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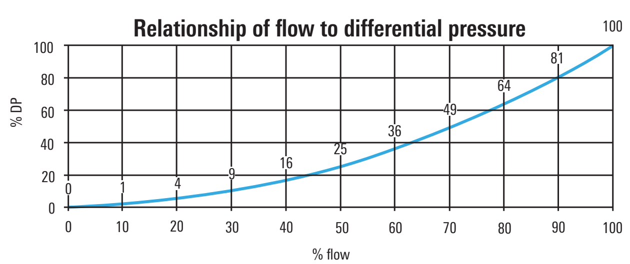
How It Works

Flow run switching and differential pressure sensor stacking

Features built into Cameron's Scanner* 3100 flow computer can expand the flow rate variability accommodated at a metering point without compromising accuracy. Certain applications require the ability to measure both low and high flow rates, for example, where energy demands change seasonally. Whether the application involves natural gas flowing in a pipeline or flowing in and out of storage caverns, or water and steam flowing in a heating plant or power generation facility, flow rates can vary greatly. These situations require a metering system with a very high rangeability (turndown) capability.

Accuracy and turndown are key considerations in flowmeter performance. All flowmeters provide the best accuracy at their maximum rated flow, but some measurement technologies are more effective in providing a large turndown because their performance degrades more slowly as the flow rate decreases. Therefore, flow turndown is ultimately governed by the measurement accuracy required for the application. Generally speaking, pulse-producing meters like Coriolis meters, positive displacement meters, turbine meters, and ultrasonic meters offer the best turndown capability in a single meter. Differential-pressure-producing meters like orifice meters, cone meters, and pitot meters that have a single differential pressure (DP) sensor are more limited due to the square root relationship of flow to differential pressure.



What is usually observed is that turndown is not caused by the limitation of the differential-pressure-producing device but by the ability to precisely sense the differential pressure. DP sensor stacking is a method to reduce uncertainty. In regard to the values presented in the subsequent example, the evaluator should consider possible limits and the additional uncertainty of the specific DP producer.

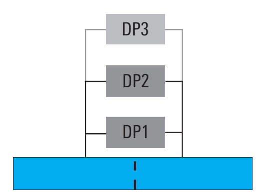
A metering system that requires 14:1 turndown means that it must be able to measure as low as 7.1% of the maximum flow rate. At 7.07% flow, the differential pressure generated across the element and sensed by the differential pressure sensor is only 0.5% of its full-scale value. A world-class differential pressure sensor, such as that on the Scanner 3100 flow computer, is accurate within ±0.05% of full scale at reference conditions and more likely ±0.1% when considering installation and dynamic influences.

Assuming a full-scale range of 400-in water column (WC), the sensor will be measuring only 2.0-in WC with the tolerance of ±0.4-in WC. Closer evaluation reveals that the 0.4-in WC tolerance in 2-in WC yields a ±20% uncertainty with respect to differential pressure. When differential pressure is converted to flow, the uncertainty associated with the rate of flow measurement is also nominally ±20%. In most applications, users would not find this level of uncertainty acceptable.

Differential pressure sensor stacking

The Scanner 3100 flow computer supports techniques to dramatically reduce this uncertainty. One of them is to "stack" two or more transmitters on a single DP producer. As an extension to the previous example, the 14:1 overall turndown requirement is divided equally across two DP sensors. Each transmitter is designed to handle a 3.8:1 turndown, which, although it will theoretically provide a 14.44 turndown (3.8 × 3.8), the actual turndown is restricted to 14:1 and the excess overlapped between the two DP sensors. In operation, the flow computer will read the lowest span DP sensor that is 100% output value.

Therefore, repeating the mathematics principles from the single DP sensor example, we can determine the improved uncertainty:



3.8:1 turndown = 26.3% full-scale flow (100%/3.8)

DP at 26.3% flow = 6.9% full scale ($[26.3/10]^2$)

Transmitter reference uncertainty = ±0.1% full scale

% of rate uncertainty at 3.8:1 turndown = 1.44% (1/6.9 × 100)

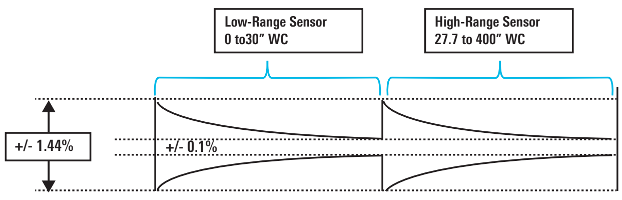
The uncertainty has been reduced from ±20% to ±1.44% of rate.

As in the original example, the full-scale value is 400-in WC; therefore, the high-range sensor would be used to measure between 27.7- and 400-in WC. A second DP sensor with a full-scale range of 30-in WC would measure between 2- and 30-in WC. This second sensor could be a Scanner 2000 flow computer communicating serially to the Scanner 3100 flow computer, or it could be a traditional DP transmitter with an analog output.

