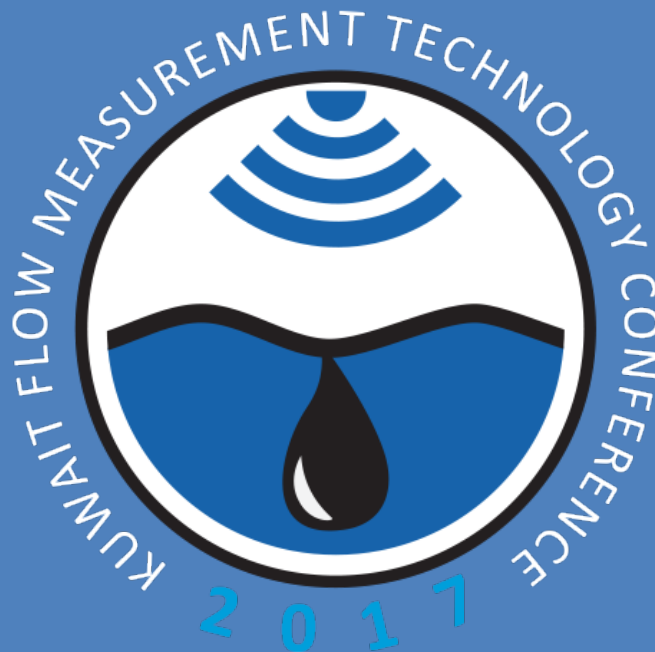




KUWAIT 3RD FLOW MEASUREMENT TECHNOLOGY CONFERENCE

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KUWAIT FLOW MEASUREMENT TECHNOLOGY CONFERENCE 2017

ULTRASONIC FLOW METERS ACCURACY AND REPEATABILITY



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SPEAKER'S PROFILE

Working as Engineer Design-Instrumentation with M/s Kuwait Oil Company. Responsible for project engineering including FEED preparation.

Executed several projects with Flow Meters especially Ultrasonic Flow Meters for critical applications such as Pipe Leak Detection Systems.

More than 30 years experience in the field of Instrumentation, Control and Engineering with specialization in DCS, ESD, Fire & Gas and SCADA systems.

HIGH ACCURACY ULTRASONIC FLOW METERS- APPLICATION

High Accuracy Ultrasonic Flow Meters find application in the following areas:

Custody Transfer/Fiscal Metering

Pipeline Leak Detection System

Allocation and Environmental areas

Custody Transfer Applications quite often follow OIML R117 and API MPMS 5.8 Standards.

Fiscal Measurement Applications comply with the Institutional guidelines as well as rules and regulations as also OIML R117 and API MPMS 5.8 Standards.

FLOW MEASUREMENT TERMS

While specifying the performance of an Ultrasonic Flowmeter (USM), we come across the following terms

Accuracy

Repeatability

Reproducibility

Uncertainty

Linearity

DEFINITIONS-ACCURACY AND REPEATABILITY

Definition of Accuracy and Repeatability is given below:

Accuracy

Accuracy is the closeness of the measured or indicated value of the flowmeter to the actual value. The meter reading should also correspond to the characteristic curve of the flowmeter. If actual flow is not known, defining Accuracy is not appropriate.

Repeatability

Repeatability can be defined as the ability of a flowmeter to reproduce a measurement each time a set of conditions is repeated.

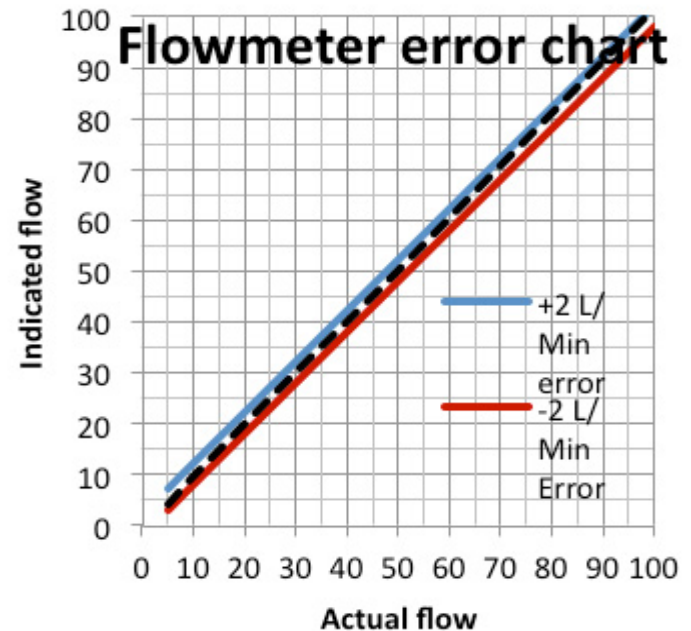
It is often debated whether Accuracy or Repeatability is more important while designing and calibrating the Flow Meters.

FLOW LINEARITY

Linearity

Linearity is defined as the closeness of a curve that approximates to a straight line throughout measurement range.

Some meter manufacturers prefer to use the term “Linearity” rather than “Accuracy”.



