



StrainCell™

Performance Tests

On Steel Skirted Silos

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by
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Background

Strain Systems Inc. offers inventory monitoring for bulk storage silos using the highest performance, nonintrusive, continuous silo weight and level measurement solutions in the world. Measurements are based on the patented StrainCell™ sensor, designed by longtime instrument inventor Walter Kistler to solve the problem of temperature impact on sensor readings – resulting in the first bolt-on sensor virtually immune to temperature change. Further, the StrainCell mounts with a single bolt, making it easier and less expensive to install than all other sensors on the market.

Bulk storage silos vary by their support structure: legged silos rest on I-beams, H-beams, square or rectangular tubing, or round tube legs, and skirted silos are supported by a series of steel panels surrounding the silo, protecting the cone and distributing weight to the ground.

Materials stored inside a skirted silo are commonly manufacturers' raw materials such as plastic pellets, flour, cement powder, limestone, gypsum, and foaming liquids. Accurate weight data on these inventories is critical because:

- a. Material is purchased in weight and consumed in weight
- b. Production downtime results from the unexpected exhaustion of raw material inventories
- c. Overflow spills are costly
- d. Running out of material may, in some cases, damage production equipment
- e. Accounting reconciliation can be a major issue if serious discrepancy occurs between actual inventory and company books.

To overcome these issues, several vendors offer solutions in the market. To date, skirted silos have been served primarily by devices that provide an indication of the **level** of the raw



material inside the silo, then conversion tables are used to arrive at weight. Serious errors may be introduced in both steps of the process because:

- a. The level of material in a silo is rarely an even distribution; the stored material forms peaks and cones in silo-filling operations, and voids, avalanches, and funnels when material is drawn out.
- b. Conversion tables do not account for density variation, which is related to the temperature of the material and even to the method of loading material into the silo.

These level measurement errors combined may add up to 20–30% of full scale of the silo in weight.

A weighing system, on the other hand, is installed on the *outside* of the silo and is therefore not hindered by the behavior of the stored material; therefore, directly monitoring the **weight** of the material provides much greater reliability in inventory management. Load cells offer the highest accuracy because their sensing elements are built into the silo support structure but they are generally too expensive for retrofitting existing silos. Bolt-on strain sensors were – until the StrainCell – hampered by the persistent problem of impact of temperature on sensor signals. In performance tests (Figure 1), bar-shaped and L-shaped bolt-on sensors reported errors as much as 30% due entirely to changes in temperature. Only the StrainCell resolves that challenge and delivers accuracies of 1 to 3% of full scale.

