



Procon Engineering Ltd



Platform Scales

Recipe Systems

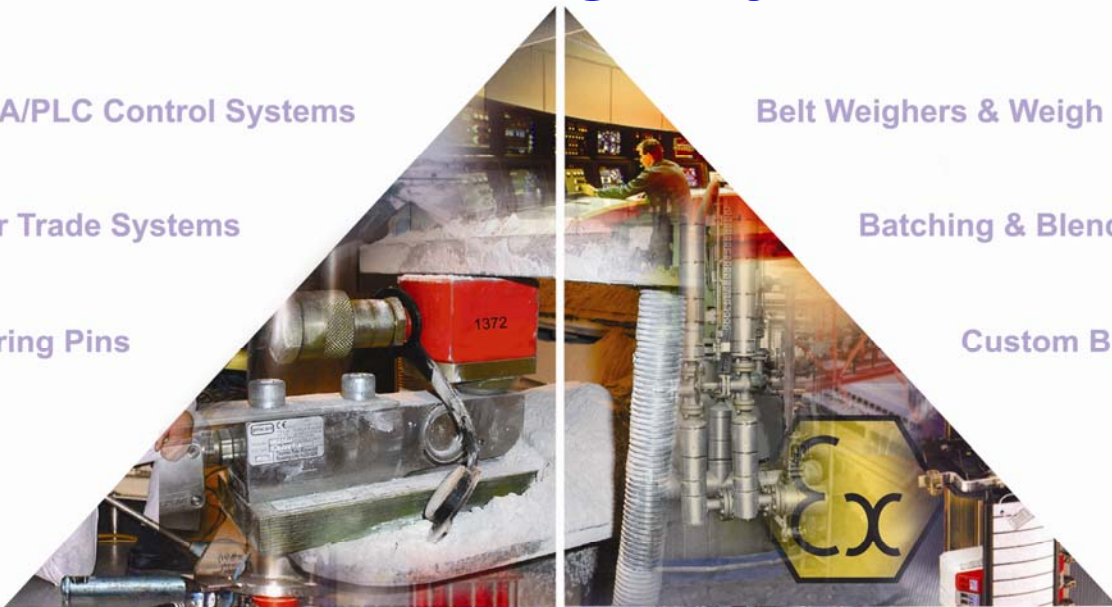
Force Measurement

Loss in Weight Systems

Nuclear Build Load Cells

Tank & Vessel Weighing

Loss in Weight Systems



SCADA/PLC Control Systems

Belt Weighers & Weigh Feeders

Legal for Trade Systems

Batching & Blending Systems

Load Measuring Pins

Custom Built Load Cells



... total weighing system solutions

Weighed Feeders (Loss in Weight Feeders)

A loss in weight feeder controls the dispensing of material by weight into a process at a precise rate. The target feed rate is generally known as the loss of weight setpoint. The measuring units of such setpoints may vary from grams per second in some pharmaceutical applications, right through to tonnes per hour in heavy industrial processes.

Application

The ability of loss in weight feeders to provide a continuous delivery of material at a predetermined rate has resulted in their utilisation in various continuous production processes, including the supply of raw material into extruders. However, a more typical application would be in a food production line employing a continuous process, which may utilise several loss of weight feeders, each dispensing different material ingredients at different feed rates (often onto a common moving belt). Here, the proportioning of the individual feed rates determines the final product recipe, and the sum of the individual feedrates determines the output of the production line. Such systems may also incorporate beltweighers delivering bulk materials into the process, (also at a predetermined rate). The complete system is then typically controlled by a central PLC/SCADA control system.

These continuous loss in weight processes are often more efficient than conventional process batch weighers, where the material delivery must be periodically suspended, whilst the weigh vessel is replenished and the next batch is prepared.

Volumetric Feeding

The principle of volumetric feeding is accomplished by simply relying on the volumetric properties of feeder to deliver product at a constant rate. For example, if a known preset motor speed is applied to a screw feeder, then theoretically, a constant volume of material will pass through the feeder per unit time.

