Silo Weighing Systems

~Siloweigh~

Installation procedures and examples
What is SiloWeigh?

- SiloWeigh tells you the quantity of contents in your silo or vessel
  -not as an empty or full signal
  -not as a percentage full signal based on a level measurement.
- SiloWeigh measures the actual weight of the silo and contents to give a true picture of the amount on hand - and it costs little more than a high-end level sensor. It uses sensors attached to the silo legs.
- SiloWeigh can display the weight of contents in practically any vessel. Examples are: cement, sand, aggregates, flour, grains such as corn, rice, wheat, oats and barley, mineral ores, coal, coke, chemicals, plastics, even liquids and liquefied gases.
- Accuracy is typically within ±2% of full scale when all legs are fitted with sensors and stress is within the recommended range.
- Install and calibrate the system yourself.
- We deliver a kit with complete instructions.
- The SiloWeigh system can be used with any strain gauge sensor. For higher accuracy, load cells can be used. For liquid level sensing, pressure sensors can be used.
Where SiloWeigh can be used?

- The name SiloWeigh implies that it is used on silos. This is true, but it can be used on any vessel that has legs or a supporting structure.
- The easiest application is on “H”-beam legs, but "O" (round) section, square, "L" and "S" sections have been gauged successfully, as well as skirted silos. The only limitations are the ability to bolt the sensors onto the surface and the available stress in the leg.
- Bins and divided vessels are a problem because the legs are shared between two or more partitions.
What is the sensor?

- Basically it is a load cell, but instead of measuring force, it is clamped onto a surface where it measures the extension or compression in the surface.
- It uses metal foil strain gauges, which consist of a pattern of resistive foil printed onto a backing material. These are bonded onto the metal of the sensor.
- They operate on the principle that as the foil is stretched or compressed, the resistance of the foil changes in a defined way.
- By connecting four gauges in a Wheatstone Bridge arrangement, the change in resistance can be accurately measured.
Stress Calculator. How? Why?

- It is important to verify that the stress is sufficient to give good results.
- First measure dimensions of leg cross-section.
- Enter these into calculator. Use English if you measure in inches and tons, Metric if you measure in mm and metric tons (tonnes).
- Enter vessel capacity and number of legs.
- Calculator automatically divides total load by number of leg and calculates stress in each leg.
- Recommendation is given at bottom.
- Stress of less than 800 psi is too low for usable results.
- If stress is between 800 and 1500 psi, application is marginal – low stress can give readings that drift.
- Above 1500 psi is a good application. The higher the stress, the better will be the results.
- If calculation gives greater than 15,000, stress is too high and structure will fail. Check your entries.
How to measure different cross-sections

- The Cross-Sectional Area is the area of the drawing you would get if you cut out a piece of leg and drew around it on a piece of paper.
- If the sides are flat, divide the area into rectangular sections and calculate the area of each section, then add them up.
- If the sides are curved or if you can put a tape measure around the whole thing, measure the outside surface and then the thickness.
- Multiply the total circumference by the thickness to get the csa.
- Enter the csa into the box “Or enter csa directly.”
- Experiment with calculator to see what it can do.
Skirted Silos

- A special case:
- You can look upon a thin cylindrical wall as a single “O” section leg
- Of course, the silo has only one leg – the skirt
- Typical skirted silos have a wall diameter of 8 to 12 ft diameter (96 to 144 inches – all dimensions have to be in inches or mm)
- Wall thicknesses are typically quite thin – from 0.2” to 0.4”. Note that cylindrical sections are very strong considering the amount of material. Try rolling a piece of paper into a tube and pressing on both ends – get the idea?
- Enter values as a single “O” beam leg in SiloWeigh calculator
- Ignore spaces for doors etc. when calculating csa
Cross Bracing effects

- Some of the silo weight is carried by the cross braces
- Although not usually a large percentage, it does reduce the stress in the legs
- This can be allowed for in the calculation
- The new Silo Stress Calculator includes Cross Braces
The Full calculator

- Calculator now includes effects of cross-bracing.
- Can use calculator without entering cross-brace info.
- If cross-brace info is available, calculations are more accurate.
- Also a recommendation is given on cross-brace effects and if they are likely to cause problems.
- Also added are different leg formats.
Where to mount the Sensor

