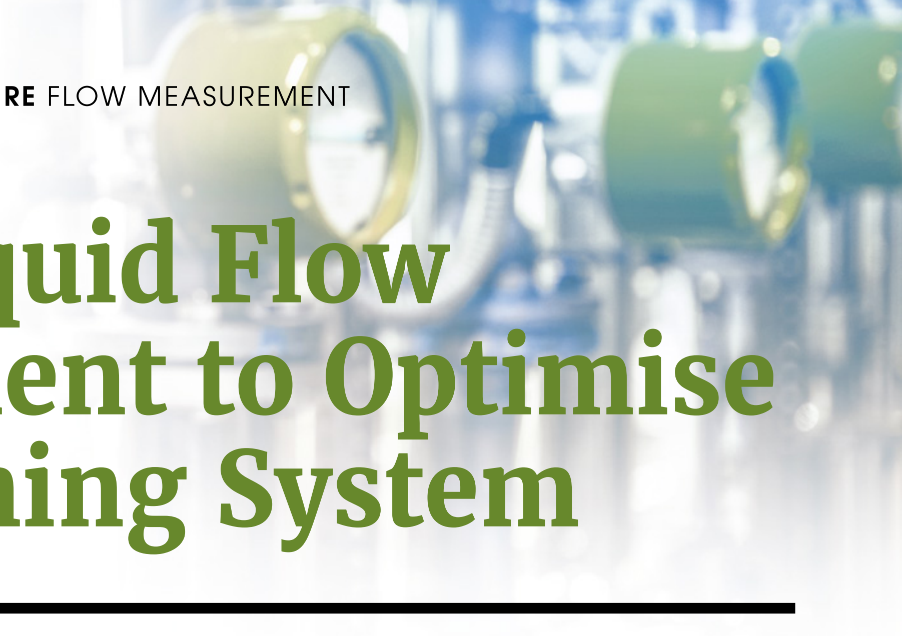


# Precise Liquid Flow Measurement to Optimise Your Batching System

***Neil Hannay** outlines the key considerations when specifying a suitable flow meter for the design of a batching system*



**BATCH filling is where a finite amount of liquid is filled into a container, vessel, or tank. Used in the food and beverage, medical, chemical, and additives industries, whether it be dispensing a cup of coffee or filling a tanker of oil, the same principles apply. However, the amount of financial investment needed for the system will be vastly different.**

Selecting the correct liquid flow measuring device for a batching system can be a complex task. Process engineers should be aware of the challenges involved in metering batches of liquid and how to assess these to ensure a successful batch-delivery design. Although batching in general is a simple process – an automated system set up to dispense the same volume, plus or minus a few percent, time after time – the variables can cause issues that impact the continued accuracy of the system.

To ensure a general batching process runs smoothly (for high-speed batching, see the boxout), the following seven key considerations are fundamental when choosing a flow meter that will deliver repeatable results.

## 1. BATCH SYSTEM REPEATABILITY IS AN ESSENTIAL ASPECT OF MEASURING LIQUID DOSING

In its simplest form, a batch-filling system consists of a liquid delivery system: a pump, a flow meter, a control valve, and the vessel to be filled. The operator pushes a button, and the vessel is filled with the same volume of liquid again and again.

The key element for all systems is *repeatability* of the fill to the same dispensed volume. The ideal system should keep all process conditions constant, but this is not always possible without investing far more than is practicable or affordable for the product.

There are multiple process variables that can change the amount of dosed liquid, causing a negative effect on the system repeatability. Temperature changes may affect the fluid viscosity and volumetric flow measurement. Variations in the feed liquid tank level supplying the process pump could cause the rate of dispensing to change, in turn affecting the flow meter accuracy and flow control valve. For a low-cost product, a company may be able to reduce the investment in the equipment by accepting a ±5% variation between batches. For high value products or precise dosing, as seen in the pharmaceutical and medical industries, the accuracy and repeatability of the flow measurement device will

### HIGH SPEED BATCHING

High-speed or rapid batch-dosing systems differ from general batching in that they are designed to handle larger quantities of materials in a shorter amount of time, thereby increasing throughput and production efficiency.

In addition to the considerations discussed here for general batch systems, for high-speed batching, further factors must be taken into account: choice of equipment, flow meter technology, piping, and overall process design.

While electronic flow meters, such as ultrasonic, Coriolis and electromagnetic devices, are generally very accurate, it is important to note that they have a discrete internal cycle time for processing the flow information. This cycle time can affect the repeatability of the process, particularly in high-speed batching applications.

High-speed dispense demands excellent accuracy and repeatability and so the use of AI software designed to overcome the limitations of, say an ultrasonic flowmeter, as well as a solenoid value response time, can deliver improvements in the system accuracy. Using bespoke interactive and predictive batch software together with careful system design, batching periods as low as a second can be achieved with an electronic flow meter.

take priority over investment cost to reduce waste and speed up the process.

