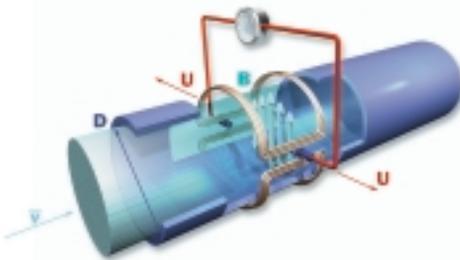


## Fundamentals of Volumetric Filling using Electromagnetic Flowmeters

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# Volumetric Filling using Electromagnetic Flowmeters

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## From glass to PET bottles

The beverage industry is increasingly replacing glass with PET bottles. The advantages of PET bottles include their low weight, less expensive transportation costs and practically no breakage losses.

### Advantages of electromagnetic flowmeters:

- Linear, accurate, stable, reproducible
- Volumetric flow measurement independent from viscosity and density
- No moving parts, no wear, no maintenance
- Suitable for liquids containing solids
- Flush, in-line, no gaps, crevices, seals except for process connections
- Easy to clean, CIP/SIP capability (clean in place, steam in place)



## PET bottles create the need for new filling methods

Each PET bottle, at precisely the same filling level, shows an individually different internal volume. The conventional filling control method uses level switches, and can therefore not ensure accurate filling volumes on PET bottles.

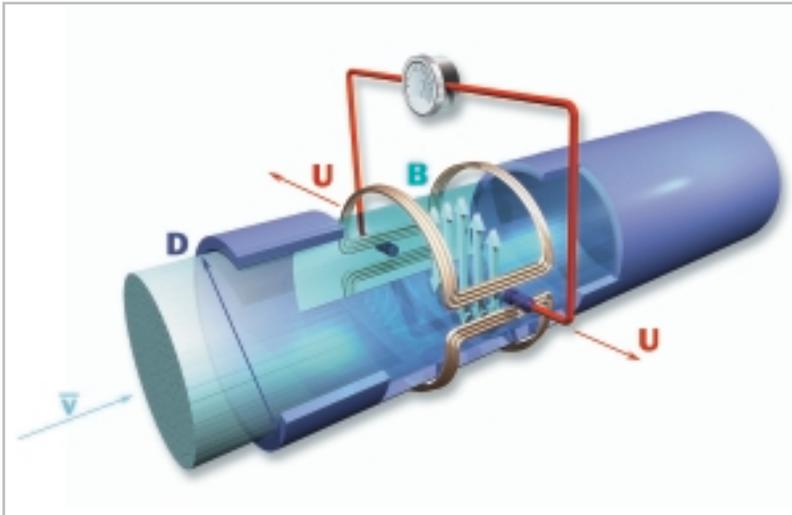
Volumetric filling is required for precise beverage volumes per PET bottle.

## Volumetric filling using of electromagnetic flowmeters

Each individual PET bottle give to varying extents when filled with liquid. By filling to a set level, each bottle will contain slightly differing quantities. In other words the internal volume varies. With precise volumetric filling, hygienic design and outstanding CIP/SIP properties, electromagnetic flowmeters created a revolution in filling technology and filling machine design.



## Measuring principle



**Fig. 1:**  
Measuring principle  
of electromagnetic  
flowmeters

An electrically conductive fluid flows through an insulating tube with an inner diameter [D] and through a constant magnetic field [B] (Fig. 1)

A voltage [U] is induced in this fluid proportional to its mean flow velocity [v].

Thus:  $U = v \times k \times B \times D$

This signal voltage [U] is picked up by electrodes. Microprocessor-based electronics converts this voltage into scaled pulses (e.g. 2 or 5 or 10 pulses per millilitre flowing through the meter's flow tube). This pulse rate is transmitted to a batch controller.

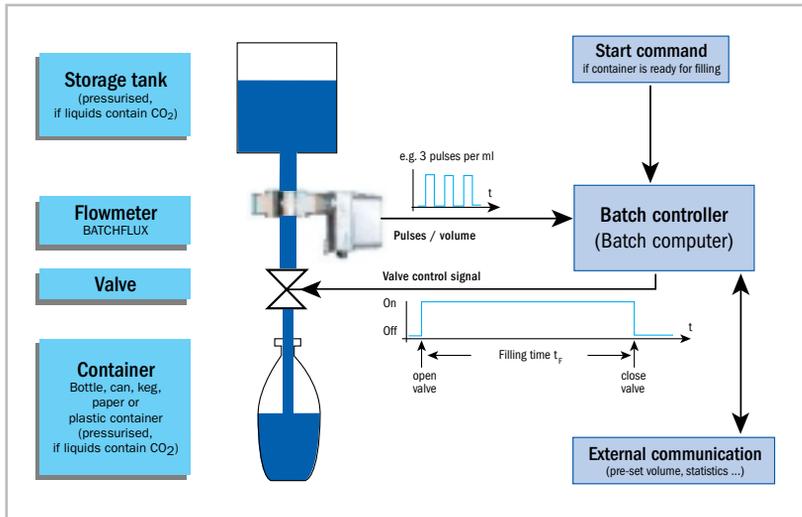
### **Volumetric filling process controlled by an electromagnetic flowmeter:**

