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10 Criteria for Selecting Your Optimal Weighing Solution

White Paper

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10 Criteria

for Selecting Your Optimal Weighing Solution

Do you really know what criteria are key to selecting a scale that ideally suits your needs? Nowadays, scales are offered in such a wide range of shapes and sizes that choosing one can be a daunting task. As a rule of thumb, a scale's suitability is determined by its application and ambient conditions. Detailed knowledge about the various selection criteria can be very helpful when selecting the scale that is best suited for your specific application. The following sections will give you an understandable overview of the various points to consider.

1. The Scale's Task in the Production Process

One of the first steps in the selection process should be to determine which tasks the scale is intended to fulfill within your production process. Generally, the scale, a measuring instrument, is integrated into the production process at a specific point where it is intended to fulfill a certain purpose. The primary use of a scale is to weigh things. For this purpose, an appropriate vessel or a moveable container is placed or driven onto the scale, the scale is tared and the solid or liquid sample is placed into the vessel or container according to the specifications. The weight is recorded manually or electronically and the sample, along with the container, is removed from the weighing pan on the scale.

A counting scale can be used to rapidly and easily count any number of capsules and tablets, pellets, small parts or any other number of objects with the same weight and determine the total quantity. This requires placing a small known quantity of pieces on the counting scale. The scale calculates the average weight of the known number of pieces (for example 10 units) and stores this number in its memory. Later, this known average weight is used to instantly count unknown quantities of the same material regardless of how many pieces are placed on the scale. The results can be stored or printed out for record-keeping or for other documents that accompany the product. The scale best suited for weighing moving items on a conveyer belt in a production line is an automatic checkweigher. This type of scale is particularly important in situations, where the need for clock speed or the requirement for 100% inspection prohibits manual weighing. The weight of each item on the conveyer belt is instantly compared with previously established product-specific limit values: Any item outside these tolerances is automatically removed from the belt.



Figure 1: Weighing platforms are available in a wide array of designs and sizes.

This type of scale can also be used for classifying items based on pre-programmed user-defined criteria. Since each unit is checked, any packages that are over- or under-filled can be identified and rejected quickly. Even the filling process can be controlled centrally. For process optimization, short- and long-term production performance can also be measured. Routine checkweighing procedures can be integrated seamlessly into simple or complex Statistical Process Control (SPC) systems. These, in turn, can be used to effortlessly carry out data analysis or for adjusting the filling heads in real time.

Batch weighing scales (for batching processes) are designed with scales or load cells, pipes, valves, electrical hardware and the process control software in an integrated control system. This kind of system controls one or several feed systems which convey the various user-defined quantities of raw materials in a common receiving vessel where the contents are mixed or made to react. As a rule, the receiving vessel is tared every time a new component is added. The system can also be set up to measure the weight loss in the individual ingredient vessels. Batch weighing scales are supplied in manual or automatic versions. Some batch weighing scales can also control other parameters involved in the processes taking place within the vessel like heating, cooling and mixing. And these are just a few of the scale's potential applications.

2. The Scale's Size and Capacity

A scale's capacity indicates the maximum quantity or mass that a scale can weigh. As a rule, desktop or benchtop balances or scales are used for weighing samples from a few micrograms up to around 30 kg in weight; stand and floor scales are used for up to around 150 kg; and floor scales only are intended for weighing items of 300 kg and more. By contrast, tank and hopper scales are the load sensors of choice when it comes to weighing containers and silos. No matter which weighing instrument you decide on, always keep in mind that the weighing capacity of the respective scale should be within the middle range. This way you will not only prevent unnecessary stress or damage to the sensitive electronic components, but you will also ensure higher accuracy. High-quality scales have a built-in overload protection in case the scale is overloaded or objects inadvertently drop on the weighing platform. This prevents, by physical means, the electronics and metrological components from suffering permanent damage. In terms of capacity, the load area on the scale is always one of the factors to be considered when selecting a scale. It is important that the container or the sample can be optimally placed within the scale's weighing area. Ideally, the sample should be centered on the platform and not hang out over any sides. To ensure this, scales are supplied in a wide variety of platform shapes and sizes for the various purposes (Figure 1). This also applies to large tanks or silos with load cells built into the base frame. What are called under-balance or below-balance methods exist for situations where it is difficult or impractical to weigh directly on the platform. In these cases, a hook attached under the scale is used to measure the weight by means of tension.

