NSC-TISI-TIS 17025
Calibration 0126

The Uncertainty of Flow Meter Measurement

By

Mr.Surachart Changpanich
Flowlab & Service Co.,Ltd.

Email : surachart.flowlab@outlook.com
Mobile Phone : 081-8617005
Line ID : Surachart_59

Introduction

Whenever a dynamics measurement of fluid flow is made, the value obtained is simply the best estimate that can be obtained of the flow rate or quantity. In practice, the flow rate or quantity could be slightly greater or less than this value, the uncertainty characterizing the range of values within which the flow rate or quantity is expected to lie that could reasonably be attributed to the measurement, with a specified confidence level.

Calibration

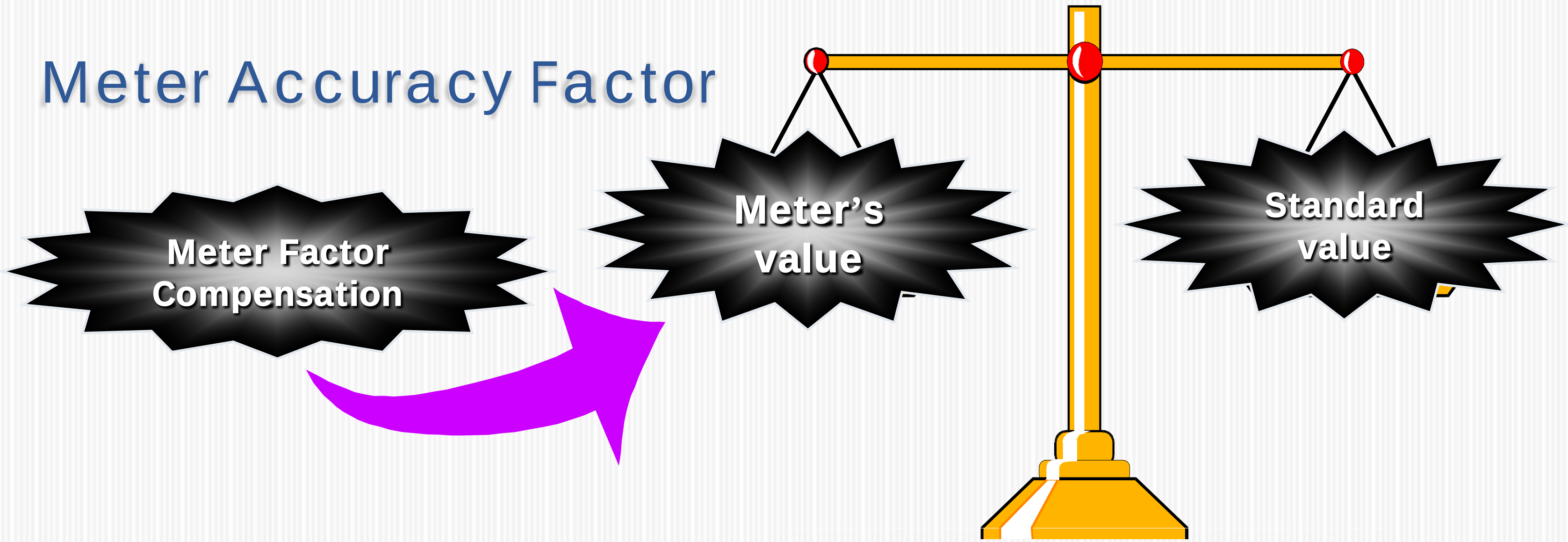
The process of using a reference standard to determine a calibration factor.Calibration adjusts the output of meter to bring it to a value which is within the specified accuracy tolerance.This process is normally conducted by the meter manufacturer.

Purpose of Flow Meter Calibration

- Improve measurement accuracy
- Product is valuable
- Checks the condition of equipment
- Trading
- Follow to regulation

$$\text{Meter Factor} = \frac{\text{Standard value}}{\text{Meter's indicated value}}$$