The following example describes the design and application of an electromagnetic flowmeter, BATCHFLUX. This type of flow meter has been specially developed for volumetric filling machines in close co-operation with leading machine manufacturers.

A flowmeter is installed in the pipe from storage tank and to filling valve (Fig. 2). When the valve opens, flow will start. The flowmeter generates scaled pulses per volume unit (e.g. 2 pulses per each Millilitre) passing through its tube. The number of pulses is counted by the batch controller. The total number of pulses precisely mirrors the volume in the bottle. When the pre-set number of pulses – equivalent to the desired filling volume – is reached, the batch controller will switch off the valve. Switching delays may be compensated for by an overrun compensation in the batch controller.

In this way each bottle exactly receives the correct product volume.

## Reproducibility of filling process, stability:



**Fig. 2:**  
The principle of the volumetric filling process using electromagnetic flowmeters

### Accuracy, reproducibility

Reproducibility of the filling process not only depends on the accuracy of the flowmeter, but also on the reproducibility of the dynamic characteristics of the valves. Standard deviation of the filled volumes with filling times of more than 3 seconds is usually  $\leq 0.2\%$ . BATCHFLUX is supplied as standard calibrated to an accuracy of 0.2%.

### Long term stability

PFA or PTFE linings commonly used on electromagnetic flowmeter flowtubes have high thermal expansion coefficients and tend to creep. This may create changes in the diameter  $D$  and subsequently influence accuracy. Steam diffusion through these liners may occasionally cause meters to fail.

To avoid this, the BATCHFLUX flow tube is made of high purity/high density  $Al_2O_3$  ceramics. Ceramics have negligible thermal expansion coefficients and unsurpassed dimensional stability, wide corrosion resistance, no measurable steam diffusion and full CIP/SIP capability. It ceramic liner have proven themselves in more than 10 000 applications with acids, caustics, and high temperatures before KROHNE decided to use it for BATCHFLUX.

Another component influencing stability is the electronic signal converter. The BATCHFLUX signal converter makes use as much as possible of digital signal processing, which shows no drift. Each individual unit is exposed to a temperature cycling test in full operation. This proves and documents stability and eliminates early failures.

## Hygienic design

### Components, materials in contact with the product

The BATCHFLUX  $\text{Al}_2\text{O}_3$  ceramic flow tube has a surface roughness of  $R_a < 0.8 \mu\text{m}$ . The measuring electrodes are made of an electrically conductive mixture of this hi-tech ceramic material and platinum. This **ceramic-metal** compound (CERMET) electrode is sintered into the flowtube ( $>1500^\circ\text{C}/2700^\circ\text{F}$ ). Through this manufactory process tube and electrodes connect completely hygienically without any gaps or crevices.

### Gaskets, process connections to the filling line

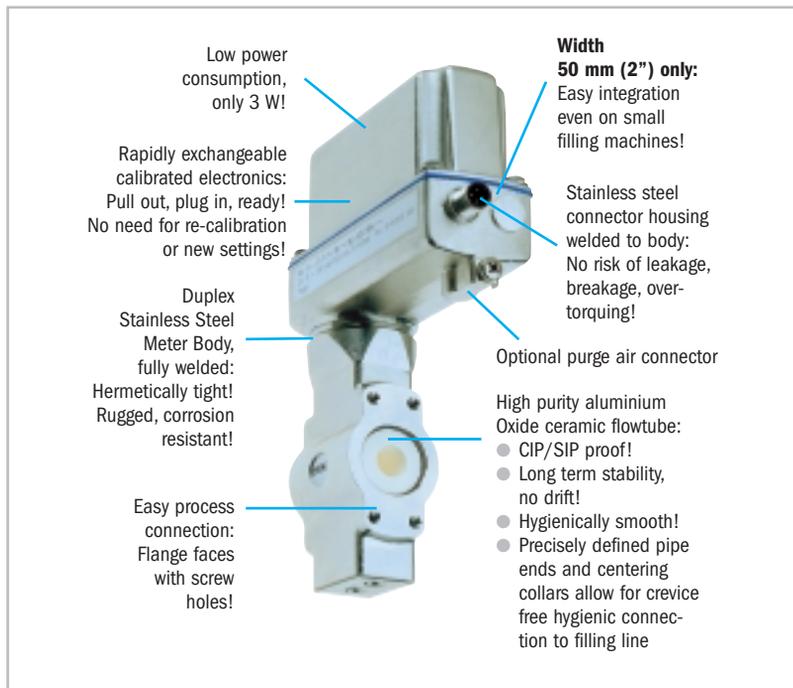
The design of the flow tube and housing, with various optional screw hole patterns on the flange faces, allows for easy and hygienic connection to the filling pipe (Fig. 3).