3. The Required Weighing Accuracy

A quantifiable characteristic of measurement – accuracy – has always resurfaced as a subject of heated debate in the entire weighing industry for the reason that no exactly specified definition exists. In actual fact, accuracy can be regarded as an interplay of many different factors; four quantifiable specifications in particular, contribute to this interplay:

- Resolution
- Reproducibility
- Linearity
- Uncertainty of measurement.

Resolution, also referred to as readability, is defined as the smallest change in mass that can still be read on a particular scale regardless of its weighing capacity. Let's take a sample, say, that weighs 114.318 kg. If we weigh this sample on one scale with a resolution of 0.001 kg, it reads 114.318 kg; another scale with a resolution of 0.01 kg will read 114.32 kg.

Reproducibility is defined as a scale's ability to display consistent results over a certain period of time and when operated by different users. To determine a scale's reproducibility, a test weight is weighed ten times. Then, these ten measurements are used to calculate the standard deviation, which is equivalent to the scale's reproducibility. The calculation can be carried out manually, although many high-quality scales perform this task automatically.

Linearity (Figure 2) is defined as a measurement of a scale's deviation (variance) in accuracy across all weight values within its capacity, including maximum weight values and values in the mid-capacity range. A linearity test is part of the annual calibrations performed by quality scale manufacturers and approved customer service centers within the scope of their services.

Uncertainty of measurement is defined as the difference between the measured weight of a certain sample compared to its true weight. Deviations can arise due to the weighing environment and additional factors. In certain applications, the uncertainty of measurement is monitored closely. For example, Chapter 41 of the U.S. Pharmacopeia (USP) specifies that the uncertainty of measurement during sample weighing may not exceed 0.1% of the quantity to be weighed. Laboratories that rely on scales generally comply with this guideline, which is also gaining acceptance in production applications (production scales).

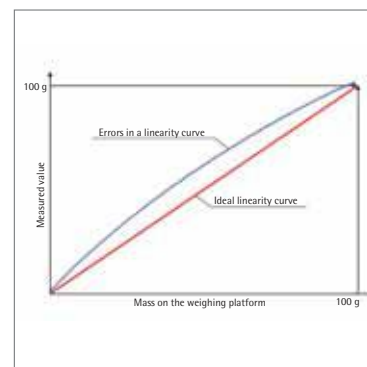


Figure 2
Linearity errors can affect the accuracy of measurements.

4. The Scale's Environment

4.1. Selecting the Materials of Construction

In simple terms: scales can be classified into two general categories: basic scales and scales subject to high environmental demands. Basic scales are made of normal materials that may include plastic, coated aluminum alloy, painted or galvanized carbon steel. Usually, these scales are used for weighing processes in areas like logistics or warehouse weighing where the ambient conditions are dry and hygiene and corrosion resistance are not critical factors. The temperatures can vary around room temperature, but can also range significantly above (summer) or below (winter); humidity levels may also be subject to great fluctuations.

In environments that require a higher level of cleanability | hygiene or chemical compatibility and environmental stability, stainless-steels of the AISI-304 and AISI-316 grades are the most commonly used materials. Also referred to as austenitic stainless-steels, their resistance to corrosion and oxidation is ensured by a passive layer on the metal surface (metal oxide or metal hydroxide) that is only a few Angstrom units thick, but sufficiently protects the metal from any otherwise corrosive substances (from the working environment or from the sample itself).

