Weigh Systems: Calculate the Cost of Inaccuracy

Since the beginning of trade, people have relied on the ability to measure weights. Not only do measurements have to be consistent, they must also relate to an absolute standard. The equal arm balance and unequal arm beam scales have been used for thousands of years and are still by far, the world's most commonly used techniques for determining weights.

In 1938, the invention of the resistance wire strain gage made electronic weight measurements reliable and economically practical. The strain gage consists of a filament of thin foil or wire which will change resistance when stretched or compressed. When a strain gage is bonded to a piece of metal and the metal is loaded with a weight or force, the resistance change of the strain gage can be related directly to the weight or force placed on this piece of metal. Strain gage-based load transducers – load cells – are now universally accepted, used in thousands of electronic weigh systems all over the world.

In its simplest form, a weigh system consists of a vessel whose contents are to be monitored, load cells that generate a signal proportional to the vessel weight, and an electronic device to power, amplify, interpret and display the signal. The accuracy of such a system depends on the vessel design (reactor, batch tank, inventory silo, etc.), support structure, piping attachments, lateral restraint system, and vessel environment (temperature, traffic, nearby equipment), as well as the proper selection of load cells, instrumentation and accessories.

Cost and Quality Depend on Accuracy

For the present manufacturing environment, electronic weighing offers significant potential advantages:

- Load cells are non-intrusive: the system remains closed throughout the process eliminating the possibility of external contamination.
- Load cell-based systems are virtually maintenance-free.
- Weight-based system diagnostics can monitor the entire batch process for impending equipment failures or dynamic, out-of-tolerance changes.
- Load cell-based systems provide the best accuracy and repeatability (0.01%).

However, not all load cell equipment/systems meet all of the criteria listed above – and not every industrial application requires them. Inventory systems typically do not require the precision specifications of high-end batching systems and, therefore, can be implemented quite inexpensively. Economical load cells/modules and low-cost indicators provide enough accuracy to track ingredient usage and alert administrative personnel to reorder/refill needs.

Low-accuracy inventory weighing systems typically have a system error of 0.5% or more. General-purpose cells/modules are satisfactory for these systems, and mechanical considerations are relaxed considerably. The weigh vessel need only be partially supported by load cells/weigh modules, usually one or two on any side or end of the vessel.

High-accuracy systems require precision load cells or weigh modules with full temperature compensation, and must be built to rigorous mechanical specifications that may require additional cells to fully support the weigh vessel. Such high-accuracy, process weighing systems typically exhibit errors from 0.25% to less than 0.05% for custody transfer or sales.

WHY ELECTRONIC WEIGHING?

The majority of electronic weighing systems are used for one of the following purposes:

Reduce Inventory Costs - Efficient and accurate control of inventory by weight allows the user to maintain the optimum amount of material on hand for efficientproduction without costly excesses. Accurate inventory can also result in a reduced number of storage vessels and area, contributing to further cost savings.

Reduce Labor Costs - Process automation through installation of automatic batching systems can eliminate a substantial amount of manual input. Centralized inventory control readouts Reduce inventory costs obviate the need for visual inspection of storage areas.

Improve Product Quality - Accurate batch control improves the consistency of end product quality resulting in improved product acceptance and reduces costly product rejects and rework. It is easily understood why an electronic weigh system has advantages over a mechanical beam type system. Some of the advantages are:

1) Due to the low deflection of the load transducer, a load transducer-based weighing system has a fast response or settling time.
2) The higher the capacity of the weighing system, the lower the cost will be of the weighing structure.
3) Remote measurements can be made.
4) The weight information can be processed directly to eliminate human error.
5) Microprocessor-based instruments communicate directly with programmable controllers and distributed control systems.
6) Electronic weighing systems often can be adapted to existing installations.
7) Load transducers and associated electronics are solid-state devices and, therefore, are not subjected to wear such as found in the knife edges, supports and flow meter paddle wheels used in other systems.

Signs that a weighing system may be incurring excessive costs include:

- Recurrent system downtime where load cells or load cell indicator is suspect.
- Product inconsistency from batch to batch.
- Unexplained spikes, surges, or drift periods encountered.
- Performance or quality tolerance specifications increase based upon customer demand.

Errors Add Up

Load cells of varying qualities, materials and shapes are combined with different grades of measurement instrumentation in an endless variety of mechanical weighing system designs, resulting in a wide choice of repeatability and accuracies from within less than 0.05% to 0.5% or more. And like most digital instrumentation, weighing systems often can be read to any number of decimal places, offering the impression of high precision and accuracy, whether or not it exists.