Volumetric feeding incorporates no feedback and is therefore 'open loop', thus limiting its potential accuracy. The principle sources of error are as follows:-

- Material density variations, which will alter the weight of the material delivered (for constant volumetric delivery)
- Feeder flow rate errors, resulting from discrepancies between the preset (desired) speed of the feeder and the actual speed, and thus volumetric delivery rate (and there is no feedback present to detect or correct this)
- Material flow inconsistencies within the feeder mechanism (perhaps material becoming mechanically stuck to the feeder components)

It is therefore clear, that pure volumetric feeders have significant accuracy limitations. However, they do provide an efficient economical solution to non-critical applications.

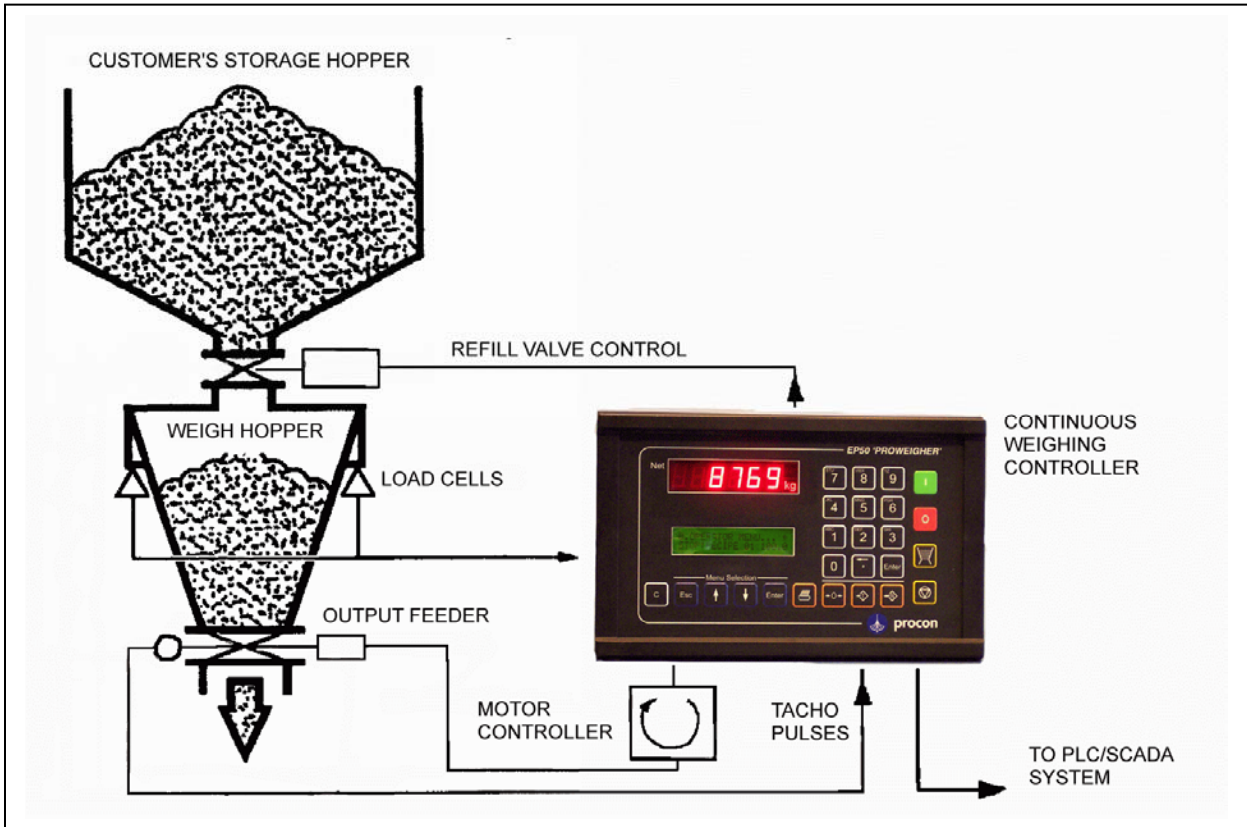


A typical loss of weight feeder complete with electronic controller

Gravimetric (Loss in Weight) Feeding

A gravimetric (loss in weight) feeder is implemented by utilising a weighing system configured to weigh the whole hopper/feeder system, together with its contents (the product to be fed). The basic loss of weight principle is to dispense the product at a constant loss of weight per unit time t , such that the material weight w , contained in the hopper is delivered by the feeder according to the rule:-
 $dw/dt = \text{constant}$

Consider a typical loss in weight control system configuration illustrated below.