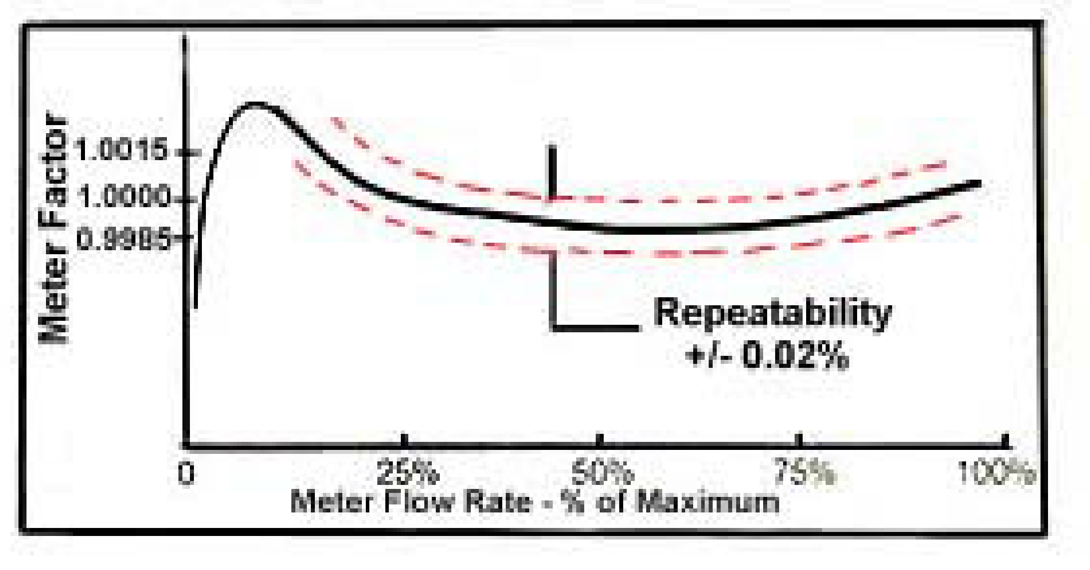
Meter Accuracy Factor



METERED VALUE X MF = PRECISE VALUE

(Simplified)

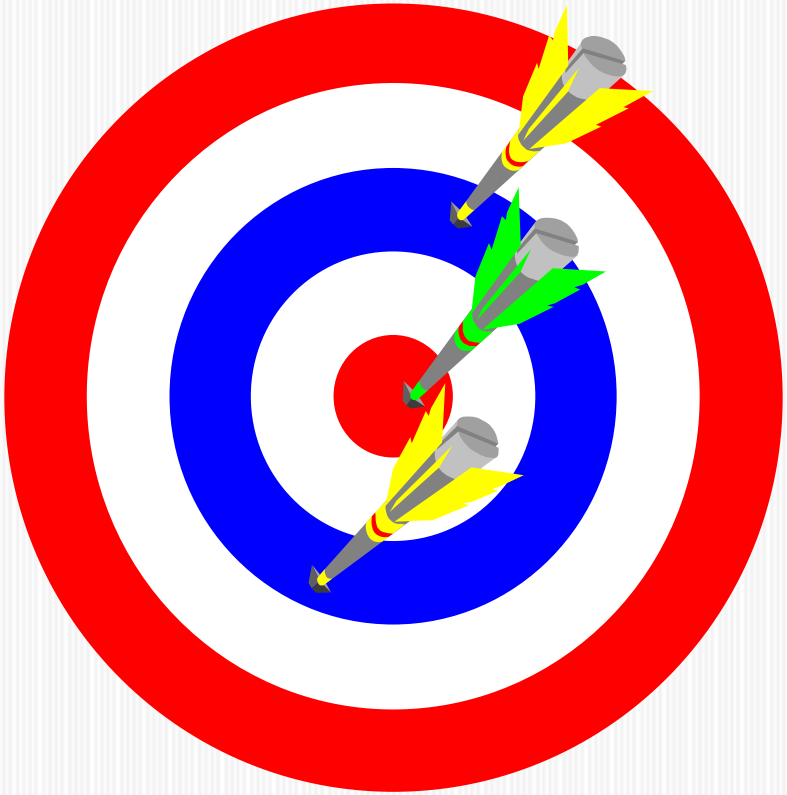
Repeatability means just what it say - how nearly the same reading a meter will provide for a given flow condition.



