AN09
Accuracy explained

1. Introduction

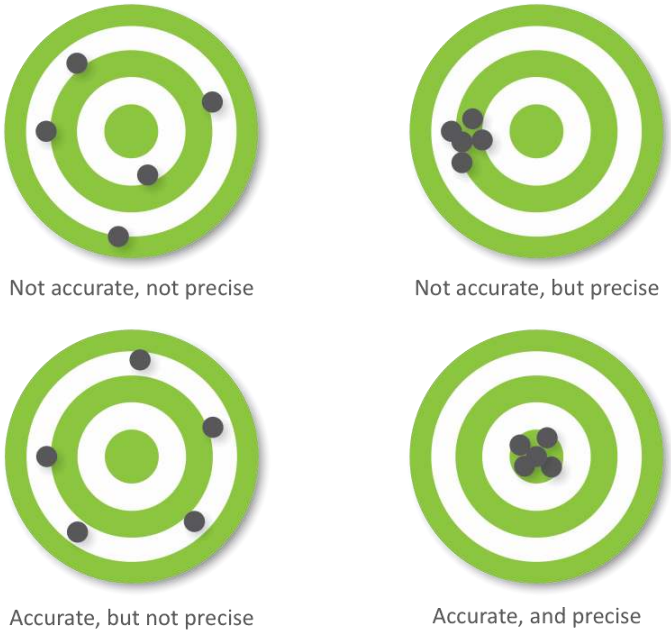
To fully understand the accuracy of flow meters you must know the difference between full scale accuracy and % of reading accuracy. You also have to understand what " turndown ratio" means. With this knowledge, you can make a better judgment on the performance of our flow meters and other flow meter technologies.

2. Total measurement uncertainty (a.k.a. "accuracy")

The total measurement uncertainty is the official definition of accuracy. It consists of the sum of all possible errors in your measurement. In case of flow meters, these errors are:

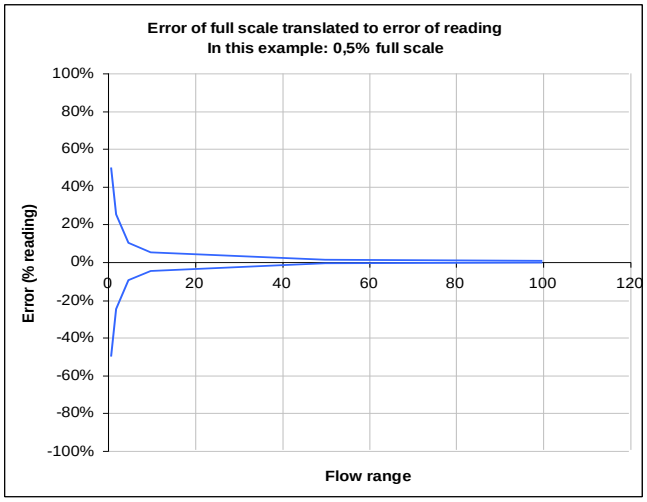
- The stated calibration error, which you can find in the calibration report. This error can vary depending on brand and type of flow meter.
- Installation errors, due to flow profile effects. The flow is measured at one point, but you can never know the exact shape of the flow profile in the pipe. This applies to all single point insertion flow meters regardless of type and brand.
- Installation errors due to mechanical effects (alignment, insertion depth of your probe). This typically depends on the skills of the installation engineer.
- Pressure and temperature effects: some flow meters, especially non-mass flow meters, are sensitive to pressure and temperature effects. VPInstruments' flow meters are mass flow meters, meaning they compensate automatically for pressure and temperature changes.

Accuracy and precision are often used the wrong way. The figure below explains the difference between the two.



3. Accuracy full scale

If a flow meter has a flow range of 0 - 100 m_n/sec and the spec was +/-1% F.S. , the error would be +/-1 mn/sec. (This is 1% of the full scale of 100 m_n/sec). The less flow passes through the device, the less accurate the reading will be, as you have to apply this error to any measurement value within the range. If you measure 10 m_n/sec, the result can be between 9 and 11 m_n/sec, which is equal to 10% error of the reading. If you check at 50 m_n/sec, the result can be 49 to 51 m_n/sec, which is 2% error of the reading. If measuring 100 m_n/sec, the result can be 99 to 101 m_n/sec, which is 1% error of reading.

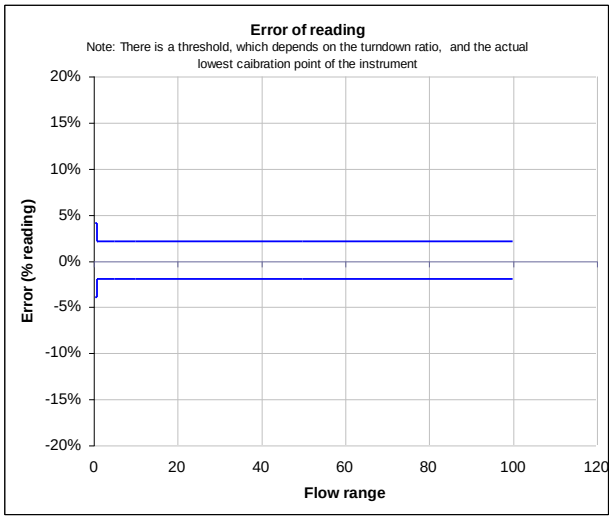


To summarize, if the error is specified as “off full scale”, the flow meter is more accurate in the higher flow range than in the low flow range. Therefore, the flow meter should be properly scaled for the application (depending on the accuracy requirements).

4. Accuracy of reading

If a flow meter has a flow range of 0 - 100 m_n/sec, and the specification is +/-1% of reading, the accuracy would be +/-1%, regardless of the actual value. You would apply that percentage tolerance anywhere in that range. If you would check at 10 m_n/sec, the result could be 9.9 to 10.1 m_n/sec. If you would check at 50 m_n/sec, the result could be 49.5 to 50.5 m_n/sec And at 100 m_n/sec the result could be 99 to 101 m_n/sec.

Every measuring instrument will have a larger error in the lowest part of the flow range. Even an instrument which is specified with “error of reading”.



This increase in error depends on the actual calibration points, the turndown ratio and any zero/ offset effects that the instrument might have due to pressure and temperature sensitivity.

5. Turndown ratio

To understand accuracy, it is also important to understand turndown ratio. The turndown ratio of a flow instrument is the ratio of minimum flow to full scale flow. Simply put, it is the minimum amount of fluid that can be measured by the device. For example, if a given flow meter has a 100:1 turndown ratio, the flow meter can measure 1/100th of the full-scale flow. Below this value, the meter will not show any value or a very erratic value.

Typical turndown ratios for different technologies:

Technology	Turndown
Thermal mass flow	1 : 300
Vortex	1 : 50
Differential pressure (orifice)	1 : 5
Differential pressure (venturi)	1 : 10
Ultrasonic	1: 50
Positive displacement (high end type)	1 : 150

So, even though said flow meter can flow to 1/100 of its full scale range, you want to make absolutely certain that the accuracy at those low flow rates meet your requirements.

6. Conclusions

- When comparing flow meters or different flow meter technologies, it is important to compare “apples to apples”: you need to compare the uncertainties in % of reading or in % of full scale. It is also important to be aware of the turndown ratio.
- When a flow meter is used outside of its range, especially in the low part, it might not show a reading at all or it will provide a very unstable reading.