

# Why does your perfect belt scale under-perform?

## Here are 10 most common reasons and what you can do about them

It might be a fruit farmer installing a belt scale on a large incline, or a salt miner placing an idler too low under a conveyor belt, or a cement producer not using a speed sensor.

In each of these scenarios – and countless others – the purchasers of belt scales may be unaware that no matter how sophisticated and capable their scale is, if the location of the equipment isn't carefully planned, the set up handled properly, and numerous other extraneous factors taken into consideration, the result can be inaccurate weight measurements.

The experts at Siemens – with their decades of experience in the field – can deliver not only superior belt scales, but the know-how to make sure everything is put in place properly so you can get the most out of your equipment. In fact, even if you know you're going to have an issue that might affect accuracy, they'll be able to help quantify the extent of the impact so the potential impacts can be minimized.

This article looks at 10 of the most common problems you might encounter, and some tips on what you can do so your operations are not adversely affected by maintenance or downtime.

**Understanding the terminology: accuracy, repeatability and linearity**  
Before looking at those issues, it's important to first review the terminology involved, because often the word "accuracy" is used in weighing without understanding it in full context (Fig. 1).

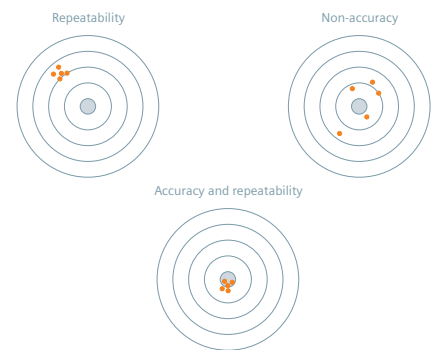


Fig. 1: Repeatability and Accuracy are both important to ensure reliable readings.

When a belt scale offers one correct measurement, that measurement is considered accurate. In other words, if 100 tons of material is transported on a conveyor and the scale reads 100 tons, the accuracy is perfect. But that is just one single data point. Accuracy needs to be repeatable. You need accurate readings over and over and over again. So if 100 tons of material is transported every day for 10 days and the scale tells you 1,000 tons have been moved, that's perfect repeatability.



Yet you still need even more than that. What if you have to adjust the load being weighed from its normal amount to a higher or lower weight? For example, your 100 tons per hour most of the time might only be 20 tons per hour on occasion. After such a “turn down,” you still need accuracy and repeatability. If you can achieve that, you now have linearity – the third leg of the measurement stool.

So keep in mind that problems can relate to one or more of accuracy, repeatability, and linearity.

**Determining the impact: every situation is different**

You also need to remember there are limits to how precise the quantifying of any one impact can be. Every application is different and will yield different results.

And most importantly, because a belt scale is part of a larger dynamic application – truly the definition of something with lots of moving parts – most often several of the problems are occurring at the same time. That makes estimating an exact impact extremely difficult. So in addressing the 10 problems outlined in this article, note that each estimated impact is based on an individual issue being looked at in isolation. In reality, it’s likely that multiple issues are involved.

In addition, all the estimates provided are not based on empirical data. They come from the real-world experience of Siemens people. Even though that experience is extensive, any numbers provided should be viewed only as an approximate guide.

**Problem #1: Inaccurate input when setting up means inaccurate output when measuring starts**

There’s an old adage in computer science – garbage in, garbage out. It

means the quality of an output is determined by the quality of an input. The integrator is your belt scale’s computer. If the information entered into it is not accurate, every measurement it produces will not be accurate.

As a result, careful attention must be paid to critical parameters that are keyed into the integrator before any measurement takes place. This includes the spacing between idlers, the belt length, the speed sensor’s pulley diameter, and the mass of the weight being used for calibration. For example, if the space between idlers is off by five per cent when that data point is inputted into the integrator, accuracy will be off by five per cent. Or if the pulley diameter is off by five per cent, accuracy will be off by five per cent. The correlation is direct no matter what the parameter.

**Problem #2: Idlers placed too high or too low – the most common and most significant source of reduced accuracy**

The single biggest problem with scale accuracy, repeatability and linearity is determining where the idler for the weighing device is to be secured. It cannot be too high above the conveyor belt or too low underneath it. There’s a “sweet spot” height to which it must be aligned. And it can be a painstaking process to get that alignment just right because if it is off from the ideal by as little as half a millimeter, there can be a sizeable negative impact.