BATCHFLUX offers:

- A metall stop to maintain a defined pressure on the gasket
- A centring collar for precise centering of BATCHFLUX flowtube and filling pipes
- Precisely smooth surfaces and edges of the ceramic flowtube allow for a flush connection

### External protection

The BATCHFLUX stainless steel housing has IP 67 protection (temporarily submersible). The only non-welded connection is the cover gasket. The housing is corrosion resistant against all cleaning agents. Its shape makes sure that the cleanser runs off rapidly. The connector housing is of stainless steel and welded to the meter body. This prevents breakage, leakage and damage during connection of external cables.



**Fig. 3:**  
Flowmeter BATCHFLUX  
for volumetric filling  
machines

**Small, rugged and compact:**

The dimensions of the flowmeter may influence – and improve – the total machine design. The slim redesigned BATCHFLUX II with its width of only 50 mm (2") and its small total volume fits best into applications with limited space.

**Modular design: Nearly no downtimes!**

In case of an electronics failure there is no need for to removal of the total meter from the machine and no need to open the pipes. The electronics can be easily replaced without reprogramming or re-calibration. Just four steps: Open cover, pull out electronics module, plug in the new module, close cover, and ready!

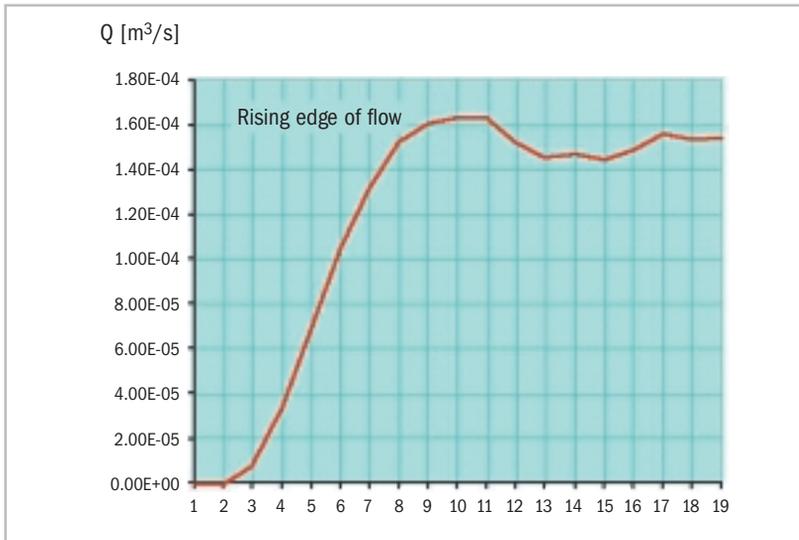
**Low power consumption:**

Often much more than 100 flowmeters are installed on one carousel type filling machine. So low power consumption of a flowmeter saves costs in power supply hardware as well as in cabling and space requirement. BATCHFLUX's power consumption is only 3 W compared to 10 W of classical electromagnetic flowmeters.

**Digital interface allows for visualisation of the filling process dynamics:**

The standard IMoCom = Internal Modular Communication interface allows for easy setting, downloading and documentation of all operating data via a PC.

In addition, the entire filling process can be visualised and documented on a PC (Fig. 4) through this interface, giving the operator a hitherto unavailable insight into the dynamics of the system and the valve. The data can be used as a basis for design optimisation of valve and filling system. In this way reproducibility, reliability can be enhanced considerably.



**Fig. 4:**  
Visualisation of flow  
dynamics by BATCHFLUX  
IMoCom (rising edge after  
opening of valve)

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**BATCHFLUX application ranges:**

BATCHFLUX comes with nominal diameters ranging from 2.5 mm (1/10") up to 40 mm (1.5"). This allows you to choose the best possible meter size for filling volumes from as small as 20 millilitres for pharmaceutical products and as large as 50 liters and more (e.g. for KEG-filling).

A version with an integrated intelligent batch controller was the final stages of development when this brochure went to press. This will reduce the amount of external hardware to a minimum.