WEIGHT RELATED PROCESS CONTROL-THE THINGS YOU NEED TO KNOW

Using Electronic Load Cell Mounts on Processing Plant Bulk Weighing Vessels & Tanks In Batching Systems?

In today's processing plants, because of their ubiquity and trouble fee design, electronic load cell mounts are preferred in most applications. Electronic load cell mounts are typically designed for Legal-for-Trade & governmental regulatory traceable commercial finished goods transactions. We know from experience that activities on the processing floor typically involve blending, mixing or dosing the components in ratios one material to another--- hence Legal-for-Trade accuracies aren't typically required on the individual component materials since the producer is not actually selling them in finished goods form. Keep in mind that the producer is commercially selling the finished product. Hence, the product in its finished form typically gets weighed further down the supply chain---if a net weight package "form factor", perhaps across an inline dynamic checkweigher. If material is sold to the end-user in bulk form, it is typically weighed across a truck or rail scale.

The question is — should the presence or absence of Legal-for-Trade accuracies in the weigh mounts factor into the overall design of the weighing system? In other words, on a processing floor designed for mixing, blending or dosing components to some finished goods compound— is Legal-for-Trade accuracy an important consideration or "driver?" The answer is —"it depends."

It is a popular misconception that bolt-on strain gage sensors designed for level measurement are equal in performance to conventional load cell mounts. Bolt-on strain gage sensors are designed to measure changes in stress in vessel supports caused by material movement. In essence, bolt-on level measurement devices are similar in scope and performance to a site glass used for outside visual confirmation or presence of material and at what current level inside the vessel. In short—an "estimator". Stated accuracies (on paper) are 1% less any environmental influence factors.

Stainless versus mild steel?

For outdoor or wash down use in a processing plant, stainless steel, temperature compensated and hermetically sealed electronic load cell mounts combine to assure consistent, legally traceable and accurate readings. Load cell mounts that have been temperature compensated and are National Type Evaluation Program (NTEP) approved utilizing analog/embedded digital strain gage technology typically have accuracies of 0.1% across the rated capacity of the mount.

Contrary to conventional wisdom, all stainless steels are not alike. And, under the right conditions, stainless steel will rust. Plain carbon mild steel holds up well in most industrial environments. There are occasions, however, when the proper use of stainless steel best suits the application. Well-known uses of stainless steel include applications set outside, in environments of wet or high humidity and in areas of varying temperatures (i.e., areas of extreme heat or cold for applications in the food, chemical or pharmaceutical industries).

Types 304 and 316 stainless steel are most commonly used in the industrial weighing and measurement industry. There are times when the use of other families of stainless steel is a better long-term choice. For example;

ferritic. Ferritics, when used in some combination of hoppers or weighing apparatus, contain the following properties:

- Low thermal expansion
- Excellent high temperature oxidation resistance
- High thermal conductivity
- Excellent creep resistance
- Easier to cut and work
- Less prone to spring back
- Higher yield strength
- Not prone to corrosion cracking

Again, the key here is to optimize the material for the intended use and ambient environment. For cost/benefit estimations, use a general rule of thumb of 2:1. Meaning that if mild steel is designed to last 5 years; stainless steel should last 10 years assuming the same ambient factors. But, for specifics, run a life cycle cost analysis (LCC), typically available free from any stainless steel provider.

The best analogy that can be drawn here is if you are the manufacturer of washing machines, what material do you use to manufacture the drum? Or, if you build automobiles, why do manufacturers' use stainless steel in the catalytic converter?

Illustration of NTEP 0.1% accuracy versus 1% accuracy via bolt on strain gages

For example, please assume the following illustration:

100 ft. long ton hopper tank
Cost of material @ $150 per ton
10 weighments per day X 5 days X 50 weeks= 2,500 weighments annually (assumes full discharge); therefore,

250,000 long tons annually

At 1% accuracy/readability: +/- 2500 long tons

At 0.1% accuracy/readability: +/- 250 long tons

Material unaccounted for in normal annual process: 2,250 long tons X $150/ton= $337,500 of material in this example:

Aside from the obvious quantitative conclusion and stated qualitatively, what really drives these decisions purely from a business intelligence standpoint?

[1] The Importance of Stainless Steel in the Weighing and Measurement Industry

- Accurate consistent on hand component material inventory
- Accurate, consistent and repeatable mixing, blending, and dosing
- Elimination of scrap or material “shrink”

The initial weighing apparatus acquisition costs, level sensors versus mounts, is typically less than ½ $X ($X=load cell mounts). Similar to making a cake in the kitchen, batch weighing systems satisfy the requirements of recipe formulation (or dosing) by accurately dispensing a targeted amount of each individual component material in the batch.

In summary, if the business drivers as reflected above are paramount to your customer, you should engineer the weighing solution for the process floor with Legal-for-Trade accuracies in mind. Your customer expects nothing less even though he or she isn’t required by law to do so.

Design of weighing apparatus using electronic load cell mounts

Typically, a rectangular dry material or weight hopper cluster, designed to dispense into a common blender, mixer or other receiving vessel is suspended from 4-8 tension mounted load cells depending upon the dimension and distance between the weigh points. Conversely, a rectangular dry or liquid material tank, vessel or silo is usually mounted on compression mounted weigh modules.