In the food and beverage, the cosmetic, paint and pigment industries and in sectors that work with large amounts of chemicals, the stainless-steels of the AISI-304 grade have proven their merits. This material is not only resistant to chemicals in the product itself, but also to the chemical agents contained in cleaning agents; nevertheless, this steel will tarnish in the presence of extremely aggressive chemicals.

If better protection is needed, grade AISI 316F stainless-steel is a more suitable material of construction. Because it contains a higher nickel content and up to 3% added molybdenum, this material has a markedly improved resistance to the pitting corrosion caused by aggressive chemicals like chlorides, salts and acids. If even further protection is required, AISI 316 stainless-steel is available in various sub-grades, including grade 316 L, which has a lower carbon content for better corrosion resistance, while 316 Ti has added titanium that gives this grade greater tensile strength and improved resistance against inter-crystalline corrosion.

To ensure that the strictest requirements for corrosion resistance and hygiene are met, for example in pharmaceuticals and medical technology manufacturing processes, the AISI 304 or 316 grade stainless-steels must be electropolished. Electropolishing decreases the surface roughness of the metal down to such magnitudes that bacteria cannot adhere to it. During electropolishing (Figure 3), an anodic workpiece made of stainless-steel is immersed in an electrolytic bath and connected to the positive pole of a current generator. The negative pole is connected to the cathode. When an electrical current is connected, the particles move away from the anodic stainless-steel workpiece to the cathode. This causes the surface roughness of the workpiece to decrease and the concentration of chromium in its surface to increase. The surface thereby created has a very low roughness which improves corrosion resistance and reduces microbiological contamination. The current standard is a roughness $<1\mu\text{m}$; however, $<0.8\mu\text{m}$ and $<0.4\mu\text{m}$ is even better in qualitative terms.

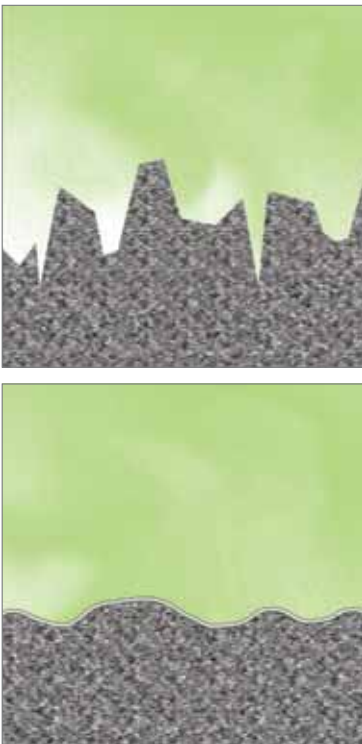


Figure 3
Stainless-steel surface before (above) and after electropolishing (below).

4.2. External Impact Factors

The ambient conditions prevailing at the place of installation are selection considerations that are often overlooked. Nevertheless, you underestimate these impact factors at your own risk. Every scale is a measuring instrument that has a task to fulfill, namely to determine a weight value, while at the same time being subject to physical effects from the environment. Although each scale is designed to operate within a certain temperature range, it is still preferable to keep the temperature of the ambient air steady. Extreme fluctuations in temperature can cause metals within the load cell to heat up and flex at different rates. As a result, during the phase of temperature fluctuations, the weighing results can also fluctuate. Whenever the temperature in the scale's environment fluctuates, the scale should be allowed to acclimate to the new temperature prior to first use. Modern scales are built to compensate electronically for the external impact of temperature.

If the sample exhibits temperature extremes, heat or cold can be conducted to the load cell where the fluctuations described can take place in the same way. In such cases, ceramic or temperature resistant pads can be used to prevent direct contact between sample and load cell. Even air currents can affect the performance of higher-resolution scales. A draft shield can be attached for such cases to reduce or eliminate the air currents (for example next to rolling gates). The presence of magnetic fields and floor vibrations can also negatively affect a scale's performance at higher resolutions.