On the one hand, if a weigh idler is placed too low relative to the other idlers, a tight conveyor belt could “bridge” over the scale. Simply stated, it could pass over the scale completely undetected. The weight of the material on the conveyor at one point in time might not push it down far

enough for a recording to be obtained. More material might be added later, so it will then push the belt down into contact with the scale, but the results will be inconsistent, with the weight being measured only some of the time.

On the other hand, if the weigh idler is too high, the opposite effect will take place. It can lead to a significant increase in belt tension, much like a rubber band being dramatically different when stretched compared to not stretched. As a result, a sizeable downward gravitational force could be exerted on the scale that exaggerates the weight, making it inaccurate on the heavy side.

Belt scales from Siemens are designed to be accurate within plus or minus 0.5 per cent, with some very high accuracy systems guaranteed to be at 0.25 per cent. For those levels of accuracy to be obtained, weigh idlers for the regular scales must be within 0.8 millimeters of the sweet spot location, and within 0.4 millimeters for high-accuracy devices. An alignment out by as little as 1.5 millimeters can throw accuracy and repeatability off by as much as three per cent. If it’s off by three millimeters, the impact could be as high as 10 per cent. And if it’s six millimeters, it’s possible for inaccuracy to be as extreme as 30 per cent.

To put that into financial perspective, consider the case of a gravel producer running an application of 200 tons per hour. If the gravel costs \$80 per ton, an inaccuracy of just 0.25 per cent would cost that company \$83,200 in lost material over the course of a year.

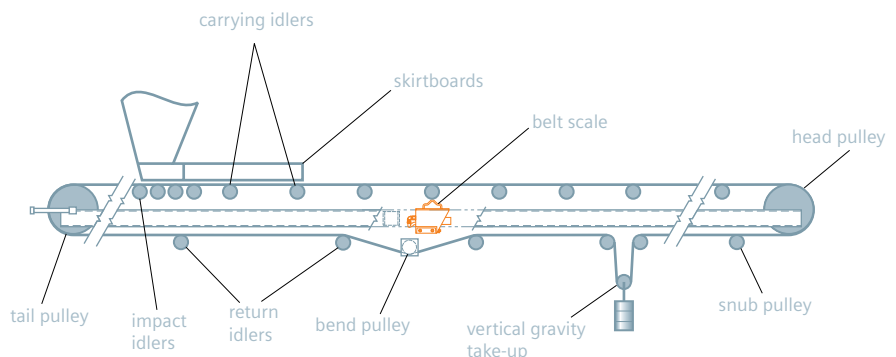


Fig. 2: Understanding the proper conveyor terminology will help avoid issues in application engineering and installation of a belt scale

### Problem #3: Belt tension too high or too low – a close second as a source of reduced accuracy

Right behind idler alignment – and closely related to it – is belt tension. If the belt tension is too high, bridging over the scale, as described in Problem #2, can become an issue. If the tension is too low, the material will shift as it rides over the “hump” of an idler. This can cause both repeatability errors, as well as material spillage.

Even if the tension is set up correctly at the outset, the ongoing operation of a conveyor can lead to tightening or loosening through of a range of factors – including temperature fluctuations, ineffective gravity tensioners, changes to the nature of the material being fed onto the conveyor, inclines that may vary along the belt path, and erratic belt tracking.

Ensuring that the belt scale is installed in an ideal location is essential for optimal performance and repeatability.

There needs to be an ideal belt tension “sag” of two percent between the idlers. The further away from two percent, the more inaccurate the weighing and the greater the number of non-repeatable results. Belt sag of less than one per cent can alter accuracy and repeatability by as much as 10 per cent. Belt sag of more than 2.5 per cent has an impact up to two per cent. If the sag is greater than five per cent, there could be major issues to address.

### Problem #4: Scale not installed in the proper location – particularly troublesome is if it's too close to inclines or sources of vibration

Choosing a sub-optimal location for the belt scale represents another leading source of reduced accuracy.

For example, both convex and concave style conveyors can present significant challenges (Fig. 3). The belt scale should be placed at least 12 meters before or 12 meters after the tangent point of a curve. Consider an agricultural facility where apples

are moved on a conveyor belt. If the scale is too close to the incline, some apples could pass over the scale, and then roll back down the incline and be measured again, making the reading inaccurate. The impact on accuracy and repeatability in this circumstance could be as great as 30 per cent.

In a variable incline conveyor, going from flat up a 16° elevation will result in a four per cent impact on accuracy. In general, inclines of just 20° can create actual roll back, and if the incline is 40° or more, the impact on accuracy can be so significant it can't even be predicted.