- Ideally the sensor should be placed on the NEUTRAL AXIS in both directions. This is where bending the beam does not stretch or compress the metal.
- The result is elimination of errors due to side forces.
- Usually the sensor can be placed exactly on one neutral axis but only at some distance from the other.
- On an “H” beam, sensor can be placed on the “A” axis NA but not on the “B” axis NB unless the metal was hollowed out.
- Small allowances have to be made, the objective being to make installation easy while minimizing the chance of errors if the legs are bent or twisted by external forces.
How to mount the Sensor

- Sensors measure the force in the leg
- The force is always along the axis of the leg, not vertical if leg is not vertical
- The Neutral Axis is on the centerline of all symmetrical legs
- Measure the centerline and place mounting holes within 1/8” (3mm) of centerline to eliminate side forces
- Locate sensors at center of longest free stretch of leg, where bending forces are at a minimum
Preparing legs for installation 1

- First, identify the legs on the silo to be fitted.
- Pick a location for the sensors. Ensure the desired mounting location is free from bumps, burrs, and weld seams. The sensors need to mount on a flat face.

- Draw a vertical line in the center of the leg, at the chosen sensor location.
- Place the drill template on the leg, so that the line & holes in the template align with the line previously drawn on the leg. Tape in place.
Preparing legs for installation 2

- With the supplied center punch, punch two marks through the two holes in the template. Strike the punch with a hammer.
- Remove the template and set aside for the next leg. Ensure the punched center marks are on the line, and deep enough to hold the drill bit in place.

- At the punched marks, drill a 1/8” pilot hole, and step up to a 1/4” diameter hole. Finally, enlarge the hole to 7/16”. Use a cutting lubricant to ease the work and prolong the life of the drill bits. Affix the sensor to the leg with the 3/8” bolts, nuts, and washers provided. Do not tighten yet. Note: If the drilled holes do not line up with the holes in the sensor and the bolt jams the sensor, it will be damaged! Take care!
Assembly onto H-beam legs
Assembly onto H-beam legs
Sensor correctly installed
Assembly onto rectangular tube legs
Sensors Connection to Junction box

- As part of the Silo weighing installation we use of the digital junction box DJB - 4 which is designed to connect up to 4 Weigh sensors or analogue junction boxes of 1-4 load cells each.
Connection to Display Terminal

In case of installing 2 to 4 silo weighing systems we use one Analogue junction AJB per silo and then all the AJBs are connected to a central DJB – 4.

Two versions are available:

- Base model RDT52A (LED display, panel mount enclosure, RS485 serial port) maybe used for approved weighing applications not requiring printouts or totalization.
- Extended model RDT52B (LED display, panel mount enclosure, RS485+RS232 serial port, real time clock, Alibi memory) maybe connected to a printer or to a PC via the additional RS232 port and allow also printouts conform to the European regulations, since it is equipped with real-time clock and Alibi memory.
Distance Silo Monitoring

There is an extension of the system in which all silos can be monitored by weight data transferring using a GSM mobile network.
System Schematics

- GSM Device
  - RS232
  - RS485
  - RDT 52
- DJB-4
  - AJB
- Multiple silos connected via RS232 and RS485 interfaces.

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Verify your Installation

- Guarantee success by monitoring the sensor as you mount it.
- Install sensors on legs but do not tighten bolts
- Make all connections in junction boxes and indicator
- Apply power and measure signal voltage at indicator (between SIG+ and SIG- terminals at indicator). You should measure between -1 and +1 mV.
- Position first sensor centrally over holes on leg and tighten bolts to about double finger tight
- Check that signal voltage has not changed outside the -1 to +1 mV band. Tighten in stages, re-checking each time. If a shift is seen, check hole alignment and correct as necessary
- Repeat for each sensor. Once this procedure becomes a habit, you can guarantee success in every installation
- If you do find holes that are not drilled at the correct centers, it is possible to utilize one of the two holes and drill a third hole above or below the first two. Exact location on the leg is not critical.
How to diagnose a bad sensor

- Sensors are checked prior to shipping. They measure force, and are prone to damage by the forces generated by dropping, hammering, bending or similar abuse.
- Each sensor should meet the zero balance specification prior to installation.
- The excitation voltage is 12V. Sensor full scale output is 1 mV/V which equals 12 mV maximum when measured between SIG+ and SIG-wires (green and white). Zero balance should be well within -1 mV to +1 mV. A voltage outside this band indicates that the sensor is under load (remove all load and try again) or it has been overstressed and damaged.
- If inside -5 to +5 mV, it is possibly still usable. If outside this band, it should be discarded and replaced with a new sensor.
Grounding for lighting protection

