Silo level monitoring: Part 4

Why measure the level in a silo?

This may seem to be an obvious question, but there are several reasons for asking it: what information are you looking for when you measure the level in a silo?

It's an obvious answer – 'to know how much is inside' – but there's a bit more to the subject than it first appears. 'How much is inside' in what sense? Do you want to know Level (%)? Volume (m3)? Weight (Kg)? And how accurate do you need the measurement to be? For example, to infer a weight from level/volume, unless the product lays perfectly flat with an absolutely stable bulk density, so realistically a measurement of bulk solids level can only ever deliver an 'indication' of weight.

Of course you can weigh your silo on load cells. But if level or volume is important to you and you get a changing bulk density, maybe because you want control points for process control commands, or perhaps overfill protection – it is better to use a level based device.

There are also occasions where you want to measure weight, but are unable put a silo or hopper on load cells, due to construction – like concrete, or the design - perhaps it's fixed into a group of silos, or too integrated into plant; perhaps it's a multi-compartmented mixing/blending silo, or maybe it is simply down to the cost of installation and the ongoing recalibration of weighing systems.

So, what information are you looking to get out?

If you are looking at a general level or volume indication for supply and replenishment, our advice is to use a percentage level or volume, rather than tonnes/kilos.

Whatever your goal - these following points generally always apply:

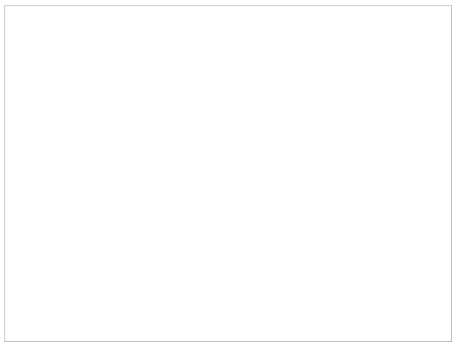
1. For maximum repeatability, the sensor's position on the top of the silo is key; and part of finding the best position is knowing how the product behaves on filling and emptying. Typically, it's recommended to be situated at 'half radius' pointing towards the outlet and on the opposite side to the fill point. This position will generally offer the best average level during filling and emptying as it measures approximately half way up the slope of material. However if the filling/ emptying points are unusual or vessel shape is irregular, a good level sensor manufacturer will advise you on site, or on drawings, the best sensor position(s) for your application.
2. Be realistic, don't expect anything much better than 5% accuracy of the full span/volume/weight. Sometimes you can, but sometimes it worse due to the configuration of the silo and material. But better to under-promise and over deliver. Remember, it's a level measurement. Often people take 3 tonnes from a 30 tonne silo and expect it to read 27 tonnes within a few KG; but a level system, even well installed and set up, depending on its position and the product surface, could be, for example +/- a tonne. But ask yourself is it important? Or are you just looking at "when it gets down to 5 tonnes I want to order another 20" …a level system will comfortably do that. The ratio between diameter and height can also have a big influence – the taller and narrower the silo the better, just like a test tube – the more level change per Kg the better the accuracy! For larger diameter silos (Biomass storage silos) multiple units can measure at key points for a surface profile/average volume, they can be used to produce surface profiles and calculate the volume of material beneath.
3. Build up on the walls or 'rat-holes' (see fig) can also create problems. Even for weighing systems, it means the silo can have a 'residual weight' when 'nothing is coming out'. If the system is mistakenly 'Tared' (or Zeroed), then how do you know how much to put back in? A level-based system can pick up on the build up and not see past it, nor read down the 'rat hole'. There is level in there but again, nothing is coming out. In these situations - what is the truth about what is in the silo? It may seem like the instruments are wrong (to the plant process operators nothing is coming out 'so the silo is empty') but they are not. The solution here is to better understand the handling of the product and how to move it to reduce these occurrences. The Wolfson Centre in Chatham UK offer excellent courses on understanding material handling and behaviour.

VEGA Controls Ltd.
Metior House Ashdown Business Park
Michael Way
TN22 2DU Maresfield United Kingdom
Tel.: +44 1444 870055
info.uk@vega.com
www.vega.com

What to use for level measurement

How can the level be reliably and cost effectively measured? Firstly here are some considerations to make (along with drawings and dimensions, temperatures and pressures) before you implement a level measurement, this will greatly assist a manufacturer of sensors to understand and advise the best method.

1. Is it a free flowing material, like a dry grain or plastic granule
2. Could it have a changing bulk density (waste, recycled product or Biomass)
3. Is there changing moisture content, that will affect material behaviour
4. Material size, e.g. waste or from different sources
5. Is there build up occurring on the walls
6. Will there be high dust levels
7. How and where is it filled? Will it interfere with a level device
8. Where can I position the sensor
9. Abrasion, corrosion are they factors to be considered
10. What accuracy do you want/need/can you work with (these may be different answers!)