Nevertheless, although on scales with lower-resolution these effects are less problematic, appropriate measures should be taken to protect the scale. Specialized vibration-isolating padding can help, or usually, the easiest solution is simply to move the scale to a more favorable location.

To a certain extent, most scales are resistant to humidity and fluids, since many branches of the industry rely on wash-down methods during cleaning. Nevertheless, their resistance to destructive chemicals or deposits should be monitored carefully. As required, the appropriate corrective actions should be taken or a more suitable scale model should be selected (e.g., scales with special protection devices).

4.3 Process Requirements

In addition to the performance characteristics mentioned in the previous section, scales can be customized with additional features. For example, wheels or special lifting mechanisms can facilitate thorough cleaning in the area under the weighing platform. Drive-on ramps, pit-frames or flat-bed scales make it easier to load and unload large or heavy items. In addition to scale-specific calibration routines, integrated software options can include pre-programmed or programmable application programs. Modern scales can optionally be connected to a PC or a network via Bluetooth, RS232, RS485, TCP/IP, Ethernet, Profibus or other porting devices.

For scales used in production processes or for remote-controlled operation, the weighing results can be displayed at locations remote from the weighing platform at control centers. If the scale is set up in a poorly lit area, a backlit display can effectively eliminate any problems with readouts, while a range of 3-key scales to scales with alphanumeric keypads ensure simple operation. Graphic displays can generate curves or bar diagrams to provide the user with added information. This feature is especially helpful for illustrating statistical variables, such as bar diagrams or time curves of measurements. Moreover, modern scales can display and print out measured values in several different languages and in multiple weight units.

In summary, it is important not only to identify the process-related features that are highly relevant to current process requirements, but also the needs to be expected in the future (for example, data collection for all production parameters).

5. Regulations and Rule Books

Numerous industries are subject to specific regulatory criteria that the weighing instruments employed must or at least should comply with. The regulations and standards listed in the following are intended to give you an overview about the guidelines applicable to certain industries. In this connection, it is highly recommended to thoroughly review regulations specific to your branch of industry.

The equipment directives of Factory Mutual (FM) and the European Union regulate the explosion protection and safety of electrical equipment used in ATEX 95 or potentially explosive atmospheres (ATEX is the abbreviation of the French term: Atmosphères Explosibles). The FM tests and approves or certifies equipment based on the standards of various organizations like ATEX, the American National Standards Institute (ANSI) or the International Electrotechnical Commission (IEC). Since they are generally recognized by the European Community, the ATEX standards are self-qualifying. Nevertheless, a notification about the approval of quality assurance measures can only be issued by European agencies.

Originally established for the food industry, the seven principles behind the "Hazard Analysis and Critical Control Points (HACCP)" concept are increasingly being used in the pharmaceutical and other industries as well. Even though the HACCP principles are supervised by a regulatory body, these self-regulating criteria stress the importance of hazard detection and prevention in a process. This way, process risks can be minimized. It's not necessary to go into further detail about the corrective actions required in the event of failure and the repercussions that come in their wake. Every responsible manufacturer understands the costs and long-term risks for his company.

The IEC is a system for classifying electrical equipment safety based on definitions according to IP codes (IP = Ingress Protection). The higher the protection rating, the better [the electrical equipment is protected against dust, foreign particles and moisture (this extends to water jets). Although the commission does not certify equipment, the standards can be self-certified. Moreover, external testing institutes can also issue the appropriate certificates.

The International Organization for Standardization, abbreviated ISO after the Greek word isos for "equal", is the standards organization that arguably enjoys the greatest recognition worldwide. This non-governmental agency develops a broad range of technical standards throughout the world which are valid for a number of industries and markets. Neutral testing organizations conduct conformity assessments and approvals. Although compliance with these standards is not mandatory, innumerable local and industry-specific organizations strongly recommend compliance with certain ISO standards. This particularly applies to ISO17025, – the most important standard governing testing and calibration laboratories and thereby also pertinent for measuring instruments like scales.

