-weight items from the line.
Conveyor Speed
The linear speed of the belt or chain is typically measured in metres per minute (m/min). The most accurate measurement can be achieved using an incremental pulse encoder (tachometer).

Deviation From Target
Deviation from target is the difference between the actual weight and the target weight, with positive and negative values. The weights can be viewed as a deviation from the target weight on the checkweigher display panel.

Dovetail Transfers
Where the infeed conveyors comprise a narrow chain or belt, there can be an overlap at the transfer point, creating a dovetail transfer that provides support for the product during the transfer between conveyor sections. This is the highest level of integration and provides the smoothest transfer. Dovetails can also be used between the various checkweigher sections, such as:
- Timing and spacing
- Spacing and weighing
- Weighing and outfeed

Dynamic Weighing
Dynamic weighing occurs when an item is weighed over the load cell whilst in motion.

Efficiency
This value is defined as the period of time which has elapsed whilst the line was running. Efficiency, as period of time, is expressed as a percentage of a given measurement of time, such as an hour or a day.

EMFR – Electro-Magnetic Force Restoration
This is a high-precision load cell principle used in both scales and checkweighers.

FPVO – Fertigpackungsverordnung
This German Weights and Measures law applies to the net content of pre-packaged products.

GFSI (Global Food Safety Initiative)
The Global Food Safety Initiative is an industry-driven initiative providing thought leadership and guidance on those food safety management system controls necessary to assure the safety of the food supply chain.

Giveaway
Giveaway is defined as the amount by which item weights exceed their labelled weight. Giveaway can be determined per package, as an average – or as the sum of a group of packages.

GMP (Good Manufacturing Practices)
Good Manufacturing Practices are the practices required in order to conform to guidelines recommended by agencies that control authorisation and licensing for manufacture and sale of food, drug products, and active pharmaceutical products.

HACCP (Hazard Analysis and Critical Control Points)
Providing a systematically preventive approach to food safety from biological, chemical, and physical hazards, HACCP (Hazard Analysis and Critical Control Points) applies to production processes that can cause the finished product to be unsafe. HACCP designs measurements to reduce these risks to a safe level, and is therefore perceived as a means of preventing hazards, rather than being part of the finished product inspection process.

IFS (International Featured Standards) Food
IFS Food is a GFSI-recognised standard for auditing food safety, quality of processes and products of food manufacturers. It applies to food processing companies or companies that pack loose food products.
Net Weight
Net weight is defined as the weight of the product content in the package.

NIST
NIST is The National Institute for Standards and Technology, which is a department of the United States Department of Commerce. NIST publishes Handbook 44, which covers Weights and Measures standards; it also publishes Handbook 133 which covers weight regulations for packaged goods.

Nominal Weight
See target weight.

Normal Distribution
Normal distribution is a frequency probability distribution centred on the mean of a population of data and following a bell-shaped curve. The width is determined by the standard deviation of the data.

Nose Roller
A nose roller is a miniature roller located in the gap between the deflection rollers of adjacent belt conveyors. A nose roller helps to ensure the smoothest possible transfer of products along the production line.

NTEP
NTEP refers to the National Type Evaluation Program, which falls within the National Conference on Weights and Measures. This is a third-party organisation in the USA that verifies compliance with standards that apply to weighing and measuring equipment.

Packages per Minute (PPM)
PPM is the throughput rate at which packages are observed at a given point in the line. The PPM can be measured over a given period of time in order to give an average rate. Alternatively, it can be measured over an infinitesimally small period of time to give an instantaneous rate. When designing a package-handling system, the PPM must be constant throughout the line, otherwise severe back-ups and jams will occur.

Package Spacing
Package spacing is the gap required between products in order to ensure accurate weighing.

Photoeye/Light Barrier
A photoeye/light barrier usually refers to a photoelectric scanner which triggers a weighing cycle when an item interrupts its light beam. Instead of a photoeye on some checkweighers, a cam switch is used – and this is activated by preceding packaging machinery.

Pitch
The measurement of pitch is from the leading edge of one package to the leading edge of the next package – or from the centre of one package to the centre of the next package.

Gross Weight
The gross weight is the complete weight of a product, including packaging.

Instantaneous Line Rate
If production-line conditions cause a group of packages to enter the checkweigher, the PPM rate will be greater than the average Line Rate. In the worst-case scenario, the instantaneous line rate is the maximum belt speed, divided by the smallest pitch. These types of occurrences need to be taken into account in order to guarantee appropriate minimum spacing.

Intermittent Motion Checkweigher
This type of checkweigher brings each item to a complete stop on the weighing section, weighs the item and then discharges it. The checkweigher therefore measures the static weight, not the dynamic weight. See ‘Checkweigher’.

Item
An item is a specific product. For example, if a product is 300g boxes of cereal, an item is a single box of cereal.