- If a nearby strike induces a charge in the silo, a voltage is developed between the silo frame and true ground, to which the plant electrical supply is connected.
- This creates a large potential difference between the silo leg and sensor body mounted on it, and the strain gauges inside the sensor which are connected to the indicator, at true ground potential.
- The strain gauge base is thin plastic, able to withstand 50 volts but not much more. This ruptures and destroys the gauges plus the electronics of the indicator.
- Connection of the silo frame to the indicator frame ground can reduce the risk of damage.
- For more extreme protection, use lightning arresters on sensor connections.
- Note that a direct strike will fry everything. Call the insurance company.
Round Legs

For each leg, mark two points on the leg, along the axis, 6 inches apart. Drill a 1/2" hole at each point.

Place the assembled jig & mounting faces on the leg. Ensure the mounting faces are centered over the drilled holes, and aligned with the vertical axis of the leg, secure in place.

Tack weld, then fully weld the mounting faces to the leg. Check periodically to ensure they have not shifted, moved, or twisted. The two mounting faces must be flat, and parallel to each other.

Once welded, remove & discard the jig, but retain the 2 holes for sensor installation.

NOTE: In order to successfully install the “Silex” sensor on round legs, flat & parallel mounting faces need to be installed.

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Round Legs with Junction Box
Sun Shields – How & Why?

- Supplied with a Siloweigh kit, are some aluminum sheets. This is used as a sun shield.
- You may notice a drift in the reading as the sun rises in the morning; this is normal and is due to a slight warping of the legs caused by sunlight. Before noon this effect disappears.
- The amount of drift depends on the geometry of the legs and the heat rise; it can be reduced by shielding the legs from the sun.
- With the system working correctly, and to your satisfaction, the legs can be wrapped with the sun shield.
- The supplied aluminum sheet should fit around a 10” ‘H’ beam leg, with a little overlap. If your legs are smaller, trim to size, or make multiple wraps around the leg.
Sun Shields

- Wrap and position the sun shield so that the sensor is centered in the wrap.
- Secure in place with bare steel wire provided. A little tape is useful to hold the sunshield once wrapped.
- Wrap the wire around the sunshield. Cross the two ends over each other, and continue twisting the ends together to secure the sunshield in place. Take care to not tighten too much, otherwise the wire will break.
- Repeat for the second length of wire, so that each sunshield is held in place with 2 pieces of wire; one at the top, one at the bottom. Additional securing methods may be used.
- Repeat for each leg.
Fitting Sun Shields

Once the Siloweigh sensors are installed, add the sun shield. Wrap the sunshield (plastic sheet) around the leg, ensuring it is centered over the sensor. Affix in place with the 2x strapping or bracing tape. Secure strapping with supplied buckle. Repeat for all legs.

The drawing and the information therein is confidential and may not be copied or used without the written permission of Scale-Tech Ltd.
Installed sensors and junction box
Sensor Kit

Each kit includes everything for one vessel leg:

- Sensor
- Cable junction box
- Waterproof cable strain reliefs
- Bolts, washers and nuts for sensor
- Screws for junction box
- Cable tie-wraps and sticky pads
- Sun shield and fastening wire
Installation kit: Thru Hole Mount Kit

- For legs where both sides are accessible, e.g. H- or L-section legs
- Each kit is good for installation of 8 Weigh sensors (can be stretched to more)
- **Kit includes following:**
  - Hole center marking jig
  - Center punch
  - Drill bits of increasing plus final clearance size
  - Anti-rust protective spray for sensors
Installation kit: Tapped hole Kit

- For legs where back is not accessible (tubular). Metal is drilled and tapped to receive the bolts directly.
- Each kit is good for installation of 8 sensors (can be stretched to more).
- **Kit includes following:**
  - Hole center marking jig
  - Center punch
  - Drill bits of increasing plus final tapping size
  - Tap and handle to match sensor securing bolt
  - Anti-rust protective spray for sensors
Installation Kit: Weld Tabs

- For legs where it is impossible or inconvenient to use tapped holes, or where leg surface is not flat. Typical example is round or “O” section of less than 8” (200 mm) diameter
- Each kit is good for installation of 8 sensors only
- Kit includes following:
  - Jig to position and hold weld tabs at correct spacing and flatness while welding
  - Sixteen weld tabs (4 shown) with threaded holes to match sensor mounting bolts
  - Anti-rust protective spray for sensors
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Best position for Sensors