Looking down into a ground ore silo: A good example of 'rat-holing' and causing a cable based sensor to deliver a level reading with no product coming out! But is it a wrong reading?

In the distant past, mechanical cable 'yo-yo' or 'plumb-bob' systems were widely used. In the 80's and 90's non-contact ultrasonic sensors were developed and implemented, along with capacitance and admittance systems, but all with issues: Cable based systems face issues with build up, abrasion of cables, roof loading, cross contamination, cable breakage, even weights falling off! Contactless ultrasonics struggle with dust, condensation, filling noise, air movement and high temperatures, especially when in combination, for example:

Condensation + dust x time = build up and deposits on transducers = impaired performance when also dealing with filling noise, dust or air movement False readings from build-up on walls, or tall narrow silos, welding joints, reinforcing bars (see fig) and signal 'skip or 'multiple echoes' bounced from steep surface angles of repose, are also common issues. However, contactless ultrasonic sensors for bulk level are still widely used, using large transducers to try to overcome signal loss. But in our experience with customers, they have weaknesses, requiring regular cleaning or re-programming visits in difficult, dusty applications. Generally, reading during filling is not possible with ultrasound.

More recently, the appearance of radar based devices – both guided wave (cable based) and contactless – have successfully entered the market place. Initial radar systems were mainly based on guided wave radar, where a signal transmits up and down a cable suspended the full length of the silo/measuring range, measuring the level by signal reflected back at the point of coverage by the product. However as this is still a cable based system and there is still installation, abrasion, roof loading, build-up retention and contamination of food stuffs to be considered. Contactless radar is an attractive technology due to its range, smaller antenna sizes, ease of installation, accuracy and high immunity to in-flight product, high dust levels with reduced surface 'skip' from surface angles. Radar sensors with lower frequency ranges, 26 GHz, and some lower in the 6-10 GHz range, proved successful in many applications. They are able to handle in flight dust and filling, but due to wide beam angles, have a few of the same fallibilities as ultrasonic devices: antenna build up, and false signals in tall, narrow silos etc. There were also a few new issues too, mainly with low conductivity (reflectivity) products to radar signal such as pure, fine plastics and powders, or products like wood shavings, ultra dry sand etc.

Now, the latest contactless radar sensors with 80 GHz technology can meet virtually every solids level measurement challenge you present them with. They have very tight focussing (3-4 degrees) for tall, narrow silos, allowing mounting closer to the sides, highly directional to avoiding filling streams and build up on silo walls. They have a smaller transducer sizes (80mm dia. measures up to 120m range) so they can be easily retro-fitted. They have advanced sensitivity, dynamic range and signal processing for coping with heavy antenna build up, measuring poorly reflective products like plastic powders, ignoring dust created by filling and handling even steep angles of repose. This new technology is helping bulk solids plant operators realise their goal of confident, reliable, long term level measurement, maintenance free and highly versatile.

The view looking down into a aggregate stone bin – where a non-contact 80 GHz Radar is mounted close to the side, with reinforcing struts and build up, yet it still measures reliably.

The product, known as a VEGAPULS 69, also offers solutions over a much wider application range. With measuring capability from 1 or 2 metres, right up to 120m, and an accuracy of ±5 mm over the full range, it still has enough performance reserves for unusual assignments, such as very small vessels or deep mine shafts. It's even capable of fast response distance measurement on conveyor car positioning systems and surface profiling. The VEGAPULS 69 is an excellent device for silo level measurement, helping with monitoring 'how much' in a variety of ways, and warning when high or low levels are approaching.

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info.uk@vega.com
www.vega.com

Summary

In this series, we have looked at sensors and systems for bulk solids level overfill, overpressure and level measurement/indication. Its important at every step to get the right information and understand your process, the technology and installation. Ask yourself “What am I looking to do, What accuracy and information do I realistically need?”. As all these issues are interconnected and important. Even with the most dependable of level measurement technologies, its also makes sense to be safe and use a suitable ‘independent’ high/low level switch - and, where needed, a pressure device to monitor safety for pneumatically filled silo overpressure. These fail-safes, when used in conjunction with a level sensor to tell you how much you have, will ensure you can operate at maximum safety and productivity, by anticipating the need for replenishment or perhaps let you know when a high or low level alarm is approaching before it gets there.

Before spending your company money and/or installing your sensor, make sure to get the ‘best’. We are not just talking price and quality, but the guidance and advice for selection, installation and long term support if there are issues, buy once and do it right. Get this from a full-range manufacturer who can provide case studies and references for your application, give you trial systems to test and prove, advise you on the best technical and commercial options, without any technology bias.

Have you read the previous articles on silo level monitoring? If not you can find them at:
Silo level monitoring Part 1: What’s the Worst Thing that Could Happen in the event of a Silo Overfill
Silo level monitoring Part 2: When a Silo High Level Alarm is not enough…
Silo level monitoring Part 3: Preventing silos overfilling

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