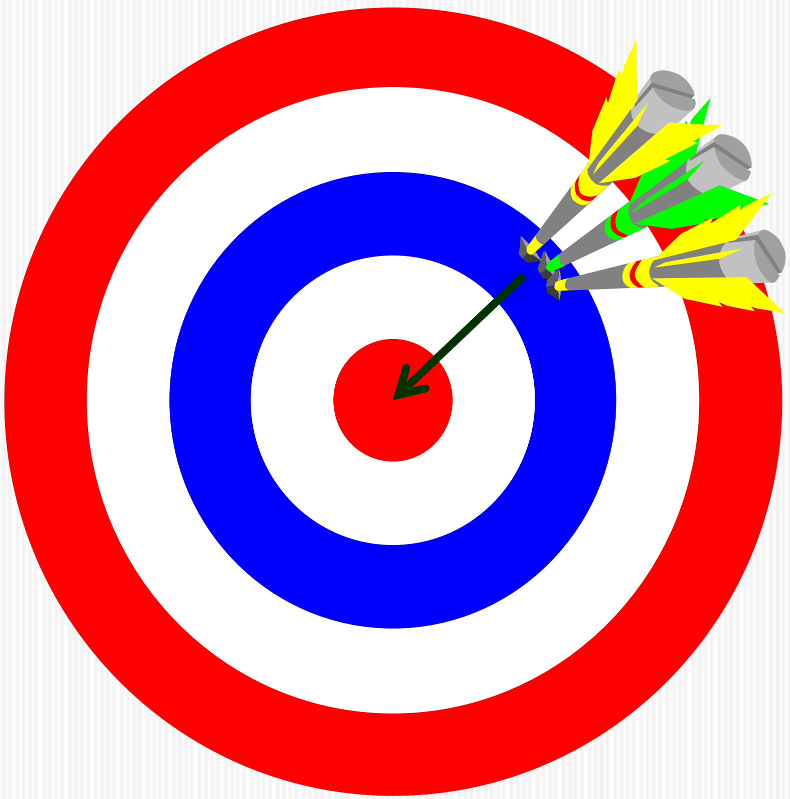
% Repeatability = [(MF.max / MF.min) – 1] x 100