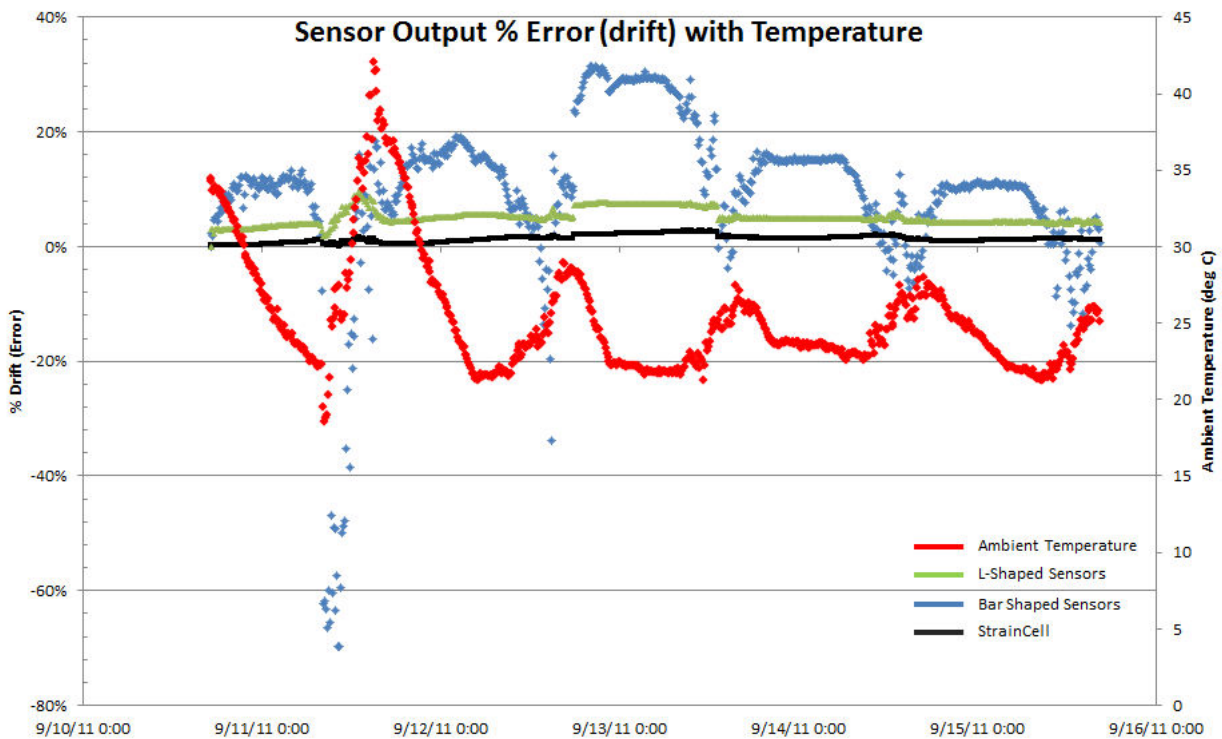


Figure 1. StrainCell™ vs. Other L- and Bar-shaped Sensors

The StrainCell-based solution pairs the sensors with intelligent electronics and virtually turns silos to scales™ – offering accurate, nonintrusive, temperature-compensated, reliable, repeatable, continuous weight and level measurement of silo inventory. The SOLO™ is designed for single silos. The ENSEMBLE™ serves silo farms. For plant managers who prefer the convenience of a subscription service rather than capital equipment purchase, Strain Systems created **mysilo.info**, a StrainCell-based service providing affordable, scalable, global, and central management for inventory on one website. Real-time readings can be accessed locally or from anywhere in the world.

Since its launch, StrainCell has been installed on both legged and skirted silos globally. Though market acceptance and feedback have been positive, the Strain Systems technical staff wanted to document the performance of the new technology to provide evidence to our customer base that the challenging silo weighing problem for skirted silos, including those with low psi (less than 1,500 psi), has been solved.

The purpose of this paper is to describe and report findings of an extended test of StrainCell performance on a **steel skirted silo installation**.

Test Site



Figure 2. Test Silo

A plastic pipe manufacturer in Washington State, USA, made available to Strain Systems a skirted silo (Figure 2) for system testing and analysis.

The silo owner has always manually calculated his raw material quantity, resulting in occasional interruption in production when stored quantities ran too low. His goals in providing the silo for the test were to gain a monitoring system that would enable him to better manage his inventory, ensure in-time ordering of raw materials, and reconcile consumption with bookkeeping.

The test silo has the following parameters:

Test Silo Parameters	
Silo Location:	Washington State, USA
Silo Type:	Outdoor skirted silo
Silo Material:	Plastic Pellets
Operating Capacity:	165,000 lbs
Diameter:	12' 72"
Skirt Thickness:	¼"
Calculated Stress:	1,375 psi
Reference Weight System:	Conair hopper/mixer

Additional engineering considerations were a slightly uneven seating of the silo on its foundation and a mechanical connection to a neighboring silo. A hopper/mixer operated in connection with the test silo is equipped with load cells, which provided a means of verifying load and draw weights throughout the test.

Test Setup and Data Analysis

After completing its usual application engineering procedures, Strain Systems installed four StrainCell sensors on the skirt of the test silo on the second tier panels (Figure 3).

