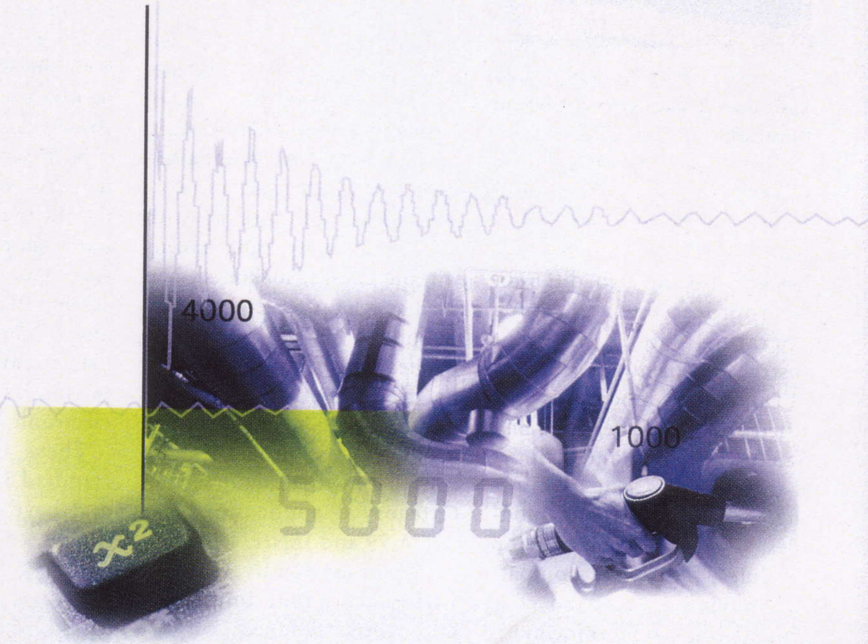
Going with the flow – multi-function flow computers

The measurement of flow is one of the most fundamental process measurement parameters and is used for a diverse range of applications — from the sale of goods such as petrol through to the dispensing and monitoring of sewage sludge. Flow can be measured to provide either a volumetric quantity or an instantaneous flow velocity, which is then normally translated into flow rate.



Over the years, a wide variety of methods have been developed to produce a signal proportional to flow, each with its own merits, shortcomings, complexity and accuracy. The choice of flow measurement methods will depend on a number of criteria including:

- Material
- Flow rate
- Accessibility
- Accuracy required
- Cost

The wide variety of flow metering methods have resulted in an almost equally wide range of accompanying instrumentation, which can present the user with two main problems.

1. Upgrading of current instrumentation can be difficult or expensive, especially if existing instrumentation has become obsolete within the useful life of the meter.
2. Spares holding on sites where a wide variety of flow measurement methods are used, can be a major headache.

To overcome these problems, a number of instrument manufacturers have developed universal input instruments which give the flexibility to be able to be integrated with most types of flowmeter. These 'smart' indicators can display either flow rate or total. One of these can be chosen by the operator to be the prime display while the other can be viewed by pressing a front panel key.

Many of these 'smart' units accept analogue signals, typically 4-20 mA or voltage. Built into many of these units is the ability to enter non-linear functions; square root, power 3/2 and power 5/2 and in many the user can also enter their own 13 point non-linear characteristic. Other inputs such as all common types of pulse signals within the frequency range 0.03 Hz to 20 KHz without loss of resolution or accuracy (Relay, TTL, NPN, PNP, Low Level and NAMUR), can also be accepted.

Option cards are available for relays and re-transmission of data which can be assigned to either the rate or the total.. Many units also have an innovative non-linear feature whereby a custom characteristic can be applied to the incoming frequency, greatly improving the accuracy to turbine flowmeters over the operating range.

A typical flow measuring system consists of an appropriate sensor, signal conditioning electronics and a display, control or alarm instrument.

Sensors usually measure flow by measuring flow velocity, which is directly related to flow rate when the cross section of the pipe is constant.

Flow measurement can be split up into four main categories:

- Differential pressure
- Open channel flow

- Positive displacement meters
- Velocity meters

Differential pressure

This method measures the pressure drop across some form of restriction in the flow line. The relationship between differential pressure and flow rate depends on the type of restriction, the most common being square root, power 3/2 and power 5/2 (rectangular or V).

Because flow is often proportional to the square root of pressure, small zero offsets can cause significant flow errors. A useful feature of some 'smart' units is the ability to compensate for this by changing from a square root function to a linear function below 10 per cent flow rates. In addition, any input below a programmable level may be 'clamped' to zero to prevent small offsets at zero flow from adversely affecting the totalised value.

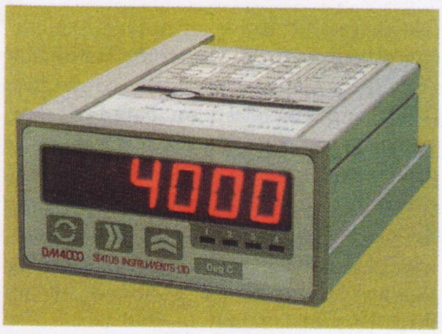
A universal 'smart' unit can be used with the most common form of restrictions including:

Orifice plate

An orifice plate is simply a flat plate installed in a pipe between two flanges, with an accurately-sized hole bored in it. The pressure drop across the plate is measured and is proportional to the square root of the flow.

Venturi tube

These provide a gradual reduction in pipe diameter followed by a similar expansion. The flow rate increases through the neck causing a pressure difference between this point and the inlet pressure. As with the orifice plate, the pressure drop is proportional to the square root of the flow.



A typical flow computer.

Pitot tubes

Here a tube is inserted into the flow at right angles. Holes facing the flow measure the impact pressure and this is compared with the static pressure. Again the difference is proportional to the square root of the flow. Although they are low cost and easy to install, small holes make them susceptible to blockage.

Open channel flow

Open channel flow refers to flow, which has one free surface. Several types of restriction are in common usage which cause a 'head' of fluid to back-up, the height of which is proportional the flow rate. The most common types of restriction are:

Weir

This is the open channel equivalent to the orifice plate and is normally either rectangular or 45° 'V' notch. The microprocessor incorporated into many 'smart' units has the required power laws as standard.

Flume

This is the equivalent of the venturi and a narrowing of the channel produces an increased flow rate, which helps to keep the flume clean. The flume produces a smaller loss of head than the weir and uses the 3/2 power conversion.

Positive displacement meters

These split the flow in small discrete 'packets' and count each one as it passes through the flowmeter. Each packet has an accurately defined volume and