Mini turbine flowmeters can boast repeatability of 0.1% or better when under the same conditions, but to meet this performance, all process variables need to be strictly controlled.

Good practice design for batching should control as many variables as possible within reasonable cost. With that in place and the accuracy of dispensed volume quantified, the equipment – flow meters, pumps and valves – can be specified accordingly. If parameters cannot be easily controlled, the equipment must be able to compensate for the changes and still meet the desired repeatability.

## 2. LIQUID PROPERTIES INFLUENCE THE BATCHING ARRANGEMENT

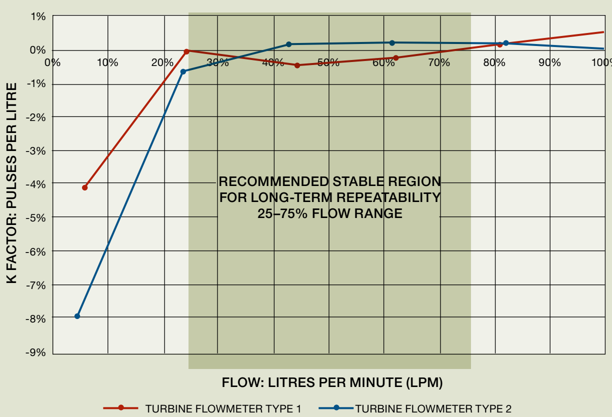
The properties of the liquid being batch-filled will dictate much of the equipment design for the system. The chemical reactivity and safety of the liquid dictates specific equipment needs outside of the batch processing itself and can limit available equipment choices. The physical properties of the liquid must be considered early in the batching design process.

For example, a pump, valve, and flow meter designed to fill water bottles will not suit a setup for dispensing mayonnaise into containers. A volatile liquid must be maintained at a pressure high enough to prevent phase transition. Any gas phase passing through would severely affect the repeatability of the fill, the gas being seen as part of the batch and thus giving a false measurement resulting in likely irregular underfilling.

Viscous liquids require a positive displacement pump and will flow slowly unless special care is taken in the system design. Such liquids can often be thinned by heating, so a temperature-controlled hot batching system could help to increase accuracy and speed of batching.

It is advisable to discuss the system requirements with the equipment supplier to ensure the correct measuring device is specified for the fluid properties within the operating conditions.

**Figure 1: Turbine meter calibration examples**




## 3. OPERATING FLOW RATES AND FLOWMETER ACCURACY – WHERE TO COMPROMISE?

Batch volume and fill rate will dictate the size of flowmeter required and the accuracy of the fill will define the type and final specification.

Rapid batch cycles require high accuracy and small granularity of flow measurement for the process to be efficient and viable. Typically, systems count pulses from the flowmeter, so the level of granularity (pulses per volume or K factor) is a key design parameter. For example, if the chosen flowmeter reports one pulse per millilitre, the best accuracy for filling a 5 ml container is limited to ±1 ml or ±20% of the volume, which may be far from ideal. If an accuracy of fill of ±1% is required, the preferred meter will need to report at least one pulse per 0.05 ml or >20 pulses per ml.

In selecting the ideal flowmeter, it is advisable to ensure the operational parameters are at the most stable and accurate point on the calibration curve for that meter. For example, the performance of mechanical devices (eg turbine and oval gear flowmeters) tends to drop off at the low flow end due to the influence of friction, so operating in the middle of the flow range is typically the most reliable (*see Figure 1*).

Compromises on cost and production speed may need to be made when considering the best operating flow rate for the batching system. An important factor here is the flow meter response time or reporting time, which must be significantly higher than the batching time as certain flowmeters may cause potential time delays during the process. Electronic meters may be able to give pulse outputs in excess of those needed, but the response time in sending the measurements could be too slow. For example, an electromagnetic flowmeter with a 50Hz internal signal processing time means a flow reading is updated every 20 milliseconds. Therefore, a high rate dispense of two seconds, gives a 1% error regardless of the meter's accuracy.

## 4. KEEP PROCESS CONDITIONS AS CONSTANT AS PRACTICABLE

Any variation in system pressure, temperature or flowrate may cause a flowmeter to operate at different points on its performance curve and lead to potentially unpredictable batch delivery. Pressure and temperature variation and flow stability will dictate the cost of the flow meter to ensure it meets the accuracy required for the batching system in all operating conditions.