The difference in accuracy and repeatability between one combination and another may be hard to quantify or seem insignificant. How much accuracy do you need? How does it affect product quality and cost? Which system(s) are accurate enough? Is it worth spending the extra cost of more accurate equipment?

A statistical analysis of accuracy and its impact on lifecycle cost should be part of the application engineering of every weigh system. Such an analysis requires access to specifications for each proposed system component, calculation of system accuracy, and the batch frequency, quantity and cost of weighed materials to calculate the cost of imprecision – the lifecycle cost of product or raw material wasted as a consequence of inaccuracy.

Syscalc, a sizing software system by BLH Nobel, performs this statistical analysis. The software calculates the exact load cell capacity, profiles actual system performance with a complete error analysis, and precisely predicts functional system signal levels for alternative suppliers' as well as BLH Nobel load cells and measurement instrumentation.

Load cell and instrument model numbers are entered into the calculator, which accesses error components based on published datasheets. It also accounts for temperature variations and in hazardous areas, any effects from using intrinsic safety barriers.

ACCURACY VS. REPEATABILITY

Do not confuse system accuracy with repeatability. As long as the mechanical error in a given system is linear with deflection and independent of the environment (temperature, traffic, surrounding vessels, etc.), the inherent system repeatability will be greater than its accuracy. For example, BLH Transducer Indicators typically have an overall accuracy specification of 0.01% of reading, of which repeatability is but a small fraction. BLH load transducers, meanwhile, typically display a repeatability of 0.01 to 0.02%. Most BLH systems will be repeatable within 0.03% of full scale, independent of how the system is calibrated.

For most batching operations, repeatability is essential, whereas accuracy (actual pounds used) is of secondary importance once the operating parameters have been established. Field calibration, when required, is generally done by electronic simulation. For buy-and-sell installations, where distribution is by weight, calibration and repeatability are essential; field calibration is always performed employing a dead weight method.

Definitions:

Accuracy - Ability of the system to perform weighing functions within an acceptable or desirable tolerance; usually stated as a percentage of either full-scale reading, or ±n count(s) referred to the total number of scale divisions.

Repeatability - The ability of the system to read the same value when the measured weight is applied repeatedly in the same manner with the same quantity under constant conditions.

Maximum accuracy and repeatability is obtained by placing high accuracy load cells/modules at all support points and connecting them to instrumentation that measures each cell/module individually.

Syscalc calculates root mean square (RMS) error, performs a capability analysis and gives the maximum probable error. This directly indicates the amount per batch that must either be overfed to guarantee a minimum, or contributes to batch quality variation.

Based on how many sequences the plant runs and the value of the product, it calculates the annual savings available through improved accuracy. Users can compare performance of alternative combinations, see how component selection affects lifecycle cost, and select the most appropriate load cells and measurement system for a specific application.

Accuracy Pays Off

The material and cost savings from even a slight improvement in weighing accuracy can be surprisingly significant. For example, a North American national brand manufacturer in the food and beverage industry had standardized on BLH Nobel systems for 15 years because the systems were reliable and prevented shutdowns. When a new process was specified with an alternative weigh system, the engineering manager was challenged to justify standardization on BLH Nobel. It's difficult to quantify the avoided cost of lost production, so he turned to BLH Nobel to help justify its systems.

Using SysCalc, BLH Nobel engineers calculated an average 0.09% accuracy differential between BLH Nobel systems and the proposed alternatives. As a result, BLH Nobel systems were installed on a high value product, both to track a 300 ton inventory and in loss-in-weight feed applications.

On one line producing 7.5 tons per day, the 0.09% accuracy advantage saves 13.5 pounds per day at a value of $3.75 per pound, an annual savings of more than $10,000. The plant uses a total of 11 systems adding up to a savings of $300 per day or almost $100,000 per year.

The BLH Nobel brand is well-established as a manufacturer of high-quality and high-accuracy weighing systems with an unparalleled 50-plus years of experience in weighing technology. BLH was first to introduce the commercial strain gage, and pioneered many classic designs of industrial load cells. The KIS beam family developed by Nobel Weighing Systems became an industry standard for quality load cells with high performance.

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For more about BLH Nobel and SysCalc, visit www.vishaypg.com/process-weighing.