A typical loss in weight control system configuration

In this example the electronic continuous weighing controller reads the load cell signals, at the same time as controlling the feeder motor and hence the feeder speed. A tachometer is also employed to measure the actual motor speed, which is fed back to an input on the weighing/motor controller. All this information is used by the control system to set the optimum motor speed (typically using 2 term control algorithms), to deliver product by weight at the desired rate (the setpoint). Some more sophisticated controllers also compare the totalised quantity of material actually fed over a period of time against the target, and following calculation, executes incremental corrective changes to the feeder speed to optimise long-term feeder accuracy.

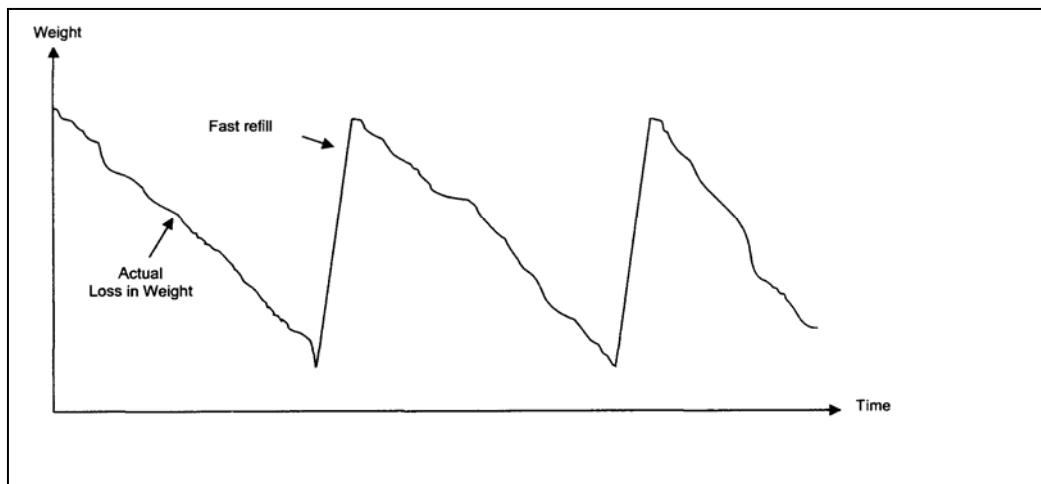
When feeding gravimetrically at low feed rates, the rate of change of net weight per unit time is typically very small, and hence high-resolution weight signals have always been desirable to discriminate very small changes in weight (to optimise feeder accuracy). In some cases, vibrating wire technologies have been utilised to form high resolution weighing transducers. However, in the case of conventional loadcell transducers, these days, the associated A/D converter devices frequently offer 20-bit resolution as standard (which equates roughly to 1 part in 1 million!). Although the absolute weighing accuracy of loadcell technology is typically only 1 part in 3,000; for the case loss in weight software processing, the detection of a relative incremental weight change of as little as 1 part in 60,000 is often considered useful (in applications free from significant noise

and vibration). Furthermore, where additional A/D resolution is available, this may also be used to pre-process and filter the weight signal, thus stabilising the lowest order signal bits, subsequently passed to the main software algorithms for loss of weight processing.

Further improvements in feeding accuracies are also being sought, by focussing attention on special software algorithms which include:-

1. Interpolation algorithms, where the loss in weight data between verified measurements is estimated. These types of calculation may be important when some measurements have been lost or discarded (perhaps due to noise or vibration), and where estimates of the material flow that occurred during this period are required (for instance for updating the material flow totalisers).
2. Extrapolation algorithms are also employed, which are effectively used to look into the future and predict loss in weight trends, thus allowing the controller to take proactive measures as necessary, to optimise the desired long term flow rates.