Note the expected overlap between 30-in WC and 27.7-in WC. The Scanner 3100 flow computer has the built-in logic to select the readings from the low-range sensor when the flow rate is increasing up to 30-in WC and then select the high-range sensor readings above 30-in WC. With decreasing flow, the Scanner 3100 flow computer will select the high-range sensor until it reaches 27.7-in WC, at which point it will transition to read the low-range sensor. By doing this, smooth stable transitions are made.

Flow run switching and differential pressure sensor stacking

In this example, the performance of the low-range transducer would also be ±1.44% of rate at minimum flow. This is because the same fraction of full-scale capability is being utilized and the full-scale uncertainty is the same.



The Cameron Scanner 3100 flow computer offers triple sensor-stacking capabilities to support further reduced uncertainties or higher turndown capabilities.

A practical application of this technique is a cone flowmeter for fluid injection measurement. By combining a cone meter, DP sensor technology, and a Scanner 3100 flow computer, the following package attributes are possible:

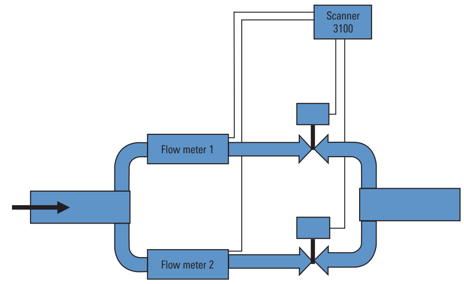
- 10,000-psi (690-bar) maximum working pressure
- 8-in nominal line size
- duplex stainless steel construction
- 20:1 turndown ratio
- ±1% system uncertainty.

While DP meters do not inherently have a high turndown capability, it is possible to achieve it while gaining other important attributes that would only be available from a DP-based flowmeter. In this example imagine the cost of a pulse-producing meter made of duplex SS with a 10,000-psi working pressure.

To further simplify measurement, Cameron offers a total package option, factory-assembled and deliverable in a single shipment, supplied with all electronic devices configured and verified. The customer simply bolts the module in place and connects power and communications to ready the line for flow.

Flow run switching functions

In applications where DP flowmeters are not the best choice or where a lower pressure drop is required, the Scanner 3100 flow computer can monitor and control multiple meters in parallel. Flowmeter technologies including turbine, Coriolis, ultrasonic, and differential producers are supported, and the fluids can be gases or liquids. Regardless of the metering technology chosen, the Scanner 3100 flow computer can maintain totals and flow rates for each individual meter as well as provide a composite total and flow rate for the meter station. Where required, multiple Scanner 2000 or 2100 flow computers can be added as subsidiary slave devices to a single Scanner 3100 flow computer to increase the capacity for compensated flow calculations and input and output quantities beyond what a single Scanner 3100 flow computer can accommodate. Through this technique, the number of parallel meter runs could be as high as 22.



Like the stacked transducer example, an overlap in meter flow capacity is used to assure a smooth transition between flowmeters and to avoid excessive valve operation. Using a turbine meter as an example, assume the application requires the measurement of a flow rate that varies between 5 and 450 galUS/min [40.1 to 3,609 m^3/h], which equates to a 90:1 turndown. Turbines might be selected due to the low uniform measurement uncertainty that can easily be less than ±0.10% of rate by utilizing the linearization feature within the Scanner 3100 flow computer.

The following table describes the operating states of the components in the above sketch. The Scanner 3100 flow computer would control the two valves referenced in the table.

Flow Rate	Meter 1	Valve 1	Meter 2	Valve 2	Increasing Flow galUS/min [m^3/h]	Decreasing Flow galUS/min [m^3/h]
Low flow	Operating	Open	Stopped	Closed	5 to 50 [40.1 to 401]	5 to 40 [40.1 to 320.8]
High flow	Stopped	Closed	Operating	Open	50 to 400 [401 to 3,208]	40 to 350 [320.8 to 2,807]
Very high flow	Operating	Open	Operating	Open	400 to 450 [3,208 to 3,609]	350 to 450 [2,807 to 3,609]

The design and operating philosophy described in the above sketch could vary or be expanded, depending on performance objectives. Variations include adding more flowmeters in parallel or eliminating the very high flow mode and then using a single two-position, three-way valve.

The previous examples are accomplished in the Scanner 3100 flow computer by using preprogrammed user-configurable features. Stacking DP sensors is accomplished via the menu options: Local I/O ↓ Configuration ↓ Input stacking. Flow run switching is accomplished by a subset of the alarm outputs function: Local I/O ↓ Digital I/O Configuration ↓ Conditional output. Each of two flow runs in the Scanner 3100 flow computer can simultaneously have stacked inputs and or flow run switching.

Cameron can supply the entire scope as a tested assembly, inclusive of valves and actuators.

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