Labelled Weight
This is the weight of the product as shown on the packaging. The mean of the total production should be equal to, or greater than, this value. Labelled weight is sometimes also referred to as ‘Nominal Weight’.

Line Rate
Line rate refers to the number of items per minute that the production line is producing; it is synonym for throughput (measured in Packages Per Minute).
Linearity
Linearity is the ability of the checkweigher to accurately measure a known value over the range of the device.

Load Cell
Different types of load cells are used on different production lines, and the load cell is the actual scale component of a checkweigher (see Electromagnetic Force Restoration and Strain Gauge). The load cell carries the weighing conveyor or weighing platform. The load cell’s electrical output is the weight signal.

MC – Measurement Canada
MC is the agency in Canada that provides Weights and Measures standards, and verifies equipment compliance with those standards.

Mean Error
The mean error is the difference between the mean value of actual data (weights) and the measured data.

Mean Value
Mean value is the sum of all values in a group, divided by the number of values in that group.

MID
MID is the Measuring Instruments Directive and describes, in detail, the processes and responsibilities for 10 types of measuring instruments (including checkweighers) during their production and commissioning.

Precision
Precision is normally referred to as ‘repeatability’ when used in conjunction with a checkweigher.

Programmable Logic Controller (PLC)
PLCs range from small component-level devices that can be part of machine systems (including checkweighers) to large devices that centralise line control and data management. PLCs are characterised by three main elements:
1. An input area
2. An output area
3. A logic device

A user interface is provided with larger systems, but smaller systems are often controlled remotely, or via an external computer.

Rejector
A rejector is a mechanism which removes items from the in-line flow, in response to a signal from a control system. The rejector often consists of a solenoid-operated valve, air cylinder and associated mechanical parts.

Repeatability
Repeatability is the checkweigher’s ability to weigh consistently over time. If the same weight is placed on and off a checkweigher 100 times, repeatability is the measure of how many times the same weight-reading occurs.

Re-zero
Re-zero (sometimes referred to as setting to null) refers to manual or automatic compensation for product build-up on the weighing section. It also compensates for gradual changes in the weight signal from the checkweigher, which occur as components become older. Re-zero (setting to null) requires an empty weighing conveyor for an instant. Usually every checkweigher must be re-zeroed at certain times.

ROI – Return On Investment
ROI is the ratio of money gained or lost (whether realised or unrealised) on an investment, relative to the amount of money invested.

Serialisation of products
Serialisation refers to the assignment and placement of unique markings on a primary package. These markings can be:
- A two-dimensional or RSS barcode
- A human-readable letter/number code, or
- Unique serialised codes that can be ‘written’ onto a Radio-Frequency Identification (RFID) tag or label

These unique codes are placed on each unit when they are packaged, using variable data printers, pre-printed labels or cartons – and then they are read by a vision system.

Side Transfer
(Conveyor to Conveyor)
Side transfer refers to the transfer of product from one belt to another. During this process, packages are continuously supported by the placing of two conveyors adjacent and parallel to one another. The checkweigher is placed in front and parallel to the adjacent conveyor.

The side transfer conveyor is placed as close as possible to the customer’s conveyor and the belts are almost touching. Guide rails are then put in place to slide the products off the customer’s conveyor onto the side transfer conveyor. The side transfer conveyor can then be integrated with the checkweigher infeed or outfeed section for smooth transfers.
Sidegrip Conveyors

Sidegrip conveyors refer to a vertical axis conveyor assembly, with two opposing belt sections that engage the sides of a package. Some tall items with small footprints cannot easily transfer between conveyors, so sidegrip belts extend over the discharge of the customer’s conveyor and obtain a positive grip on both sides of the product before it reaches the gap between the customer’s conveyor and checkweigher.

The product is therefore suspended between the belts as it travels over the gap and is released onto the infeed section of the checkweigher. Sidegrip conveyors are also used to bridge the gap between the checkweigher outfeed section and the following conveyor.

Spacing Conveyor

A spacing conveyor is an infeed spacing section used to speed up packages, so as to create the proper gap for weighing. Spacing conveyors typically use a transport belt or chain, and run faster than the customer’s conveyor, thus increasing the gap between packages. If the production line is to be properly effective, the customer must deliver the product at the same consistent pitch and belt speed for which the unit was designed. Any variations in pitch and belt speed on the line will cause spacing errors.

Standard Deviation

Standard deviation is the spread of data around a central point, with data following a normal distribution. A unit of standard deviation can be expressed by the Greek symbol $\sigma$, i.e. ‘sigma’.

Static Weighing

Static weighing is the process of weighing an item whilst it is at rest on a scale platform.

Strain Gauge Load Cell

The standard strain gauge load cell is the most common type of load cell used throughout the world, due to its low cost and exceptional robustness. Its quick response capabilities are ideal for checkweighing.

