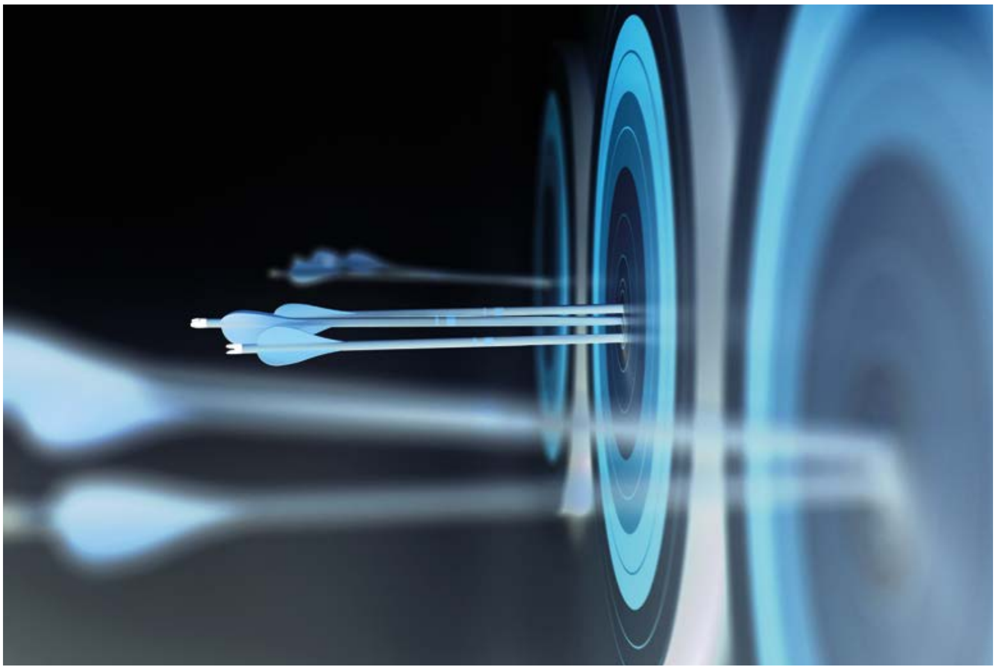
High Speed Weighing

Meet the Speed Challenge

Six Keys to Automated Weighing Accuracy

Increase machine's accuracy and throughput by selecting automation components that significantly improve dynamic weighing through faster signal processing and a holistic view of the control chain.



Six Key Considerations in Detail

1.0 Latency
2.0 Filtering method
3.0 Communication type
4.0 Networking requirements
5.0 Controller capabilities
6.0 Actuator optimization and material

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Introduction

Weight-based control is an excellent choice for many machine builders and system integrators due to higher productivity and consistency of results when compared to other means. Moreover, an added benefit is that weight sensors or scales do not physically contact the products that they are measuring; this avoids cleaning and risk of cross contamination.

While this method can be used for processes measured in minutes or hours, it can also offer significant advantages for high-throughput systems with processes measured in seconds or less.

If your company is developing the latter, there are six key considerations to take into account when crafting machines that function along the automation measuring chain. These considerations are:

- Latency
- Filtering method
- Communication type
- Networking requirements
- Controller capabilities
- Actuator optimization and material

This paper provides detail on all of the above, along with notes that will help you avoid many of the most critical pitfalls when using weight-based control.

Accounting for these design aspects will help you automate your machine using less hardware such as extra feeders or valves while helping your customers achieve the highest level of processing quality and operator safety.

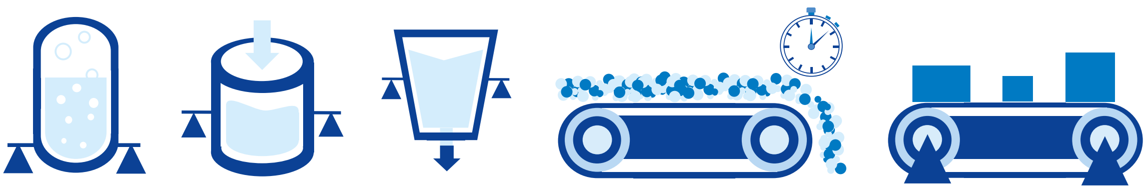


Figure 1: Weight-based control is an excellent resource for fast applications such as reacting/mixing, filling, dosing, rate control and carton weighing.