To address conveyor inclines and prevent roll back, some belts have cleats in them for added material traction. But those parts of the belt with the ridges will not behave in the same manner as the rest of the belt (in particular, not enabling a proper “trough” position that is needed for measuring), which can also limit accuracy.

Vibration is another key issue to consider in selecting where to put the

scale. For instance, in the aggregate business, mobile crushers are used that can generate a lot of vibration. If the proper scale design is not used, they can cause the load cells to move up and down, creating erroneous outputs of up to two per cent. If vibration is not visible, there is generally no need for concern. However, if it is visible, accuracy and repeatability can be affected. In fact, in rare extreme cases of vibration, a scale could fail. Mounting a scale close to a support structure can be a good idea to combat the effects of vibration.

Other installation locations to avoid include those that are:

- too near transition idlers that change the profile of the belt, leading to a change of as much as 15 per cent on accuracy and repeatability;
- under skirt boards or seal strips where material can “pinch” into the belt at the scale idler, which might mean a change of as high as 10 per cent;
- near a winged pulley, as the pulley can wrap around the conveyor belt,

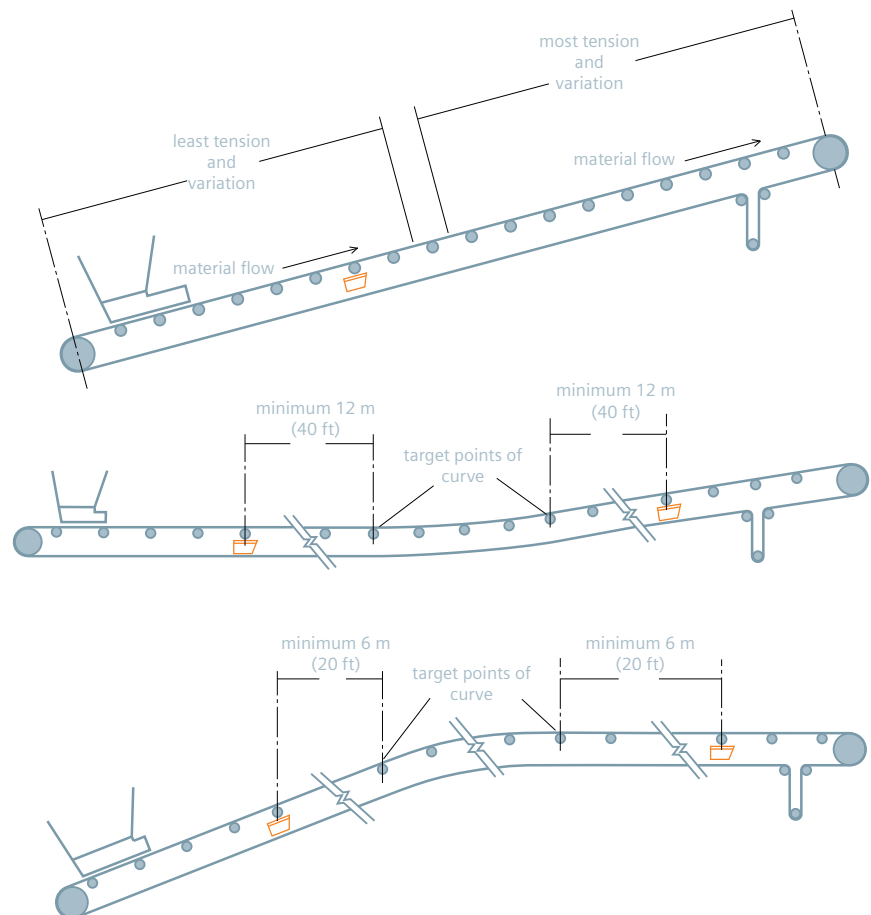


Fig. 3: Conveyor design and scale location all play a part in the performance of the belt scale system

“whipping” it off the scale, which could result in an impact of as much as 10 per cent; and

- close to metal detectors, having an inaccuracy influence of up to five per cent.

To avoid these problems, installation guidelines should be carefully followed.