The overall liquid flow should be kept constant, if possible, avoiding any pulsation within the batching system. Introducing a continual varying flow rate will negatively affect the ability of the flowmeter and valve controls to repeatedly meet the batch volume. In this instance, installing inline pulse dampening is always recommended for systems using diaphragm, piston, or

**Figure 2: Flow meter aliasing example, sampling rate near 1:1 pulse rate**

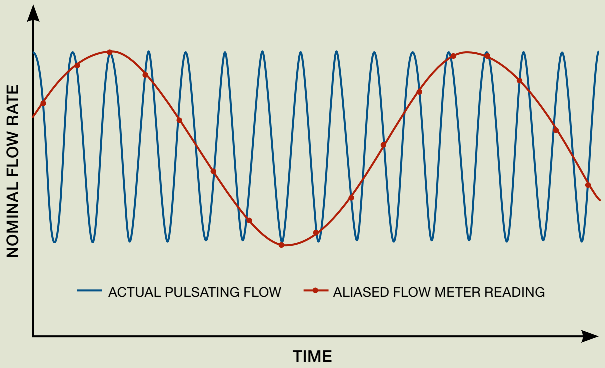
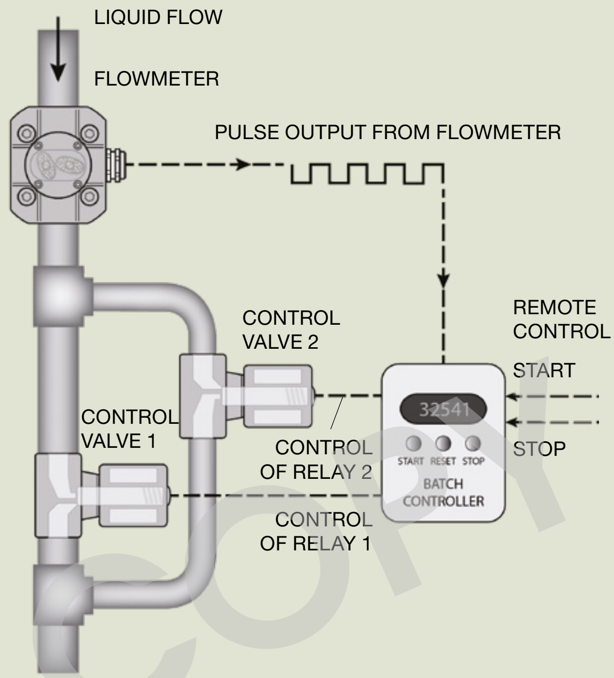



**Figure 3: Two-stage batch controller**




peristaltic pumps for example. If pulsation is inherent due to the method of pumping required and cannot be fully dampened, the choice of flowmeter must be closely examined to ensure the correct type and response time to prevent aliasing or other detrimental effects (*see Figure 2*).

## 5. VALVE CONTROL CONSIDERATIONS

As suggested, designing the batching system to minimise process variations will achieve the most reliable results. Fixing the flow rate of the system and incorporating a quick valve stop signal will deliver the best repeatability. This may entail a solenoid or alternative valve; a dual system can be operated with two control values and flowmeters (*see Figure 3*). The first, larger valve and flowmeter allows for rapid initial fill, switching to the second smaller valve and flowmeter for the final top-up before the batch size is reached. If a batch-filling system includes a dynamically changing flow while maintaining accurate repeatability, proportional valves can be utilised. However, measuring flow rate can be challenging. Fluctuating liquid flow rates can be compensated for by linearising the meters' calibration via software (eg using a pulse convertor) or investing in a higher specification measuring device.

## 6. CONSIDERATIONS OF FLOWMETER VERSUS REPEATABILITY

When specifying the accuracy of a flow meter for batching, the repeatability of the device is generally more important than the measurement accuracy across its flow range. For example, low-cost beverage turbine meters are used throughout the beer dispensing industry due to their excellent repeatability. These types of turbine flowmeters are often supplied without a calibration curve, as they can be easily calibrated using the batching system they are installed in as the volumes are relatively small.

However, when batch-filling a 1 $m^3$ container with corrosive chemical, a pre-calibrated meter would be necessary as in-situ calibration is not practical.

## 7. SYSTEM DESIGN INERTIA

Any batching system will have an amount of inertia of response, ie the timing of the control system and the amount of liquid dispensed will have an offset.

Simple modifications can be made to the system to reduce the effects of inertia, such as specifying a rapid control valve and positioning the flow meter near to that valve. If the measurement point is immediately before the dispense valve, the flowmeter will perform much better.

Modern control systems will also offer automatic compensation, whereby the controller "learns" when it needs to time the valve shut-off to ensure the required liquid quantity is dispensed. Assuming the repeatability is good, the automatic compensation will normally take 2–3 doses to reach the correct amount. Any changes introduced to the process, such as altering the volume of liquid, mean the system must relearn the compensation required for the new conditions and account for them accordingly. ■

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