GOOD REPEATABILITY DOES NOT NECESSARILY MEAN GOOD ACCURACY

POOR REPEATABILITY MEANS POOR ACCURACY



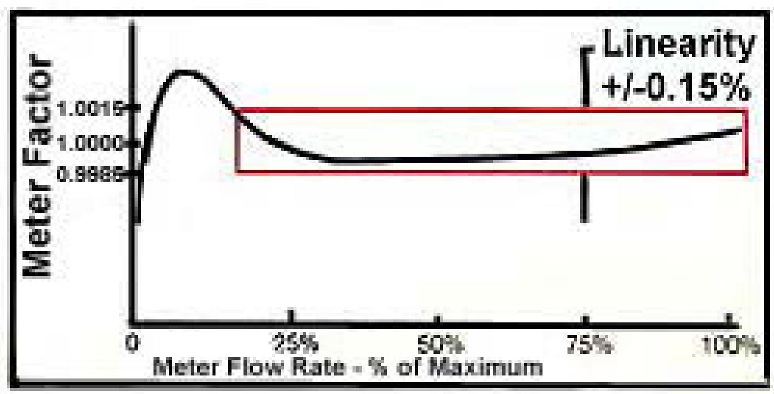
GOOD REPEATABILITY TO BE ADJUSTED FOR THE RESULT IS GOOD ACCURACY



AFTER ADJUSTMENT THE ACCURACY IS GOOD

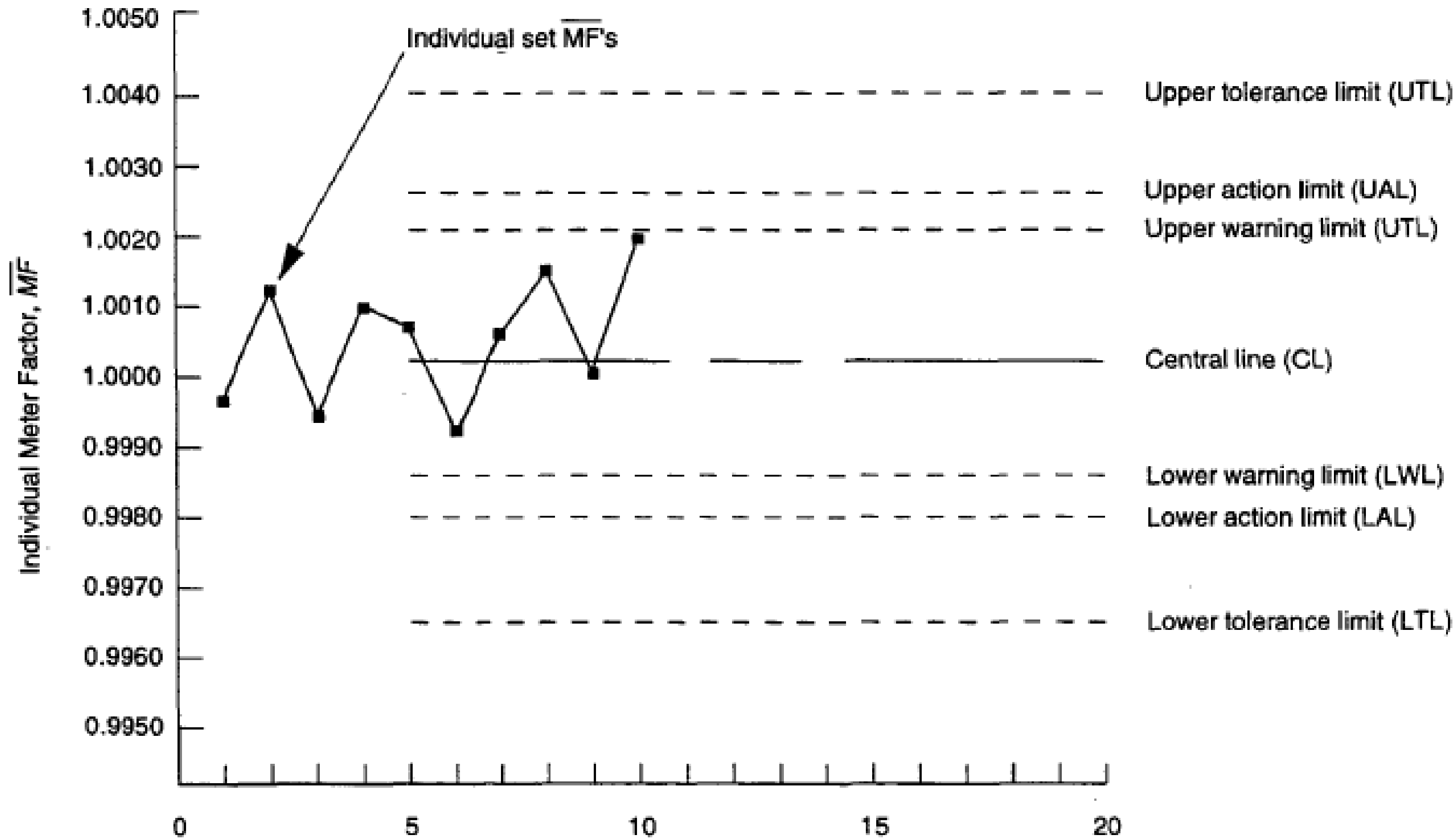
An important point in this discussion is that the meter can insure accurate measurement, even with marginally performing meter. The reliability which can be represented to measurement parameter following:

Linearity is meter accuracy within a **Rangeability** expresses the flow range over which a meter operates while meeting a stated accuracy tolerance. It is often stated as ***"Turndown"*** maximum flow divided by minimum flow over the range as 250-2500 LPM, the range ability is 10:1 .



$$\% \text{ Linearity} = \frac{\frac{1}{2} \times [(MF.max - MF.min)] \times 100}{Avg.MF}$$

Stability: **T**he indication is when the meter factors maintain stability over time by continuously having values within a set tolerance.



METER FACTOR SEQUENCE / METER FACTOR STABILITY

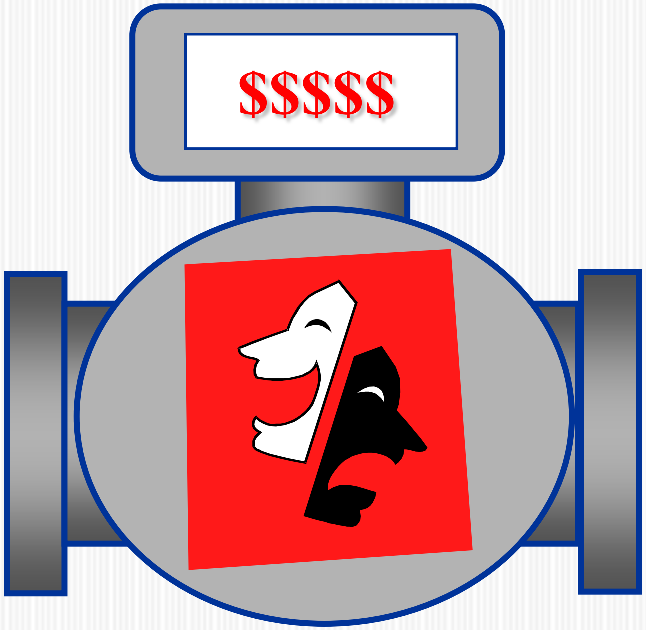
STABILITY

- ESSENTIAL TO ACHIEVE A HIGH CONFIDENCE LEVEL

- BEST INDICATION THAT THE METERING SYSTEM IS UNAFFECTED BY RANDOM ERRORS

A STATISTICAL RECORD OF METER PROVINGS IS THE BEST MEANS TO ESTABLISH THE LEVEL OF SYSTEM UNCERTAINTY FOR A METERING INSTALLATION

Accuracy VS Uncertainty



Accuracy : The closeness in the agreement between the result of a measurement and the true value of the measurement. ***The quantitative expression of accuracy is in terms of uncertainty***. Good accuracy implies small random and systematic errors.