The 6 Key Considerations in Detail

1.0 Latency

Or, how quickly does the measuring device you are considering react to changes in weight?

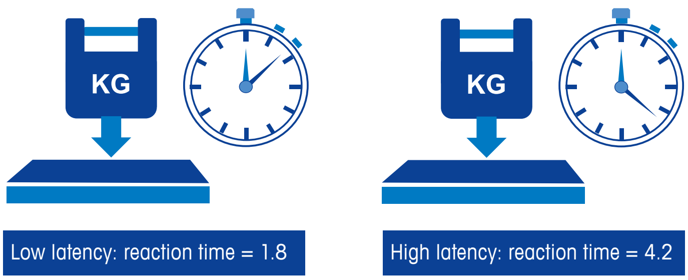
Consider how fast your device, or system, reacts to a change in weight. If you are a designer who expects higher productivity and better quality, latency is your most critical factor. Low-latency devices are devices capable of providing the highest accuracy (trueness and repeatability) in the shortest time so your control system can make precise decisions in the right moment.

Low-latency devices allow you to profile material flow so precisely that you can refine your control variables and algorithms. A true low-latency device is one that provides you what you want in your PLC to make control decisions in less than ten milliseconds. In other words, if your systems are decentralized, then your weighing devices must complete the input-decision-output cycle in this timeframe. This allows you to control your feeding valve, gate, or conveyor with a high degree of precision. For example, low latency allows you to eliminate "slow" speed filling valves or feeders and accurately control with only one material feeding device while simultaneously increasing the speed of your system.

When choosing a weighing device to place in your design, it is always a good idea to test the complete scale or sensor for its latency and see if it meets your process requirements. For best results, this can mean assessing the whole measuring system: the scale mechanical interface, suspension components, sensor(s), and terminal or transmitter that interprets the weight for the controller. It is also important to pick high quality components that will guarantee repeatable and reproducible results. Some companies eliminate critical weighing hardware to save cost only to find that the machine's precision and speed (latency) has been compromised: For example, a simplified weighing device reacts slowly due to mechanical instability, electromagnetic interference, or hyper-sensitivity to vibration.

Note: Pay attention to the details. Many weighing-device specifications indicate the analog-to-digital conversion rate in Hertz as an indication of low latency–but this is only the first part of the story. Hertz indicates how fast data is processed inside the device, but not how fast it is being pumped into your control system. To complete the story you should evaluate the remaining considerations that are listed below and are highlighted by the following example:

Compare the Hertz example to an everyday device such as the tachometer of your car. The tachometer shows how fast the engine is turning – not the actual speed of the car. You want your engine to be able to spin fast enough to provide desired speeds, but many other system aspects impact automobile performance.



You see the weight 2.3x faster here

Figure 2: Low latency allows you to improve your dynamic accuracy to speed up your throughput or fill.

Figure 3: A tachometer only tells you how fast the engine is turning, not how fast the car is moving.

2.0 Filtering

Does the device provide active or adaptive filtering?

Many weighing installations are in environments with vibration caused by moving parts, mixers, and agitators. A weighing device with a fast active filter allows your system to continue providing accurate results when the environment is not perfect.

Avoid fixed or averaging filters that increase system latency, slow down your process and cause inconsistent results. These filter types do not provide the kind of precise adjustment required for low latency because they rely on an average vs. showing you the **actual weight minus the vibration component**.