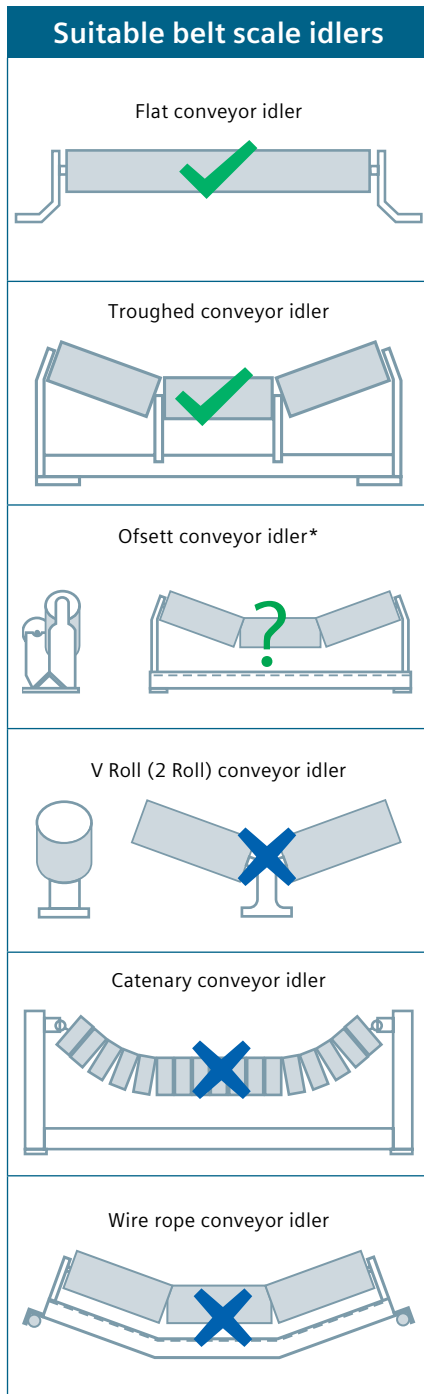


Fig. 4: These positions are ideal. For geometry outside these guidelines, please contact Siemens technical support. \*Acceptable in some applications.

**Problem #5: Poor conveyer quality or incompatible conveyer design**

The quality of conveyers and their components can significantly influence accuracy.

A frame that is improperly designed or has deteriorated from age may not adequately support the weight of the material, and cause the conveyer to twist, which might mean a reduction in accuracy and repeatability of up to 20 per cent. Another issue is that idlers could be worn out or not rotating properly. That can create friction, which leads to vibrations that can mean measurement inaccuracies of up to 10 per cent. Faulty tensioners are another common source of concern, because they are incapable of serving their intended purpose of compensating for loading or temperature changes on the belt. And of course, the belt itself is also a key factor. It could have poor splicing, holes, or tears, resulting in lost materials and therefore inaccurate measurements.

There are also conveyers that may be brand new but they can be even more problematic than older, poor-quality ones. That’s because their design may not be suited to housing a belt scale. If they use flat or troughed idlers, they should work fine. But v-roll, catenary, and wire rope idlers will simply not be compatible. In the case of the wire ropes, even though the idlers may be rigid, as soon as the conveyer begins to move, all of the measuring equipment will move around by the very nature of using the ropes (Fig. 4).

The type of belt used is also a factor. Some customers choose belts that are

over-engineered for their needs, most typically a belt that is too thick or with a core of steel. In these cases, the belt might not flex enough to give the sag needed to come into contact with the scale (Fig. 5).

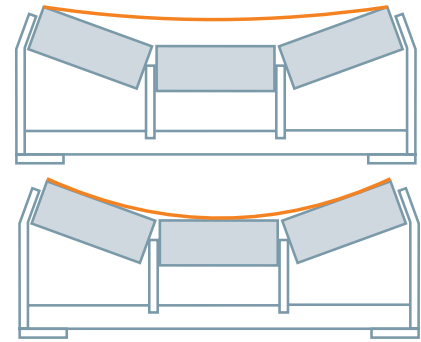


Fig. 5: Proper belt flexure is required for belt scale accuracy

**Problem #6: Thinking you don’t need a speed sensor**

In a dynamic weighing environment, speed monitoring is just as important as load sensing. It demands the same care and attention, and utilizing a speed sensor gives you the peace of mind you need to ensure that part of the weighing equation is covered (Fig. 6).