Uncertainty : The parameter, associated with the results of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurement.

Evaluation of the uncertainty in a measurement process

The first stage in an uncertainty evaluation is to define the measurement process. For the measurement of flow rate, it will be normally be necessary to combine the values of a number of input quantities to obtain a value for output. The definition of the process should include the enumeration of all the relevant input quantities.

The sources of introducing uncertainty in a measurement process can be divided arbitrarily into the following categories:

a) Calibration uncertainty;

b) Data acquisition uncertainty;

c) Data processing uncertainty;

d) Uncertainty due to methods;

e) Others

The effecting cost of inaccuracy

- Application for pipe line transfer or marine loading which throughput of 500 m^3/h.
- The cost per m^3 = 26,890 THB. (HSD _5 Nov'15)
- **Value of each 0.XX % of bias.**

  Example

  1. For 0.15% of bias of Marine loading for 8 h/Day ;
     a) THB 161,340/Day
     b) THB 58,889,100/Year

  2. For 0.10% of bias of marine loading for 8 h/Day ;
     a) THB 107,560/Day
     b) THB 39,259,400/Year

- ***The deviation 0.05 % which to be save: THB. 19,629,700 per year.***

The sources of uncertainty can be classified as following;

- Random uncertainty : Type A evaluation
- Systematic uncertainty : Type B evaluation

Random uncertainty

The sources of errors that cause a variation in output reading even when the input parameter has no changed. Type A evaluations of uncertainty are those using statistical methods, specifically, those that use the spread of a number of measurement.

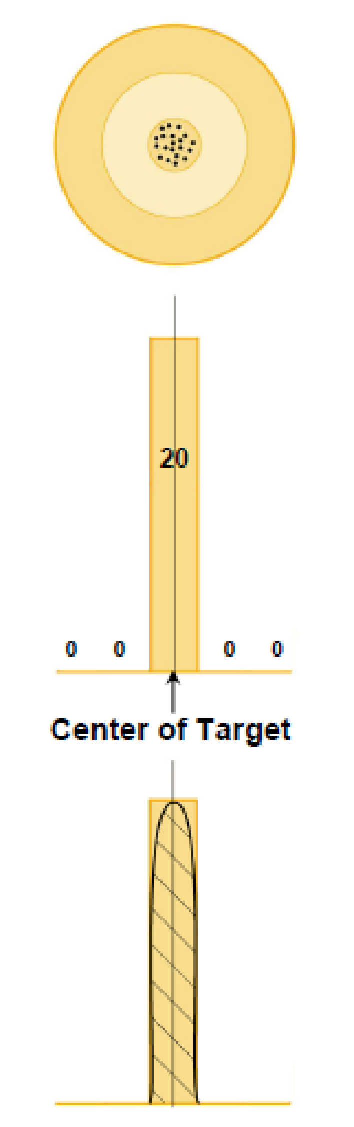
An estimate characterizing the range of values within which the true measured value of a quantity lies and how frequently the reading does lie within this range per confidence level is 95%

Evaluation: Custody measurement starts with verification or proving a meter to *a repeatability of 0.05% of 3 consecutive runs*. The evaluation is an uncertainty of *+/- 0.073% at 95% confidence level*.

Accurate Measurement

The accuracy of measurement is +/- 0.1%
repeatable 20 out of 20.
100 % confidence level.

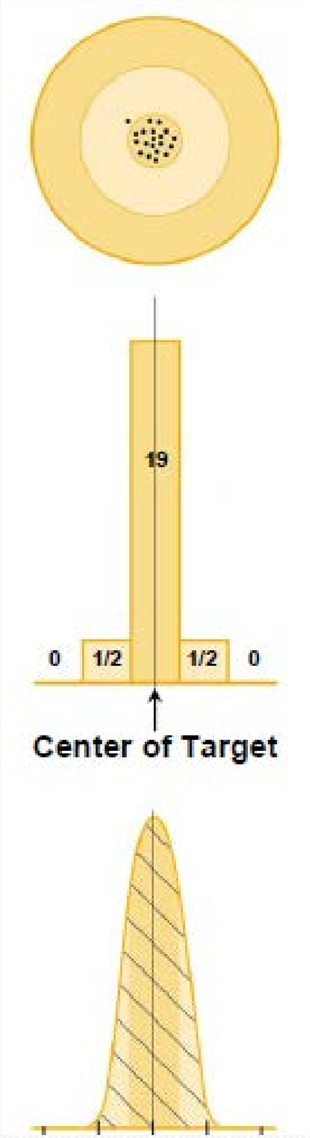
Zero bias



Custody Measurement

+/- 0.1% repeatable 19 out of 20
95 % confidence level.