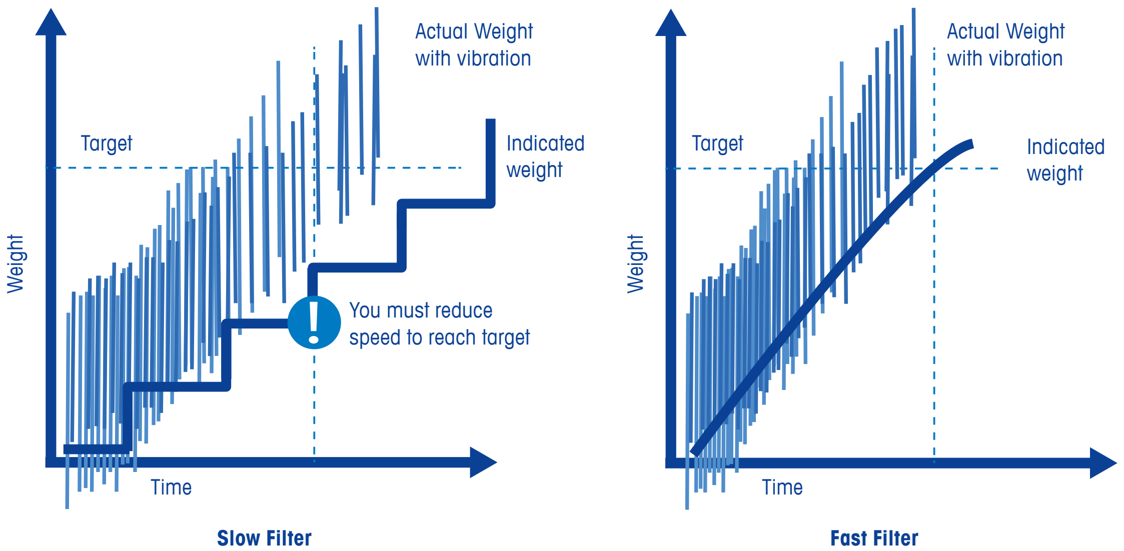


Figure 3. Slow averaging filters are less precise and tend to both cause process inconsistencies and increase latency (reduce speed), damaging both accuracy and throughput.

When you review device specifications, remember to look for any tables that show significant system speed reductions when filtering is enabled. Many devices on the market use slow fixed or averaging filters and are not ideal for high-accuracy, high-speed automation. If you chose a product with a fixed filter, you will need to slow down your process to get an accurate result; therefore, always chose a product with a fast filter to gain the highest throughput.

Note: Isolate the device around low frequencies. If your system will be located in an area that is subject to low-frequency vibrations of two Hertz or less, it is a good idea to isolate the weighing device mechanically. Low-frequency noise can be mistaken for change in weight and cannot be effectively removed via electronic filtering. Once you have removed low frequency vibration you will see a dramatic improvement of your machine's throughput.

3.0 Communication

Will the weighing device send weight data cyclically?

Acyclical communications (one command – one response) should be avoided if processing speed is your goal. Sending weight data cyclically will ensure the fastest speed possible.

When data is received in a floating-point format, your system can easily compare incoming data in your control algorithm without reprocessing the data or looking for decimal points

Include critical cyclical data bits such as alarm, heartbeat, motion, center-of-zero and data-okay status help to ensure that your system is secure and stable and your weight is fault-free.

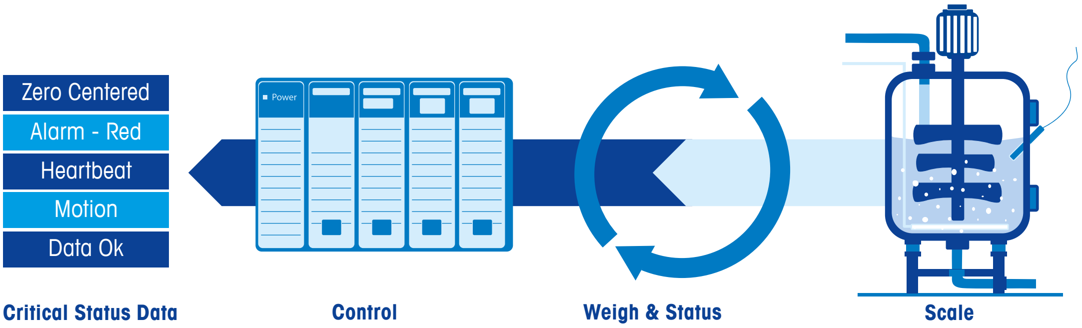


Figure 4. High-speed cyclical weight allows you to quickly and easily compare incoming data in your control algorithm without further reprocessing your data.

4.0 Networking

Is the weighing device compatible with Industrial Ethernet?

Industrial Ethernet networks transport weight data to your PLC at rates up to 1,000 times per second.