UNCERTAINTY- AN IMPORTANT TOOL

UNCERTAINTY

For Ultrasonic Flow meters, it is always advisable to use the term “Uncertainty” rather than Accuracy. The reason is that Accuracy is meaningful only if the True or Actual Value of flow is known.

Uncertainty can be defined as the band or margin within which the true value (the actual flow) can be expected to lie.

Uncertainty however has to be expressed with certain degrees of confidence specified as “Confidence Level”.

Uncertainty of measurement is basically an estimation of the flow rate.

UNCERTAINTY- AN IMPORTANT TOOL

It is to be understood that when we measure flow, the readings or indication obtained is not the actual true flow value but an **estimate** of the same. There is always an element of “incorrectness” about the measurement.

The extent of “incorrectness” is a measure of Uncertainty. A measured flow rate can be **expressed if we know the Uncertainty and the Confidence Level.**

Thus, for example, a statement such as 50 m³/hour with Uncertainty of +/- 0.027% at 95% Confidence Level will be an appropriate statement.

UNCERTAINTY- AN IMPORTANT TOOL

UNCERTAINTY CALCULATION

The calculation of Uncertainty adopts mathematical methods and is a good tool for estimation of the flow rate. Uncertainty takes into account factors such as

- Installation of the flow meter
- Environmental effects
- Effect of aging of the flowmeter electronics
- Noise and vibration
- Variation in operating conditions-Temperature, Pressure and Humidity

WHAT DO THE MANUFACTURERS SPECIFY?

Extracts from Manuals of leading Ultrasonic Flow Meter Manufacturers

MANUFACTURER-I

Accuracy $< \pm 0.15\%$ of measured value for $v = 1...10$ m/s
 $< \pm 0.20\%$ of measured value for $v = 0.2...10$ m/s

Repeatability $< \pm 0.02\%$ ($n = 2$)

Uncertainty $< \pm 0.027\%$ (95% confidence level) as per API

MANUFACTURER-II

Linearity $\pm 0.12\%$ of measured volume for flow rates between 0.3 and 10 m/s

Repeatability 0.02%

Uncertainty $\pm 0.027\%$ according to API MPMS 5.8

API MPMS-GUIDELINES

API MPMS Chapter 5.8 specifies the Repeatability with respect to Uncertainty of meter.

If we test Ultrasonic Flowmeters as per API guidelines, then to achieve a 0.027% meter uncertainty factor at a 95% confidence level we may need several runs.

Better Repeatability is achieved when the meter Testing Runs are more.

To achieve a Repeatability of 0.02% with an Uncertainty of 0.027%, the meter has to be checked in three (3) consecutive Runs which may be difficult to achieve.

Runs	Repeatability Band % (R)	Uncert. %
3	0,02	0,027
4	0,03	0,027
5	0,05	0,027
6	0,06	0,027
7	0,08	0,027
8	0,09	0,027
9	0,10	0,027
10	0,12	0,027
11	0,13	0,027
12	0,14	0,027
20	0,22	0,027

ACCURACY AND REPEATABILITY

A Flow Measurement

- Can be accurate but not repeatable
- Can be repeatable but not accurate
- Can be both accurate and repeatable

A general observation is

- Good accuracy leads to good repeatability
- Poor repeatability leads to poor accuracy
- Good repeatability may not result in good accuracy

ACCURACY AND REPEATABILITY

Accuracy or Uncertainty can be further expressed as a percentage (%) factor of the Flow Rate or of the Span or Full Scale of the Meter.

It is to be noted that a flow meter with an accuracy or uncertainty specified on the full scale is less accurate at the low end of the scale.

On the other hand a flow meter uncertainty specified on the rate will give better results.

VERIFICATION RESULTS

During a recent flow meter verification, the following interesting results were obtained for a Flow Meter with a Range 0-11000 m³/hour.

Meter calibration was verified across six points.

1. For very low flow rate, both accuracy and repeatability values were not good and stable as is expected in a Ultrasonic Flow Meter.
2. Only for two flow points, Repeatability could be achieved within three runs. For many flow points, as much as 10 runs were required to achieve Repeatability as per API MPMS table.
3. Repeatability value of 0.02% was not achieved consistently across all flow points. This is an important aspect to be considered as many Data Sheets for Ultrasonic Flow Meters state Repeatability to be achieved as 0.02%.

ACCURACY OR REPEATABILITY

What is more important?

Accuracy/Uncertainty or Repeatability

The project or the application involving the flowmeter has to be carefully studied before specifying the requirement. It has to be ensured that impractical or unrealizable values are not specified while preparing the Data Sheet.

Non-critical applications do not require high accuracy or highly repeatable meters. To specify a high accuracy and high repeatability meter, will increase the cost of the meter and will be surely an over-specification.

ACCURACY OR REPEATABILITY-CONCLUSION

CONCLUSION

All the terms used have their own importance and relevance. It is the Design Engineer's responsibility to specify and develop Data Sheets for Flow Meters keeping in mind the project objectives and requirements.

While Accuracy and Repeatability are important, the concept of Uncertainty is very much relevant and in use nowadays in Flow Metering. The skill lies in specifying what is practical and achievable so that the meter can be tested to ensure compliance to the specifications.



Thank You