

Inventory Control Tank & Silo Weighing

Gravimetric level control is one of the most accurate inventory control methods available. Its high degree of accuracy makes it particularly helpful when measuring high-value solids, liquids and sometimes even gases.

Due to the fact that load cells are placed outside of the tank it is perfect for measuring aggressive, hot, frozen, non-free-flowing or non-self-leveling materials.

Tank/silo weighing is preferred in many applications for other reasons as well. Because of the system's inherent design, operators never need to handle materials being weighed. This makes it almost impossible to contaminate stored materials. Also, results are independent of tank shape, measured materials, or process parameters such as temperature or material viscosity.

A well designed, properly installed system has very low maintenance requirements and promises long life. On a typical one-year maintenance and calibration cycle, a moderately used tank scale provides decades of reliable inventory control and weighing.

This paper further explores the benefits of tank/silo weighing as well as points to consider for their optimization.



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1 Advantages of gravimetric level control

Highly effective inventory management can be obtained using gravimetric level control. This is primarily because tank-based gravimetric inventory control is independent of many influences that other technologies must cope with.

Tank design can be optimized for the material that will be measured. Therefore, gravimetric inventory control offers a great deal of production flexibility. Materials and other process parameters such as temperature, viscosity, density and pressure can be changed without recalibration or sensor adjustment.

Accuracy

The gravimetric method provides the best accuracy combined with high flexibility for inventory control over a long time. Even simple systems achieve accuracy levels of one percent or better. Accuracy can be as good as to 0.1 percent or lower of applied load in optimized systems. No other inventory control technology for tanks comes close to this level of optimized material use.

Capacity

Single load cells and weigh modules are available from a few kilograms to several hundred tons. Multiple cells or modules can be arranged under one tank for a net capacity of several thousand tons.

Ruggedness

Load cells can be integrated into complete weigh modules with factory adjusted overload protection. Dedicated mechanisms protect the load cells from damage due to under load coming from the effects of wind forces. The tank can even be protected from tipping over in case of earthquakes or very strong wind forces. Stabilizers protect the load cells from torsion effects which result from mixers inside of the tank.

Hygiene

Gravimetric inventory control requires no direct product contact with the sensor. No special access to the silo or direct contact with material is required as it is with other technologies. The entire maintenance is possible without getting into contact with the material or the inside of the tank. Thus the tank can be optimized for hygienic aspects and low contamination thread.

Free Choice of Tank Material

Manufacturers have the ability to choose the most suitable tank material and surface quality without compromising accuracy. This simplifies the design phase and construction of food-grade tanks and silos.

Flexible Use but always Accurate Results

Tank weighing provides a high level of flexibility to a weighing process. Results are independent of:

- Tank shape: Gravimetric inventory control works with all tank shapes, which allows material flow to be optimized without compromising sensor requirements.
- Measured material: Gravimetric inventory control is independent of material. It works with liquids, high viscosity liquids, grind materials, sticky bulk materials, foam, etc. Change of material does not require recalibration or sensor changes, which adds to the method's flexibility. It is possible to measure input of different materials in batching or mixing processes.
- Process parameters: Changes of temperature, pressure, density and viscosity don't influence the result. Gravimetric level control always works.

One Single Measuring Technology for the entire Process

One common level/mass control technology for the entire process is possible. This reduces training needs for operators and maintenance to understand functionality, calibration and limits of many different sensor technologies.

Long Life / Low Maintenance Requirements

Gravimetric sensors or their so-called load cells are low-maintenance parts. They require less calibration than many other inventory control technologies. Depending on environment conditions, proper installation and protection measures, load cells can last for decades with no performance loss.



METTLER TOLEDO Compression Weigh Modules

2 Tank scale design

Weigh modules help easily convert almost any tank, hopper or silo into a scale. They contain all features required for load cell accuracy as well as safe operation, including the ability to operate under the effects of various temperatures.

There are two basic types of weigh modules:

- **Compression** weigh modules are designed so that a tank or other structure can be mounted on top of the weigh modules.
- **Tension** weigh modules are designed so that a tank or other structure can hang from the weigh modules.

Whether compression or tension weigh modules are used depends on the specific application. The chart below provides an overview of general design considerations affecting the choice of weigh modules.



METTLER TOLEDO Tension Weigh Modules

Design Consideration	Compression Weigh Modules	Tension Weigh Modules
Floor Space	Requires enough floor space to accommodate tank size. Might require buffer space around tank	Requires no floor space and can be suspended to allow free movement beneath tank
Structural Restrictions	Weak floors might require additional construction or a special installation to accommodate weight of filled tank	Weak overhead supports/ceilings might require additional construction or special installation to accommodate weight of filled tank
Weight Limit	Generally unlimited. Even load distribution is inherent with three vessel supports, and is increasingly difficult to achieve as the number of weigh modules grows beyond four	Tension weigh modules are available up to 10t (20,000lb). This and structure considerations limit tension system capacity
Load Cell Alignment	Designs may vary and must consider floor deflection, available support beams, and tank size, shape, and condition	Cell alignment will not vary significantly because tension rods and other support equipment tend to accommodate most deflections

A tank scale's support structure should deflect as little as possible, and any deflection should be uniform at all support points. Excessive deflection can cause inlet and outlet piping to bind, creating linearity errors. When deflection is not uniform, it can cause repeatability-, linearity- and zero return errors due to creep. In extreme cases it can result in overloading those load cells which are placed on a more rigid part of the support structure.