The high accuracy mode of gravimetric feeding must unfortunately be interrupted from time to time, when it becomes necessary to refill the hopper. When the controller detects a preset low-level threshold it automatically initiates a refill cycle, and subsequently controls hopper refill by weight. During this refill cycle it is not possible to feed gravimetrically, and consequently the controller must revert to volumetric feeding (since the discharge weighing system has been rendered 'blind' whilst the controller is weighing fresh material into the hopper). It is maintaining feeding accuracy during this refill cycle, which is generally considered one of the most challenging aspects of loss of weight controller design. The figure below depicts the cycles of a loss in weight system.



The cycles of a Loss in Weight System

Totalisers

Loss in weight controllers are normally equipped with software totalisers, which determine the total throughput of material by measurement and integration.

Feeding alternative materials

Industrial processes often demand that alternative materials can be fed through a single loss in weight system. Since such materials are likely to have different densities and characteristics, some loss of weight controllers may store data on the characteristics of multiple materials, which may be subsequently recalled to optimise feeding accuracies when these materials are dispensed.

Construction

The material to be fed is stored in a hopper deployed above the feeder, which must be replenished with material from time to time, without interrupting the dispensing process. The whole mechanical system (including the hopper) must be weighed to allow the loss of weight principle to operate.

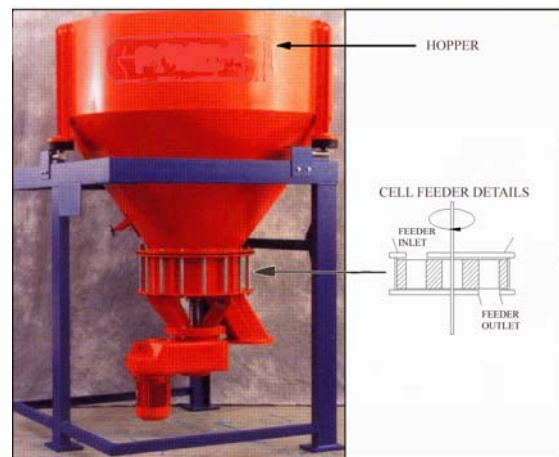
The mechanical feeder devices that are often employed at the heart of a loss of weight systems include screw feeders, rotating cell feeders, belt feeders and vibratory feeders.

When handling of more difficult materials, the hopper assembly may be fitted with agitators and rotating bridge breakers. The design of the hopper profile and the material of construction are all optimised to supply a consistent source of material for the feeding mechanism below.

The construction of a typical screw feeder and a rotating cell feeder are both illustrated in the figures below. In each case, the feeder is driven by a motor (which forms part of the assembly). The flow rate of the material is proportional to speed of the motor.



A screw feeder system



A cell feeder system

The feeding mechanism may be a vibratory feeder, where material is fed from a hopper onto a vibrating tray. The material is then fed off the end of the tray, with a feed rate that is a function of the amplitude of the tray vibrations. Typically, the tray is vibrated electromechanically or pneumatically.

Belt feeders, comprising a motor driven belt combined with mechanisms to assist the transfer of an even and controlled layer of product from hopper to belt are also used. Here the feed rate is a function of the depth of the material layer and the speed of the belt.