- Technician is pointing at the best place to mount sensors – mid way between braces
- This silo demonstrates the simplest and easiest installation
- Work can be done from ground level
- No extra structure to be concerned about
- Each silo is separate
- Expect excellent results. Good subject for customer evaluation and “showcase” for other clients
Best position for Sensors

In this case, mezzanine floor supports two silos, eliminating the possibility of sensor installation on bottom section.
Best position for Sensors

In this case, mezzanine floor supports two silos, eliminating the possibility of sensor installation on bottom section.
Skirted Silos

- Here the wall is the support. The discharge cone is attached at the second joint up from the ground.

- Install sensors in center of second ring, out of the influence of the door and away from seams.

- Four sensors, equally spaced, with the door midway between sensors.

- Best location is inside silo, where sunlight will not heat sensor.
‘L’ section legs

- Neutral axis is at corner of section. Install sensors inside (away from sun) as close to corner as possible while staying on flat surface, not on radius of corner.

- All these pictures are without sun shields, for clarity.

- Do not use sun shields in skirted silos – it sets up differential expansion in skin and alters stress.
Large silos with ‘O’ section legs

- Two silos stand side by side. Capacity 1400 tons. 10 legs of 24” diameter each
- Sensors were attached using drill/tap method, one on each leg, midway between bracing points as shown
- Installation was very successful
- Output was very high – close to full capacity of sensors. Legs were designed specifically for the application and had high stress level
- This was near Montreal – no need for the extra seismic allowance that is necessary in general purpose silos
- Waterproof bonding of thin metal plant roof to silo walls is usually not a problem, since the bond is usually flexible
Structure built-in

- This one’s a bit more difficult. It seems to have a very solid structure built-into the legs.

- Our recommendation would be to install sensors on the bottom section, where the legs are free of structure.

- The upper section looks as though it would be suitable but the solid structure between the legs seems to be connected to the discharge cone and may cause variations in the stress in these upper sections.
Tubural frame

- It’s hard to determine the success level with this one. Small diameter legs with a very sturdy bracing system that almost certainly carries a proportion of the load.

- We would not promise perfect results on this one. It’s worth trying though, on a “return it or pay for it” basis. Many of these trials are successful.

- These applications help to build experience and confidence.
Agricultural Silos

- Roll-formed mild steel legs are very flexible and prone to bending, which gives large errors

- We were unsuccessful in convincing this customer that we could solve the problems

- We did gain some useful experience, however, and were ready to demonstrate a better installation method but the customer ran out of patience

- We believe that we can now successfully install sensors on these silos and we are looking for a suitable test site
Ready-mix Silos

- The square silo here is mounted on two vertical legs and two angled legs.

- In general, angled legs are no problem but here the odd combination will make the stress in the front legs higher than that in the rear legs.

- It would be better to install on the lower sections, even though the cement scale and aggregate conveyor hang from the frame above. The weight changes due to this will be short and minor.

- Note that even this bottom frame is different on both sides and needs slightly different levels for the sensors in the center of each free section.
Indoor, heavily braced

- This is an easy application

- Cannot install above attachment of heavy braces. Leg loading will not be reduced, since force in braces will merely bend legs slightly and all weight is still borne by legs, but upper legs will have twisting/bending forces as a result

- Lower legs are free of this and will respond well
Stantard silos. “O” section legs

- These are no problem

- Top section has braces to silo but middle or bottom sections will be fine – chose easiest working position (this is important too)

- If leg diameter is wide enough, use Drill/Tap method to provide threaded mounting holes

- Alternatively, use weld tabs

- In every installation, consider effects of side forces from conveyors etc. and install on legs at right-angles to application direction of such forces

- Also consider localized heating by sun and install on shaded faces where possible
Rectangular section legs

- Ready-mix plant with aggregate belt and cement scale below silo
- Note that aggregate belt is supported separately and will have no contact with the silo legs
- Cement scale has only minor effect, even when fed from a second silo on left
- Best position would be in center of top section where man is working
- Bottom section would also be adequate and much easier for working
Large agricultural silo

- Picture shows sensors installed on 16 out of 18 legs of the roll-formed type
- Note sun shields around sensor area of leg
Thank you for watching!

More Information on:

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