Numbers of Weigh Modules Needed

For an existing installation, the number of supports determines the number of weigh modules. If a tank has four legs, four weigh modules are required.

For new installations, a three-point support system is preferred. Using a three-point system, correct load distribution on the weigh modules is assured. However, if wind, fluid sloshing, or seismic loading factor into operations, the tank might require four or more supports for additional stability and protection against tipping.



Design Considerations in Context with Calibration

The method of calibration has to be determined before start of design since there are three different methods which influence design of tanks and silos.

A full capacity calibration with certified weights traceable to the national standard ensures best accuracy and reduces risks. This method is applied for expensive material or if it is not possible to fill tank to full capacity with material that is finally stored on water.

A step calibration is applied in using weights of 20% of full capacity only. After the first step of calibration the weights are taken off and substituted by water or any other suitable substitute with the weight of 20% of full capacity. In the second calibration step the weights are added again to reach a total of 40%. In the third step weights are substituted by water again. Then the weights are added again to reach 60%. This procedure is repeated until 100% of full capacity is reached.

The METTLER TOLEDO CalFREE™ method ensures reasonable accuracy without using weights on site. The actual calibration of the load cells is performed on production. The deviation from the traceable test weight is recorded and listed. Each individual load cell, which can be used for CalFree, is delivered with its deviation values. A dedicated weighing electronic is configured with these values on site to substitute calibration with weights.

The full capacity and the step calibration require fixtures to hang or place weights with an equal distribution on the tank. The application of the CalFree method requires weight transmitters or weighing terminals with the capability to input the deviation values of the load cells.

3 Tank scale installation

A tank scale's accuracy and safety depends on correct installation and calibration. It is advised to use dummy load cells during welding on the support structure and while mounting the tank to avoid damage from overload or flow of electric currents through the load cell. These dummy load cells should also be used while concreting the base plates for the weigh modules. An initial calibration with at least 20% of full load in using certified weights which are traceable to the national standard is recommended. A step or even full load calibration should be performed if expensive material is stored or a high risk is related in case of inaccurate results.

It is recommended that technicians with experience in weighing technology handle initial installation and calibration in order to achieve optimum accuracy and safety. The initial calibration should be certified with a document issued by a notified body. Such a document confirms correct installation and calibration right from the beginning of operation.

4 Weighing terminals and transmitters

Simple weighing terminals display the weight. Transmitters just transmit the weight via serial interface or Fieldbus to a PLC or ERP. However, advanced weighing terminals don't only display and transmit weight. They also play an important role in providing accurate results if they have advanced filter technology to eliminate effects from sloshing liquids, environmental

vibrations or mixers. A predictive maintenance function warns the operator from a potentially coming failure. This feature is described in the next chapter. The terminal with METTLER TOLEDO CalFREE™ enables calibration without weights. This can save installation and repair cost for applications with low accuracy and no traceability requirements.

5 Maintenance

Regular maintenance of weighing equipment is recommended.

A 1-year interval at 20% of full load is adequate for many applications. However, a maintenance schedule should always be based on a thorough risk assessment that takes into account impacts of incorrect results, minimum weight, and raw material costs. METTLER TOLEDO provides proven, professional methods for determining optimal calibration.

During regular maintenance visits, experts check the status of load cells, connection boxes, cables and terminals. They will also perform load tests with certified weights which are traceable to the national standard

and recalibrate the modules if necessary. With this minimum amount of maintenance effort, a tank scale typically works trouble-free for decades.

Advanced weighing terminals and transmitters offer predictive maintenance functions in permanently checking the signals of the load cells for abnormalities. In such situations they inform operators. In extreme cases they can substitute a defective load cell electronically until replacement.

6 Summary

Gravimetric level control using tank scales is one of the most accurate methods to determine inventory level. It provides maximum freedom to optimize tanks to material and process while also allowing a high degree of flexibility surrounding materials being managed.

Pristine hygiene and process flexibility are inherent in tank/silo weighing. Parameters such as material temperature, density and viscosity do not affect results, so recalibration and sensor changes are not required when changing materials or recipe formulations. This flexibility also enhances the method's cost-effectiveness.

The choices of compression versus tension weigh modules, as well as the number of weigh modules required, is determined by application and current use

considerations. For new systems, a three-point weigh module design is preferred for balanced load distribution. More may be considered when other process parameters come into play.

Maintenance requirements of tank/silo weigh modules are few. A well-designed system working in moderate environmental conditions only requires testing and calibration once a year and provides decades of reliable use.

With gravimetric measuring, one technology can be used for all tanks and many other applications on the production line. METTLER TOLEDO can help with complete product range, weigh module, installations and maintenance consulting through a variety of engineering documents and service capabilities.

7 Additional resources

- METTLER TOLEDO's Tank/Silo weighing
www.mt.com/tank-weighing
- METTLER TOLEDO Weigh module offering
www.mt.com/weighmodules
- Download comprehensive engineering documents
www.mt.com/ind-system-handbook

www.mt.com/ind-food-productivity-guide2

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