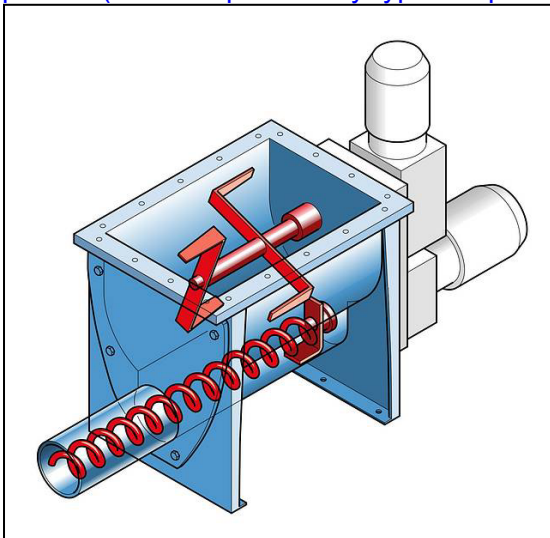
Typical Performance

When combining modern control and instrumentation systems with well designed mechanical feeders dispensing a free flowing material, it is possible to generate good short term feed rate accuracies, with even better long term flow rate results.

As a guide, a long-term accuracy of $\pm 0.2\%$ or better may be achieved.

Factors affecting Performance

- Bulk Density Variations - When a loss in weight hopper is full, there will be a tendency for the material at the lower part of the vessel (compressed by the head of material), to be of a higher density than the uncompressed material at the upper levels (the magnitude of this discrepancy will be dependent on the material characteristics and absolute density). As a consequence, when feeding volumetrically during the refill cycle, there will be discrepancies between the weight of product dispensed per unit time, as a function of the material level in the hopper.
- Hopper Profile Variations - variations of the internal hopper profile will influence the volumetric feedrate also as a function of the material level in the hopper.
- Material Handling Issues - If a loss in weight system is handling an optimum free flowing granular material, then impressive feeding accuracies may be achieved in a well-engineered system. However, many materials encountered will prove to be far less than perfect (for example - many types of powders). These materials may bind into lumps in the feeder causing an inconsistent material flow, or stick to the sides of the hopper (causing rat holing), or worse still, cause bridging within the hopper.



A typical screw feeder assembly incorporating a material bridge breaker

Various methods are employed to assist with the feeding of difficult materials, such as the implementation of hopper agitators (which are initiated periodically under the control of the instrumentation software). A further preventive measure is to have all the feeder and hopper parts fabricated from stainless steel. To detect material flow problems, most loss of weight controllers are equipped with flow deviation alarms, which will be triggered if the measured material feed rate falls outside preset limits.

- Feeder Issues - Rotating cell feeders and to a lesser extent screw feeders may exhibit instantaneous flow rates that are inconsistent (the material flow tends to pulsate slightly, especially with poor flowing materials). However, these are very short-term variations, which are not normally of any consequence in most processes. Vibratory feeders however, exhibit a very consistent instantaneous flow rate, but only with optimum free flowing granular materials. In general, vibratory feeders may not be used with materials that have a tendency to stick or bind, or materials that could be subject to segregation when vibrated. A mechanical feeding mechanism will have a degree of feed rate non-linearity (that is variations in the actual feed rate over the whole feeder range compared with a target straight line). In a loss in weight system this effect will be manifested as an initial feed rate error when the controller selects different feed rate set points (which will of course be

automatically corrected over time during gravimetric feeding). However, basic vibratory feeders are particularly non-linear in this respect, and therefore a large initial deviation from set point may be expected. However, many modern sophisticated vibratory feeders incorporate internal intelligent control and linearisation algorithms to somewhat alleviate this problem.

- Shock and Vibration - In many environments, loss of weight systems may be subject to occasional physical disturbances, which can potentially upset the sensitive process of gravimetric feeding. Typical sources of such disturbances include general plant vibrations together with accidental physical impacts. Such disturbances may be mechanically minimised by the use of mechanical shock mounts, and the use of flexible process connections to the loss of weight system (this is especially helpful in blocking the transmission of vibrations). Furthermore, modern electronic loss of weight controllers incorporate intelligent digital filtering that greatly attenuate disturbances in the weight signals, and most controllers may also be configured to detect significant disturbances in the weight signals, and automatically revert to volumetric feeding during such periods.
- Refill Valve Failure - In practice, another common source of inaccuracies in loss of weight systems, occurs when the refill valve fails to close completely, and thus a trickle of material is still being fed into the hopper during the normal gravimetric feeding cycle, upsetting the feeding measurement process.