There are standards of protection in place for all types of electrical products, e.g., IP and NEMA, including a standard for the protection of electrical production equipment against dust penetration and the protection of equipment used in cleaning processes. A neutral testing laboratory conducts product certifications. In this process, the vendor is also required to furnish a declaration of conformity, although certification is not mandatory.

In Europe and other countries, OIML or CE rules and regulations apply. Scales that satisfy these rules are approved for use in legal metrology. In the USA, the NTEP (National Type Evaluation Program) declaration of conformity is issued by the National Conference on Weights and Measures (NCWM). It evaluates the performance, operation, and compliance of weighing and measuring instruments based on established criteria. Even though such approval is not mandatory, a U.S.-recognized certificate of conformity is issued after the procedure has been completed successfully.

All of the CE, UL, ETL, CUL and CSA standards provide guidance on product safety, especially that pertaining to electrical production equipment. The Underwriters Laboratories Inc. (UL) is an organization that evaluates products according to accepted safety standards like the National Electrical Code (NEC) and awards a UL or CUL (Canadian) trademark for products that meet or even exceed the criteria. CSA International is the body that tests and certifies a wide variety of product types for applications in the USA and Canada.

For the pharmaceutical and healthcare products industry, it is the United States Pharmacopeia (USP) that is responsible for setting quality standards. The most important standard for the weighing industry is found in USP Section 41 which deals with testing of weighing instruments at their site of installation. Certified weights are used for the testing to determine whether the scale in question is functioning properly in its specific environment. Also known as the uncertainty of measurement test, this procedure can additionally establish the smallest sample quantity that can be weighed on a particular scale.

To obtain further information on the individual standards and regulations, visit the respective websites listed in Table 1. In parallel, you may want to contact your company's Quality Assurance Department.

Table 1: Websites for additional information about regulations and standards

FM	www.fmglobal.com
ATEX	ec.europa.eu/enterprise/atex
HACCP	www.cfsan.fda.gov
IEC	www.iec.ch
ISO	www.iso.org
NEMA	www.nema.org
NTEP	www.ncwm.net/ntep
UL/CUL	www.ul.com
ETL	www.intertek-etlsemko.com
CSA	www.csa-international.org



Figure 4
During installation, a scale should be adjusted to the ambient conditions as needed.

6. Setup, Installation and Startup

As part of the installation process (Figure 4), the room in which the scale is to be used should be set up in such a way as to minimize effects from humidity, corrosion, vibrations and electrostatic influences. These factors can all negatively impact a scale's performance. After unpacking the scale and checking that the delivery is complete, the scale is set up at its final location and connected to any accessory devices. On many scales, the display and control unit can be set up at a remote location as a means of protection against potential hazards or for reasons of operator convenience.

The resolution | readability should be set and the initial calibration carried out to enable the scale to function as intended. A corner load test should be conducted whenever multiple load cells are being used; this will ensure that the identical weights are measured in all corners and corner load errors are prevented.

The operating programs in electronic scales feature options to adapt the scale to its place of installation (e.g. to set a higher weighing time in unstable environments in order to keep the readout more stable).

To ensure that a scale produces optimal performance, a scale should not be moved from its place of installation after initial installation. The reason for this is that external variables like a very uneven floor can affect performance. Re-installation is not required on scales that are equipped with wheels to make cleaning easier as long as the scale is returned to its original location after cleaning and prior to further use. If a scale has to be re-installed at a new location, the installation procedure must be repeated. Normally, the end user can perform the installation. However, if traceability and documentation are important concerns, then it is recommended that the installation be performed by an authorized technician so as to ensure proper installation and calibration documentation.