It’s common to hear some operators say their conveyers run at a constant speed so there’s no need for a speed sensor. Unfortunately, no conveyer actually runs at one uniform speed. There is always some variation. For example, at a rock quarry, a site manager might have a conveyer running at 100 feet per minute. The assumption is that it’s always at that rate. But when the conveyer is tested, it generally is off a little, running at, for example, a speed closer to 102 feet per

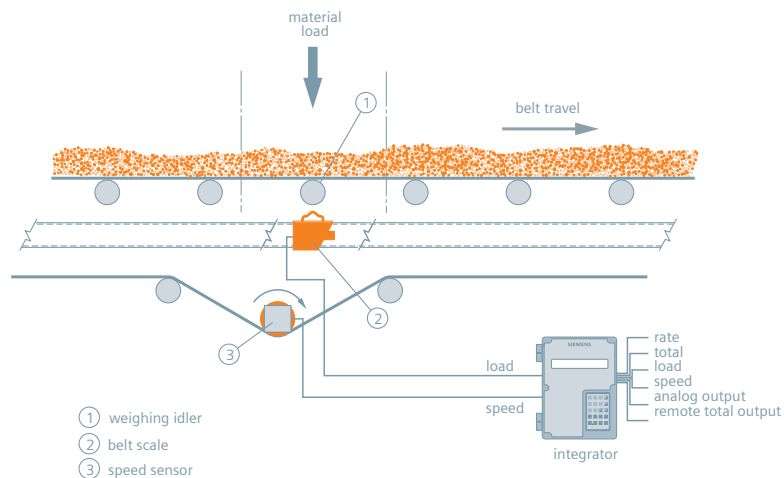


Fig. 6: As material enters the weigh span the load is measured by the deflection of the load cells while the belt speed is monitored by a speed

minute. That two per cent difference translates directly into accuracy being off by two per cent.

#### **Problem #7: Belt speed too fast and/or material not on load scale for long enough**

Materials can begin to “bounce” off the conveyer if it’s moving too quickly. If measuring takes place during the period of time when bouncing material is in the air, that weight will be missed. In addition, when the material lands, it will create a turbulence effect, which can also affect accuracy at the time of measuring.

Belt speeds greater than six meters per second can create inaccuracy of one to five per cent, which can be an issue if high accuracy is required.

Consistent material profiling can help mitigate the impact of this issue if the bouncing effect is repeatable. However, other factors would also need to be kept consistent at the same time, including moisture content, bulk density and particle size.

Similarly, whether it’s from bouncing or another reason, it’s important that the material being weighed is on the scale itself for a sufficiently long period of time that its weight can be accurately recorded. The load cells are essentially springs. There needs to be adequate “retention time” for changes in forces to settle on that spring, and the weight to then be captured and communicated, before the material can be moved from the scale area. This multi-step process will not take place accurately if the material moves too quickly over scale.

As a general rule, product specification is attainable if the retention time is greater than 0.4 seconds. If it is 0.25 to 0.4 seconds, there can be a 0.5 to two per cent impact on accuracy and repeatability. If it’s less than 0.25 seconds, the change can be one to five per cent.

#### **Problem #8: Dynamic frequency ratio causing a resonance effect**

In 1940, one of the most famous engineering failures in history was captured on film when the Tacoma Narrows Bridge collapsed, twisting itself and ripping apart spectacularly because of a resonance effect in which the natural harmonics of its design became unstable in a heavy wind.

For a belt scale, a similar effect occurs with the device’s “dynamic frequency.” Oscillation on the scale creates a resonant effect and this must be taken into consideration. In the weighing system, there is a natural frequency associated with the force the belt exerts on the weigh idler, as everything is supported on two load sensors. The loading, spacing between idlers and the speed of the conveyer can potentially work together to induce enough oscillation to match the natural frequency of the load cells. If that happens, the whole arrangement could become unstable. At that point, it becomes not just a matter of reliability but safety as well.

To ensure this does not occur, you need belt scale experts, such as the team at Siemens, to do some complex mathematical analysis and determine your scale’s “dynamic frequency ratio.” On one side of that ratio are the idler, belt loading and belt speed. On the other side is the deflection of the load cell.

If that ratio is one to one, the load cells will fail, just like the bridge collapsing. In fact, any value above 0.3 could be problematic, with an impact on accuracy of up to 10 per cent. In the case of the Siemens weighing team, if they encounter anything above 0.3 they will intervene to find solutions to try to get the number down to 0.2 or lower, where the impact is minimal.

#### **Problem #9 Load cell signal too low**

If we use our cell phone without any interference, we tend to enjoy great signal quality, and the little icon on our device will verify that with five bars in the top corner of the screen. If there is lots of interference, the signal can be really weak and we might strain to have an audible conversation. That is confirmed with just one bar on the signal strength indicator.

There’s an analogous situation with the belt scale and its signal from the load cell to the integrator. Each load cell needs a clear “resolution” in which detailed weighing information about the material being conveyed is captured, while any non-material weight (such as the weight of belt scale itself or the idler) is able to be dismissed as being irrelevant. Consider an aluminum can recycling operation. Each can

is very light so there must be high resolution to weighing them, because an influence like a belt tension change could have an impact greater than the actual weight of some cans.