The feedback from the weighing system is used to make automatic compensations ('closed loop' control) during the gravimetric cycle, to reduce the effect of these variations on the overall system performance.

With simple loss in weight controller systems, it is common to hear a sudden change in feeder speed at end of the refill cycle (known as a bump!). This is when the controller (having reverted to gravimetric feeding) is correcting for discrepancies between the volumetric feed rate applied during the refill cycle, and the required feed rate as calculated in the gravimetric mode. However, sophisticated modern loss of weight controllers, apply software algorithms to regularly adjust the volumetric feed rate during the refill cycle (as a function of the level of material as weighed in the hopper), with a view to compensating for the sources of error described above.

Further improvements in overall system accuracy may be obtained, by the expedient measure of keeping the refill cycle as short as possible (or more precisely keeping the mark/space ratio of gravimetric feeding to refill cycle time as large as possible - typically at least 4:1). However, such measures tend to demand the provision of larger and larger hopper sizes, and since there are often limitations in physical space, the final choice of hopper size will normally become a compromise.

Calibration

A loss in weight system is initially calibrated statically (known as the static weight calibration), to achieve this, the primary controller display (normally used to display flow rate), is often switched to display static weight (as with a conventional weighing indicator), and then a static weighing calibration carried out in a conventional manner using traceable standard or reference weights.

Subsequently, the flow rate accuracy may be verified. Typically this may involve running the feeder, whilst diverting the material to an alternative destination for a set period of time (using a stop watch). This sample batch of material is then weighed on a conventional weigh scale. The sample weight may then be compared with the theoretical quantity, which should have been dispensed (determined from the feed rate set point and the interval of time recorded). The total weight of the sample batch may also be compared with the amount of material purported to have been fed, according to information in the controller's totalisers.

In normal operation, the purported material flow rate may be read from the feed rate display on the loss in weight controller. The controller derives this flow rate from the weight signal (statically calibrated), and its internal clock, from which it may calculate the weight dispensed per unit time (the flow rate).

The fundamental calibration of a loss in weight system is its flow rate calibration, which is derived from the system static weight on and its internal clock. Therefore the overall calibration uncertainty of the system will be a function of the uncertainties of the static weighing and clock calibrations.



Our Pedigree

Procon Engineering Limited is a leading manufacturer and supplier of turnkey solutions for Process Weighing and Control Systems. The company incorporates the well-established names of *Defiant & Negretti Weighing*, and *Inflo Belt Weighers*.

We have experience across a broad spectrum of industries, especially in **mineral, building materials, chemical, food and beverage, general engineering, nuclear, aerospace and aviation, pharmaceutical, toiletries and utilities**.

Our long term customers include: **AstraZeneca, Akzo Nobel, BNFL, Glaxo SmithKline, Nestlé Group and Tarmac.**

We are an ISO9001:2000 accredited company, and have Quality and Health and Safety approvals from institutions such as Lloyds Register, National Weights and Measures Laboratory, National Britannia, together with industry relevant Passport Schemes.

Scope of supply

Procon Engineering provide fully integrated process weighing solutions - from load cell transducer design through modern interfaces to complete PLC, HMI, PC and SCADA based systems. We offer a broad spectrum of tried and tested load cells and mounting kits, instrumentation, equipment and systems. Electrical, electronic and pneumatic control panels, including MCC and multibay units, are built in-house specifically for each project using standard components. Panels are functionally tested and fully documented.

Our approach ensures that customers receive a balanced blend of modern control and data acquisition technology, together with well engineered solutions within the process itself. The factory floor and 'upstairs' management systems become one environment, where real time data can be used to its best advantage. We also have significant expertise in plant upgrades, ensuring new equipment integrates seamlessly with minimum disruption to operational activities.

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Procon Engineering Ltd

A subsidiary of National Oilwell Varco

Registered Office
Vestry Estate
Sevenoaks
Kent TN14 5EL

Tel: 01732 781300
Fax: 01732 781311
e-mail: sales@proconeng.com
website: www.proconeng.com

Registered in England
No. 01201645