Serial-based networks or serial-to-Ethernet converters will not meet expectations for a fast control experience for either one or two reasons:

- **Inherent low speed.** The networked system is incapable of exchanging data at required speeds, and/or…
- **Communication inconsistency.** Data from the device or sensor arrive to the control system in an inconsistent non-repeatable time sequence (in other words, communication is not deterministic).

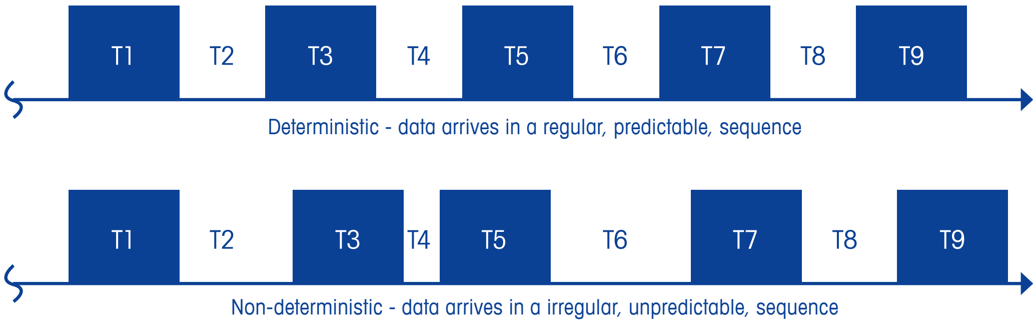


Figure 5. Deterministic devices send data in a regular and predictable sequence for accurate, repeatable, control.

5.0 Processing

Can your controller handle the necessary data speed?

The speed of your controller plays a huge role in overall system performance, so it is important to select one that is fast enough to process weight information and still be able to perform its other intended functions.

If speed of control is required, then all the control must be placed in the weighing sensor or terminal where the device controls the actuators. However, be careful: Speeding up your control system requires that your material-handling system respond just as fast.

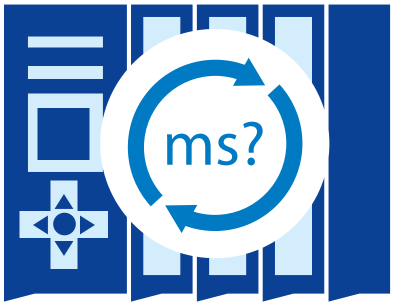


Figure 6: PLC speed, architecture and size of program play a significant role in system latency.

Note: Keep program size small. Additional tasks given to the controller will have an impact on speed and consistent (deterministic) behavior, especially if you select a scale plug-in card, or module, for your PLC. It is always a good idea to keep program size as small as possible while still maintaining desired capabilities or to select a controller with a higher processing speed.

6.0 Actuators

Have you optimized your control system?

Once you have improved your weighing and control system, consider the actuators that control the material you are weighing.

A slow control valve could be the biggest hindrance to building an extremely capable system. Actuators must react fast enough (open / close) to decisions from your control algorithm for accurate material delivery, as any delays will cause extra material to flow through, giving you too much.

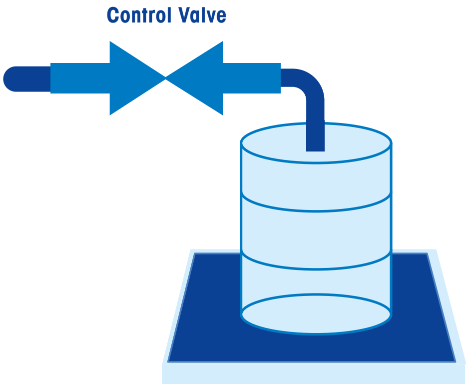


Figure 7: Valves should be selected for speed and repeatability.

The consistency with which a valve opens and closes a feeder or a conveyor starts and stops goes hand-in-hand with accuracy. Consistency helps you guarantee great results and makes your control algorithm more robust.

Note: Consistent particle sizes can enhance machine speed and accuracy. At top speeds, the best control can be achieved when your material has a consistent particle size and flows well. Therefore, liquids and fine granular powders are ideal.