Tamper Evidence

Tamper evidence is a requirement of the EU Directive 2011/62/EU. The outer packaging of pharmaceuticals needs to be equipped with a tamper-evident feature in order to ensure first opening verification (i.e. proof to the end customer that they are the first person to open the package). First opening verification is often proved by the presence of perforations (in the closing lid of the packaging) which rip off when the packaging e.g. a folding box is opened for the very first time.

Tare Weight

Tare weight is the weight of the packaging without any product (i.e. an empty box).

Target Weight

This value is the desired weight of the product being produced. The target weight can sometimes be used to describe the nominal or labelled weight of a product. Under normal circumstances, the target weight is set slightly above the labelled weight, to ensure that the mean weight of the total production does not lie under the labelled weight. This ensures compliance with packaging regulations.

TCO – Total Cost of Ownership

The purpose of TCO is to help consumers and enterprise managers determine direct and indirect costs of a product or system. TCO is a management accounting concept which can be used to make sure that all associated costs, over a given time period, are considered when acquiring an asset.

Throughput

See Packages per Minute.

Timing Conveyor

A timing conveyor is used to regulate packages to a consistent pitch. If the customer cannot guarantee consistent spacing, or if the items are spaced far apart and running particularly fast, a timing section is typically used to slow the items down. This will cause them to be positioned close to one another, thus ensuring consistent package delivery. A spacing section always follows a timing section and spaces the product to the correct pitch for weighing. A timing conveyor can either use a transport chain or a transport belt.

Timing Screw (also known as a Helix or Worm)

A timing screw is a varying helix that rotates about an axis that is parallel to the direction of package travel; its purpose is to release packages at a consistent pitch. For products such as cans, it is easiest to space them using a timing screw.

For these purposes, a timing screw is usually a plastic rod with one long groove cut into it, similar to the thread on a screw. The groove is slightly larger than the can diameter, allowing half of the can to be within the groove. Instead of being a constant pitch like that of a screw, the pitch expands, easily spacing tall unstable products. A wide and silent chain is used under the timing screw to carry the products.
**Transients**
Transients are spikes on an AC power line which interfere with control functionality.

**Transport system**
Transport system is the product-handling mechanism (such as a conveyor) on a checkweigher.

**Weigh Cell**
See load cell

**Weigh Light Barrier**
A weigh light barrier is usually a photoelectric sensor at the beginning or end of the weighing conveyor. Its purpose is to ensure the right point in time for weight measurement. It instructs the controller to measure and display the weight of the product when it is the sole object on the weighing conveyor.

**Weighing Conveyor**
The scale section of all checkweighers is called the weighing conveyor. The length of the weighing conveyor is critical in both calculating the weigh time and in determining the maximum throughput (PPM).

**Weigh Time**
The weigh time (sometimes also referred to as ‘measuring time’ or ‘measurement time’) is the amount of time that the package, on its own, is fully on the weighing section. The weigh time can be calculated by subtracting the package length from the weighing conveyor length and then dividing by the belt speed. Depending on the main frame and control, weigh time ranges from 60 milliseconds to over 350 milliseconds.

Example:
Given:
PPM = 100
Package Length = 200 mm
Using a 305 mm long weighing section to ensure that only one package is on the weighing section, the minimum pitch is set to 355 mm.
Using the Golden Rule, (Belt Speed = Packages Per Minute x Pitch) the belt speed is calculated as:
355 x 100 = 35.5 metres per minute.
Weigh time = (305 – 200)/(35500/60) = 0.177 seconds.
This figure is probably acceptable, depending on the type of product and the level of accuracy desired.

**Weight Display**
As the line runs, the weight display is the display of each item’s weight or of each item’s ‘plus or minus deviation’ from the target weight.

**Weight Signal**
The weight signal is the analogue or digital output signal from the load cell. On an analogue signal, the output voltage is proportional to the weight applied to the load cell.

**Weight Zone**
The weight zone is the range of weights between two consecutive zone limits.

**Zone Indicator Lights**
These lights show the classification of each product. See Figure 15.1 for an example of colour indications.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Weight Zone 3 Zone Indicators</th>
<th>Weight Zone 5 Zone Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Zone 2 – Underweights</td>
<td>Zone 4 – Underweights</td>
</tr>
<tr>
<td>Blue</td>
<td>Not Used</td>
<td>Zone 3 – First under</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Usually acceptable but too light)</td>
</tr>
<tr>
<td>White</td>
<td>Zone 1 – Acceptable</td>
<td>Zone 2 – Acceptable</td>
</tr>
<tr>
<td>Amber</td>
<td>Not Used</td>
<td>Zone 1 – First over</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Usually acceptable but too heavy)</td>
</tr>
<tr>
<td>Green</td>
<td>Zone 0 – Overweights</td>
<td>Zone 0 – Overweights</td>
</tr>
</tbody>
</table>

Figure 15.1: Zone allocation example