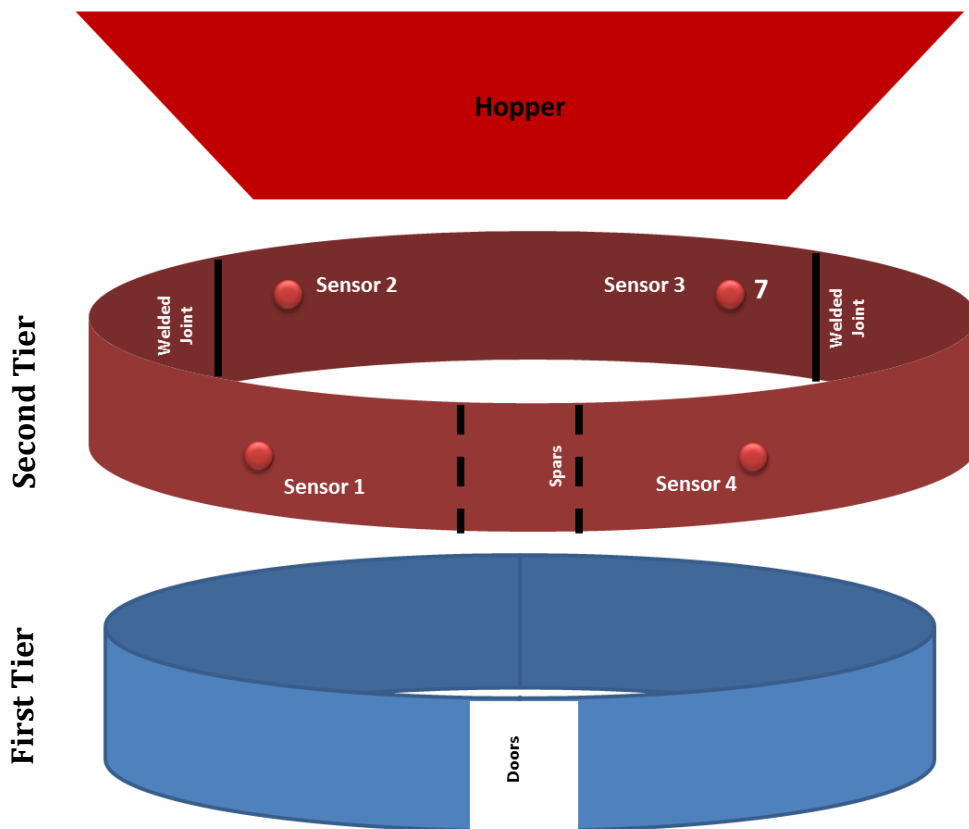


Figure 3. Sensor Installation Layout

Display and electronics hardware were installed in the manufacturing area. Several remote displays in Strain Systems' Bellevue offices provided for remote monitoring of the silo. Silo weight readings were continuously monitored remotely, and daily weight readings were recorded both from the Strain Systems' weighing solution display and the Conair hopper/mixer display. After initial monitoring of the silo for several weeks, a customized calibration curve was generated for the silo. These calibration parameters were entered to the software/electronics remotely via email. This is another "first" Strain Systems has introduced in the industry: remote calibration and troubleshooting of the weighing solution via email.

During the test period, ambient temperatures varied from 35 to 50 degrees F, with sporadic sunshine.

Results

Data collected both from the StrainCell-based weighing system and Conair hopper/mixer during the test period were plotted over time (Figure 4). The blue line in Figure 4 indicates readings collected from the StrainCell system. The red line indicates the readings taken from the Conair system.