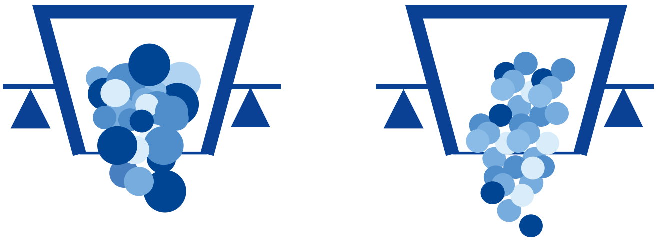


Figure 8: Valves, gates, conveyor reaction time and material flow play key roles when optimizing automated weighing speeds. Asymmetric particles affect your ability to gain consistent results – the larger the insistency the more difficult it will be to maintain repeatability.

Summary

Weight-based control allows machine builders and system integrators to provide their customers with the kind of precision, consistency, and product handling that enhances accuracy, productivity, and operator safety.

To optimize weight-based control, ensure that each element of your weighing and control system is selected for maximum performance.

- Go behind the simple specification of A/D conversion speed (Hertz) and look into weighing sensors and scales that include active filtering to ensure high weighing speed and low latency.
- Pick a network, data type, and controller that fit your device and processing speed requirements.
- Consider the impact your product's material characteristics will have on the overall performance of your entire system.

The above points include six distinct considerations that machine builders and system integrators should consider when designing high-speed automated weighing systems.

For more information or to schedule a product demonstration, please contact your local METTLER TOLEDO representative.

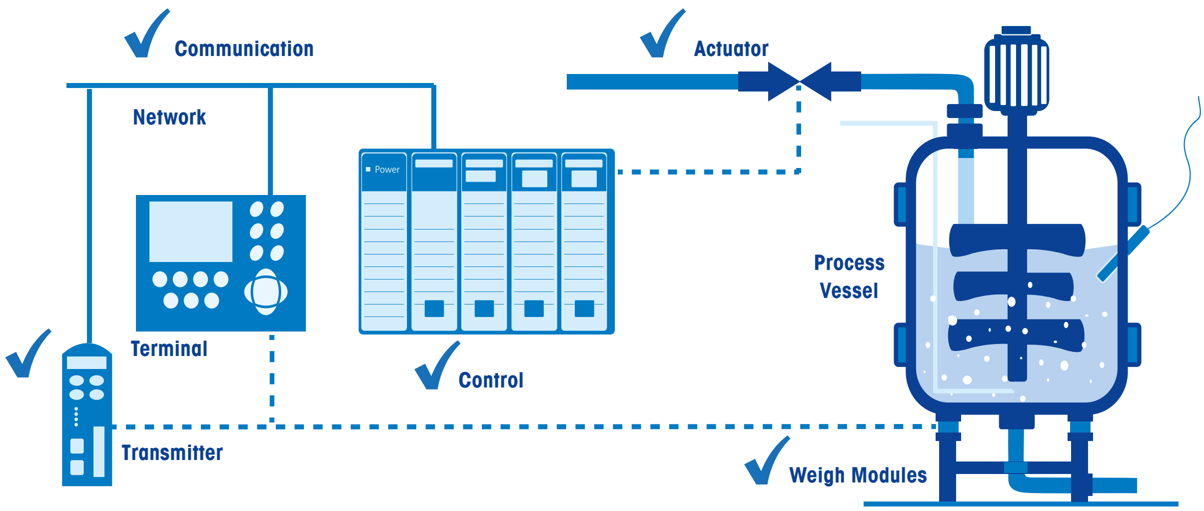


Figure 9: Optimizing your weight-based control system will help you create systems that provide the highest in accuracy, quality and safety.

Meet the Speed Challenge

Additional References:

ISO: ISO 5725-1:1997 Accuracy (trueness and precision) of measurement methods and results
http://www.iso.org/

VIM: JCGM 200:2012, International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM), 3rd edition, Joint Committee for Guides in Metrology, 2012.

DoWT: Dictionary of Weighing Terms - A Guide to the Terminology of Weighing, R. Nater, A. Reichmuth, R. Schwartz, M. Borys and P. Zervos, Springer, 2009.

Further reading Reading:
White Paper: "7 Tricks to Avoid Hidden Losses in the Beverage Industry" METTLER TOLEDO 2016
White Paper: "Successful Batching Outside a PLC" METTLER TOLEDO 2012

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