7. Scale Calibration and Service

Scales are made of electronics and moving parts which are constantly exposed to stress. With time, this wear and tear can cause the accuracy of the scale to shift. In turn, these changes can affect the overall weighing results and cause problems, especially for scales with higher resolutions. For these reasons, every scale must be calibrated regularly. Without regular calibration, consistently accurate and verifiable results cannot be ensured.

The process of calibration measures the weighing accuracy of a scale or load sensor. Ideally, calibration is performed at the place of use of the weighing instrument. This will avoid the quality problems that can arise at every step of the manufacturing process whenever weighing results are out of specification. During a calibration routine, a series of certified test weights are placed, one after another, on the weighing platform and the measured results are noted down. Special procedures apply to load cells attached to large vessels or tanks where extremely heavy weights can be involved. To correct any out-of-tolerance results, manual or automatic corrections can be made whenever the displayed results deviate from the known test weight. This correction procedure is called adjustment. The operator can carry out this test as part of the routine accuracy testing. However, the certification itself (Figure 5) may only be performed by trained and authorized technicians using certified and verifiable test weights. This approval or certification is issued according to a specific set of standards like NTEP or ISO 17025, for example. Depending on the ambient conditions, frequency of use and company-internal regulations, the instruments should be calibrated regularly. As a guideline, common

practice dictates that calibrations are performed four times a year. In certain cases, daily calibration may even make sense and indeed is carried out in critical sectors like in the pharmaceutical industry.

A calibration certificate issued by the German Calibration Service (DKD) is the most reliable way to effectively prove a scale's metrological qualification at the point of use. Such certificates can only be issued by accredited testing laboratories (as a general rule, by the scale manufacturer as well), after solidly demonstrating their capabilities and reliability. Hereby, testing must be carried out using test weights of prescribed accuracy classes guaranteed to be traceable to the kg standard (Figure 5). The customer service of the manufacturer or an authorized representative must be called upon whenever the scale or load cell is outside of acceptable calibration limits or a more serious problem occurs. If the customer performs repair work themselves, this will often make any product warranties or service contracts invalid. Service contracts can be custom-tailored to the individual customer's needs and often cover regular calibration as well. Moreover, service contracts can also provide for prompt emergency repairs to shorten downtimes.

8. The Price

Obviously, no discussion about scales is truly complete without addressing the topic of price. Not until you have chosen a scale by applying steps 1 to 9, you can make an objective assessment of the costs and benefits. It goes without saying that you will have to lower expectations in terms of quality if you purchase a "cheaply" manufactured scale. This investment will probably not pay off in terms of quality or life cycle costs though. The bottom line can start to look pretty bad if costs for replacements or repairs have to be factored in. Not to mention how expensive interruptions in your processes or reworking can be as well.

Having said that, the most expensive scale isn't always the right choice either. Before choosing the scale that fits your requirements, give the criteria listed above thoughtful and objective consideration. To narrow down the selection, take your current and future weighing needs into account when budgeting your overall expenses. The best thing is to seek noncommittal advice from a weighing specialist.



Figure 5

Proper maintenance and calibration certification by an authorized technician ensures accuracy and optimal performance.

Sartorius in Brief

The Sartorius Group is a leading international laboratory and process technology provider covering the segments of biotechnology and mechatronics. In 2007, the technology group earned pro forma sales revenue of 622.7 million euros. Founded in 1870, the Goettingen-based company currently employs approximately 4,500 persons. The major areas of activity in its biotechnology segment focus on fermentation, filtration, purification, fluid management and laboratory applications. In the mechatronics segment, the company primarily manufactures equipment and systems featuring weighing, measurement and automation technology for laboratory and industrial applications. Key Sartorius customers are from the pharmaceutical, chemical and food and beverage industries and from numerous research and educational institutes of the public sector. Sartorius has its own production facilities in Europe, Asia and America as well as sales subsidiaries and local commercial agencies in more than 110 countries.

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