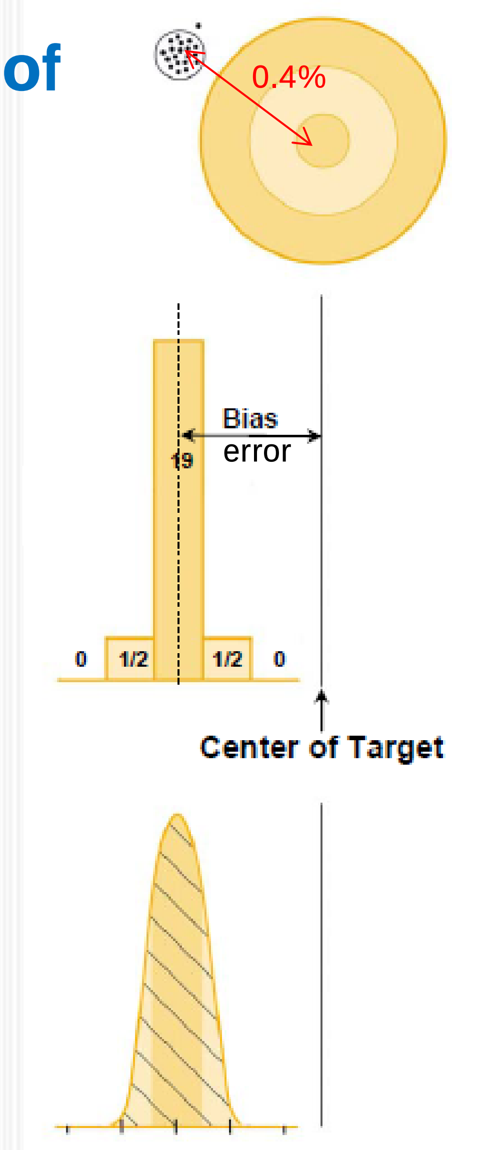
Zero bias



Repeatable occur a bias error of measurement.