The guideline is to use at least 30 per cent of the entire load cell capacity to prevent the effects of other influences from having a disproportionately large impact on the scale’s performance.

**When a scale is installed, a “zero calibration” is conducted to determine the weights and forces of everything other than the material being weighed.**

Accordingly, a live load signal indicates the amount of output the load cell can generate based on material loading. If that signal is less than 2 mV – reflecting a low resolution – there could be a one to five per cent change on accuracy and repeatability. If it’s 2-3 mV, the impact can be 0.5 to two per cent. Product specification for resolution can be attained at greater than 3 mV (using a 2mV/V-style load cell).

#### **Problem #10 Calibration not performed frequently enough, or wrong calibration method chosen**

When a scale is installed, a “zero calibration” is conducted to determine the weights and forces of everything other than the material being weighed. For example, if no belt-related weight is recorded when doing that initial calibration, that weight will not be discounted when actual measurements take place.

That initial calibration might be perfect. But dynamics can change significantly – whether an hour, a day, a month or several months later – as a result of a variety of factors, such as material building up, the onset of conveyer belt issues, or changes in the environment. It means you will need a certain frequency of conducting calibrations to ensure accuracy, repeatability and linearity. If it’s a high-accuracy scale or a critical application, calibrations may be needed twice a

day. For most applications about once a week tends to be sufficient. Some might find once a month is acceptable in their situation. The key is to have enough calibrations to establish a clear pattern for predictability.

Each case must be looked at individually. Consider temperature to illustrate the point. Belts at outdoor sites need to take different temperature conditions into account. A belt running early in the morning will have different properties than later in the day. In the morning, there might be extra weight from mildew that will have dried off by later. And rubber typically seen in belts will be less stiff in the afternoon after it has been running for a while with warmer temperatures and the sun shining on it. (Half an hour of warming up the conveyer should be done before any belt scale calibration.) Similarly, seasonal temperature changes will have an impact, as a belt in the summer will have much different characteristics than a belt in the winter. So repeatability might be affected if calibration is not done at various times to take those types of fluctuations into account.

Extreme temperatures can be especially tricky. Belt scales from Siemens are operational from -50°C all the way up to +60°C. But there are occasional circumstances – such as a mine in the far north – where it might get colder than that. In those circumstances, some

installation modifications to protect the integrator from the cold might be needed, beyond ensuring proper calibration in light of those extremes.

In addition to frequency, the method used for calibration is also an important consideration. You need to make sure you are choosing the right solution for your particular application. Using the actual material being conveyed for verifying calibration is the best method to ensure the scale can achieve the highest possible accuracy.

If that is not possible, using test chains (representing 40-60 per cent of load) is the next best option for optimum accuracy because these most closely simulate material flow on a belt. Static test weights (representing 25 to 40 per cent of load) can be used, but will not be as effective as chains because all the dynamic forces of material in motion will not be captured. Typically, chains should be used for critical or high-accuracy applications. Weights will be more acceptable for less accurate applications.

A third choice is electronic calibration, so there is no physical placement of weights or chains at all. This would be acceptable only for a very low-accuracy application.

As a general rule, you can expect using electronic calibration to result in a one to five per cent impact on accuracy, weights to have a 0.5 to five per cent

effect, and chains at 0.5 to two per cent.

### **Make sure you choose the right scale from the right manufacturer**

After you ensure all of these 10 problems are understood and managed, you still need to make sure you have a high-quality belt scale. That is once again where Siemens experts can help, as they have long been offering superior belt scales.

The systems delivered by Siemens feature the simplest mounting and lowest maintenance requirements on the market. They have no moving parts, include corrosion-resistant load cells, and are designed for 300 per cent of ultimate load cell capacity. Together with high-resolution speed sensors from Siemens, you can achieve high measuring accuracy, repeatability and linearity.

Not all scales are created equal, if you are looking at a model with bearings, leaf springs, pivots, bushings, counter balances or check rods consider the maintenance impacts. These assemblies require much more attention for proper operation and also suffer from slower reaction time to changes in loading as well as hysteresis from temperature and long term wear.

Best of all, everything sold comes backed by the knowledge and experience of a team of industry-leading experts who are always available to help you.

For more information about any of the belt scale issues outlined in this article – or details on Siemens belt scale offerings – visit [siemens.com/weighing](http://siemens.com/weighing).



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