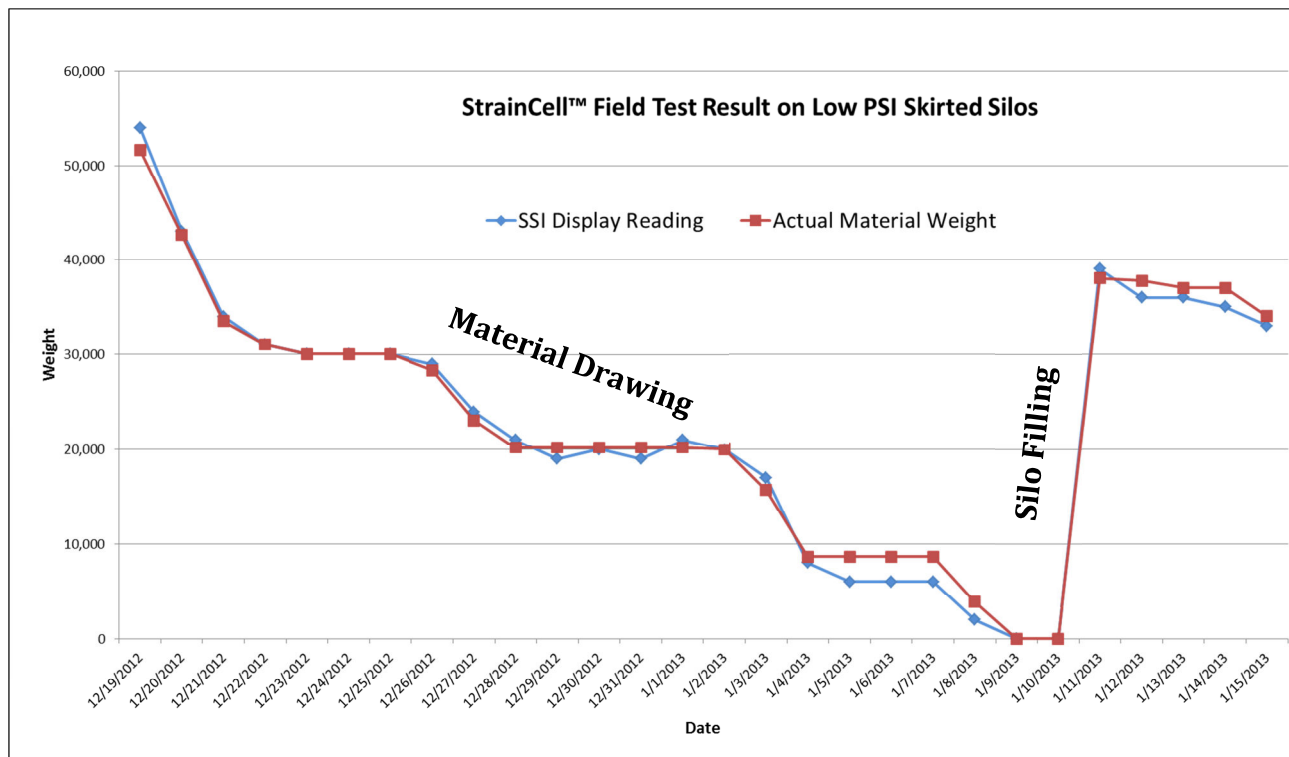


Figure 4. StrainCell System Performance

The four-week test segment shown above started after the silo owner loaded 54,000 pounds of material into the silo. As material was drawn for production, Strain Systems’ weighing solution continued tracking the weight changes all the way to the point that the silo was empty. While the silo was empty, the Strain Systems display continuously indicated a zero (silo empty) value and started picking up weight changes as the silo was reloaded with material.

Strain Systems’ weighing solutions, unlike other solutions in the market, are continuous weight measurement solutions. This means the measurement system will sense external factors such as mechanical constraints, temperature variations, vibration, wind, shock, etc. Because the solution includes smart algorithms in the electronics and the sensor is intrinsically temperature compensated, fluctuations in the measurement system during the test remained within 2,000



to 3,000 pounds (less than 2% of full scale) of the actual material weight as plastic pellets were drawn for production.

Based on the reference measurements of the Conair system, the StrainCell system readings stayed within a total error band of 2% of the 165,000-pound silo throughout the test. The total error band statement includes maximum uncertainty errors for linearity, hysteresis, short-term repeatability, temperature drift, zero offset, full span offset, and all other errors caused by the external factors mentioned above.

Strain Systems is proud to announce that it has overcome a long-lasting problem in the silo weighing market with the StrainCell technology.

As a result of the test conducted, Strain Systems can confidently state that the StrainCell-based skirted silo weighing system can weigh skirted silos within a total error band of better than 3% of full scale (less than 5000 pounds in the test case) assuming that a good calibration is performed on the weighing system.

Contact Strain Systems for further details at support@strainsystems.com

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