+/- 0.1% repeatable 19 out of 20.
<u>95 % confidence level.</u>

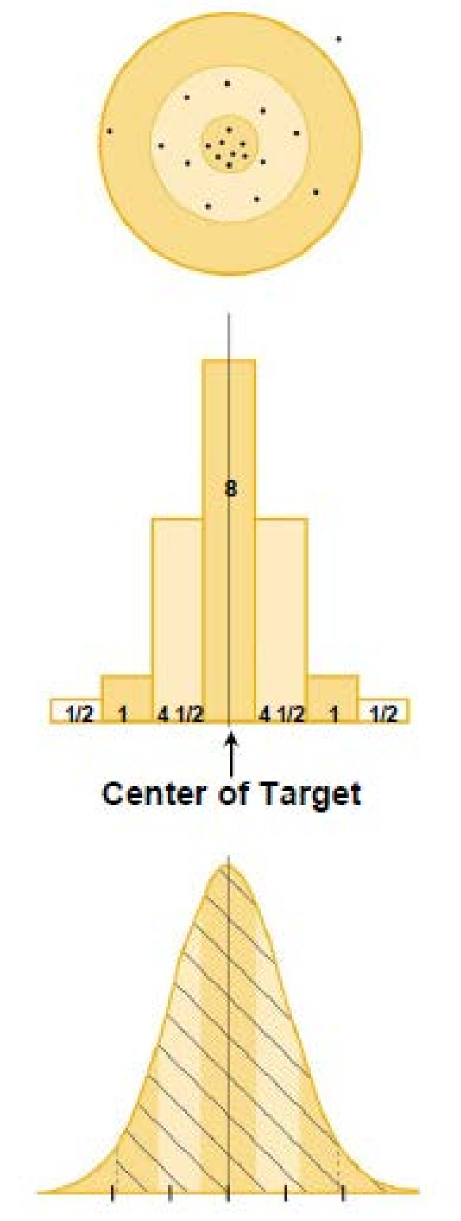
0.4% bias error



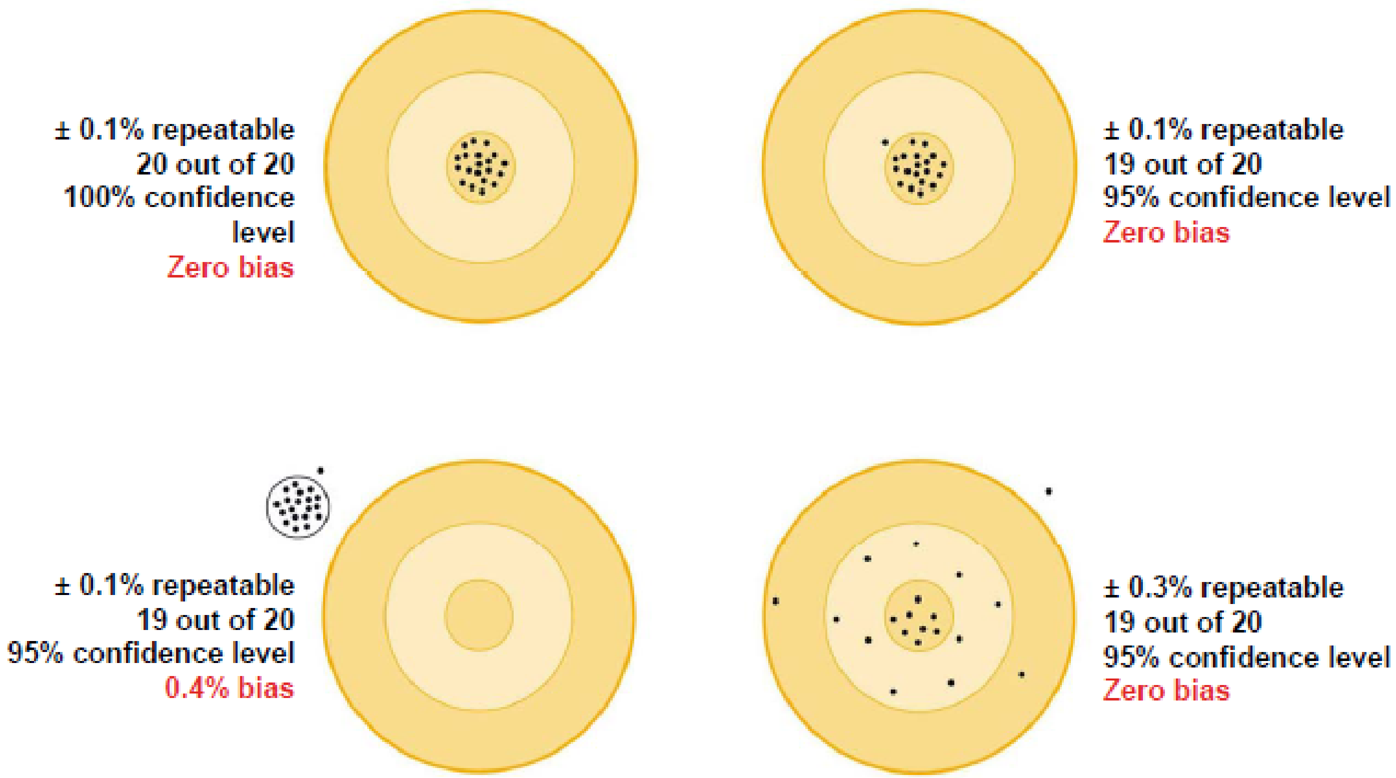
Poor repeatability of measurement.

+/- 0.3% repeatable 19 out of 20.
95 % confidence level.

Zero bias



Basic Measurement - Summary



American Petroleum Institute

Manual of Petroleum Measurement Standards Chapter 4.8

Operation of Proving Systems

SECOND EDITION, SEPTEMBER 2013

Averaging passes may be used as an alternate method to summing. It has been an industry practice to average a number of passes utilizing the resultant average as representing a proving run for comparison to similar runs to determine repeatability.

Common examples of pass, run, and repeatability combinations are:

— 3 passes per run, 5 runs at 0.05 % repeatability (15 passes);

— 3 passes per run, 3 runs at 0.02 % repeatability (9 passes);

— 5 passes per run, 5 runs at 0.05 % repeatability (25 passes);

— 10 passes per run, 3 runs at 0.02 % repeatability (30 passes).