There are many varying factors to consider such as size and type of vessel, support structures, pipe connections, movement during filling, environmental aspects, etc. Especially note that spring tension (length vs. thickness) is an important consideration with any attached piping to the vessel or tank but in total— all of these factors can have an effect on the accuracy of a weighing system.

The first step in selecting load cells is to determine the total gross weight to be supported. This is found in the equation:

Total gross weight of vessel or tank = (Tank contents + shipping weight vessel + attached appurtenances)

Appurtenances can include, but are not limited to, pressure relief valves, local HMI displays, mixers, agitation motors, safety ladders, insulating jackets and their contents—you get the idea. Flexible or rigid conduit should be exempted from the weigh vessel or tank because the desire is to have free vertical movement. However, we must account for this overall weight in the system design. If the weight of the vessel and associated appurtenances is excessive compared with the contents of the tank or vessel, the accuracy of the system could be affected.

Consideration should also be given to vessels designed for changes in state between liquid and vapor based on the introduction of temperature or catalyst induction or changes to the process.

Environmental factors

As mentioned previously, overall vessel/tank/hopper weighing performance can be affected by many factors, including but not limited to, temperature, vibration and structural stability (level), and should be shielded from direct radiant sunlight, wind and seismic activity (if applicable for area).

By design, most electronic load cells are temperature compensated for both zero reference and span. Individual cells and/or electronic load cell mounts should optimally be designed to operate within the ambient and operating temperature ranges of the expected system environment.

When temperatures are expected to exceed the design threshold of the cell or mount, thermal (designed for excessive hot or cold) insulating pads should be utilized. Cell to tank insulating pads custom cut to match the footprint of the cell top mounting plate should be utilized. This is a special case. As a result, thermal expansion calculations are recommended by a licensed Structural Engineer.

Isolating the weighing system supports from adjacent structures is preferable. Further, isolated foundations are advantageous over those foundations that support heavy induction motors or vehicular traffic. Optionally, vibration absorption or suppression pads are commercially available to isolate the load cells from the vibration of the tank or vessel, but performance is optimized when these pads are not required. Digital weight indicators are typically designed with limited onboard noise filtering capability. During static weighing, all material inflow and material outflows should be suspended. Additionally, any motors and/or mixers that are attached to the weighing vessel tank should be turned off during the actual static weighing process. In continuously agitated vessels, baffle plates should be added to reduce surging and gyration of the contents.

Seismic forces are a special design case. Typically, these are the strongest forces known that can be introduced into a tank or vessel weighing system. Seismic forces are similar in scope and measured in the same way as wind shear. Please contact Rice Lake for assistance in special situations where wind shear or seismic calculations are desired.

Load cells typically can withstand up to 150% of their rated capacity in side loads. If a vessel is bumped by a vehicle or is otherwise disturbed, the cells should be checked for damage and the weighing system should be re-calibrated.

Supporting structure

First and foremost—we can't stress enough the subject of LEVEL. The support structure should be level to within 1/8 in.; otherwise, leveling shims should be placed under the cell (s) to provide a level loading plane. In both compression and tension applications, the vessel load must be transferred through the load cell to the centerline of the web of the supporting steel. This will prevent twisting of the beams. Reinforcing gussets are helpful and should be provided at each of the support locations.

Number of cells required

Tension support is recommended only for weighing small vessels because of the limited weight ranges of most tension mounted load cells. In tension type installations, one to four load cells are typical. In compression installations, usually three or more are required. Recall that Legal-for-Trade accuracies are 0.1% full scale. When Legal-for-Trade accuracy is not desired (0.5% full scale or less) and the tank contains a liquid, costs can be reduced by replacing load cells with dummy cells. Vertical round tanks are typically supported on three cells. Four cells are used for square or horizontal vessels. It is preferable that all load cells in the system be the same rated capacity.

Vessels that are very large, have unbalanced loads (like a washing machine full of wet towels), or contain hazardous materials, or are at risk of overturning due to ambient environment may use additional mounts. If wind shielding is not available for the vessel, the mount capacity must be increased to also provide for the uplift and down thrust caused by wind gusts that can lead to undesired tipping.

Three tension mounted cells provide optimal weighing because three points define a plane. Therefore, the load will equalize naturally in normal suspension. Four or more cells require load adjustments. The minimum load cell size is obtained by dividing the gross weight by the number of support points. Barring special or unique circumstances, select the next standard cell which exceeds the calculated requirement. If introducing a safety factor is important, add a safety factor of 25% to the gross weight before making the above calculation. Other safety factors to consider include a dynamic loading factor if, prior to weighing, the load is dropped onto the scale. The vessel support structure must be rigid and stable, while leaving the tank completely free to move in the vertical position.

A good rule of thumb regarding load cell sizing relative to total tank or vessel capacity and expected resolution is 1:5000. In an application with four 10K cells, expect to get an 8# resolution.

For more detail and illustrations, please refer to Rice Lake part number 43918, “Weigh Modules and Vessel Weighing Systems.”