Random Uncertainty Statement

The range of repeatability per proving runs				
Uncertainty : +/- 0.027%			Uncertainty : +/- 0.073%	
Proving Runs	Repeatability		Proving Runs	Repeatability
3	0.02%		3	0.05%
5	0.05%		5	0.14%
8	0.09%		8	0.25%
10	0.12%		10	0.32%
15	0.17%		15	0.46%

Systematic uncertainty

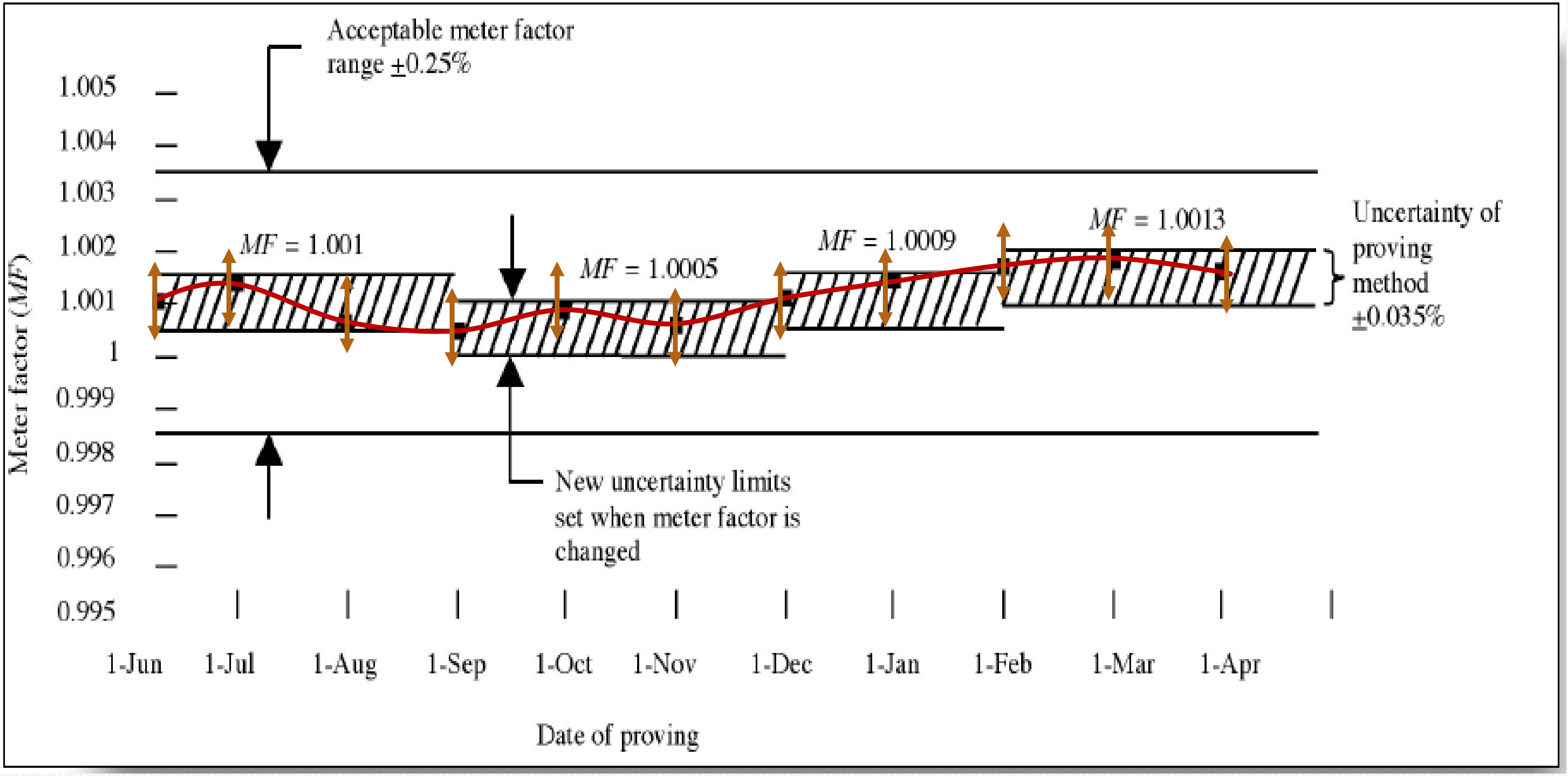
Type B evaluations of uncertainty require a knowledge of the probability distribution associated with the source of error that relate with systematic within this range per confidence level such as;

a) Uncertainty due to methods; Tank Prover, Master Meter, SVP.

b) Data acquisition uncertainty; Flow Meter, Temperature, Pressure, Density, and Electronic Batch controller.

c) Data processing uncertainty; Product Calculation.

d) Others


Acceptable meter factor range ±0.25%
1.005
1.004
1.003
1.002
1.001
1
0.999
0.998
0.997
0.996
0.995
Meter factor (MF)
MF = 1.001
MF = 1.0005
MF = 1.0009
MF = 1.0013
Uncertainty of proving method ±0.035%
New uncertainty limits set when meter factor is changed
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
Date of proving

Q/A;

-
-
-

Thank you