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Your Text

Benefits of Calibrating Meters Under Process Conditions

- All liquid (*and gas*) flowing quantities measurement technologies are more or less sensitive to their conditions of use

  (*and to variations of these conditions over time*)

- Meter Performances (Linearity AND Repeatability) are impacted by:
  - **Process and installation conditions** such as:

    Flowrate, Temperature, Pressure, Upstream/Downstream pipe sections length ...

  - **And Fluid characteristics** such as:

    Density, Viscosity, Speed Of Sound, Vapor Pressure...

- This is why …

<u>Verifications must be done as close as possible to process conditions</u>

Many applications don't allow the "comfortable" online calibration (*the only method thqt considers actual fluid characteristics and process conditions … during proving*) and so, to guarantee expected performance level …

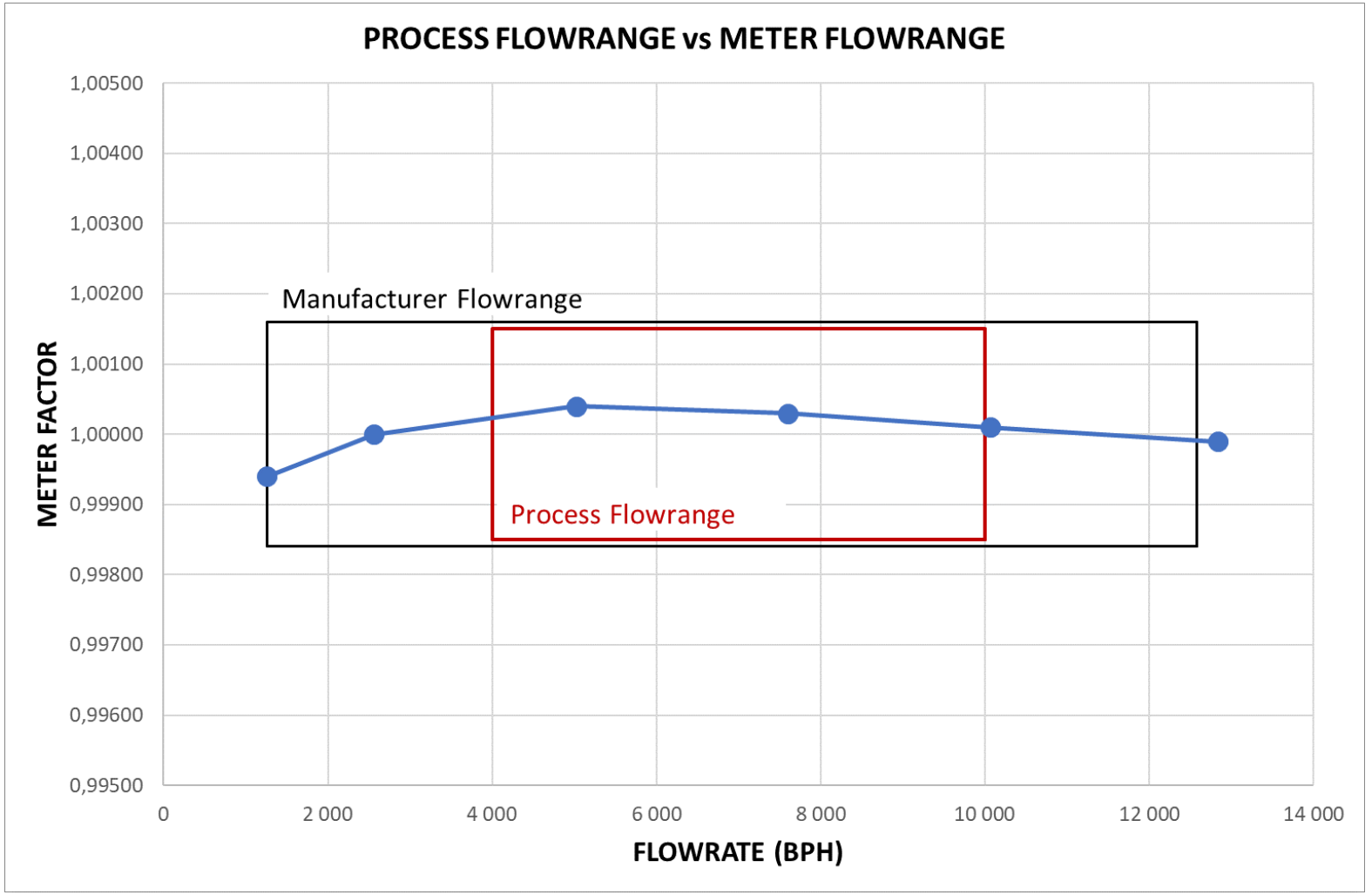
It is imperative to reproduce the conditions of use described above, not only when selecting the meter, to be sure that the meter (or the Master Meter !!!) fits the application, as well as during periodic verification of meter performances.

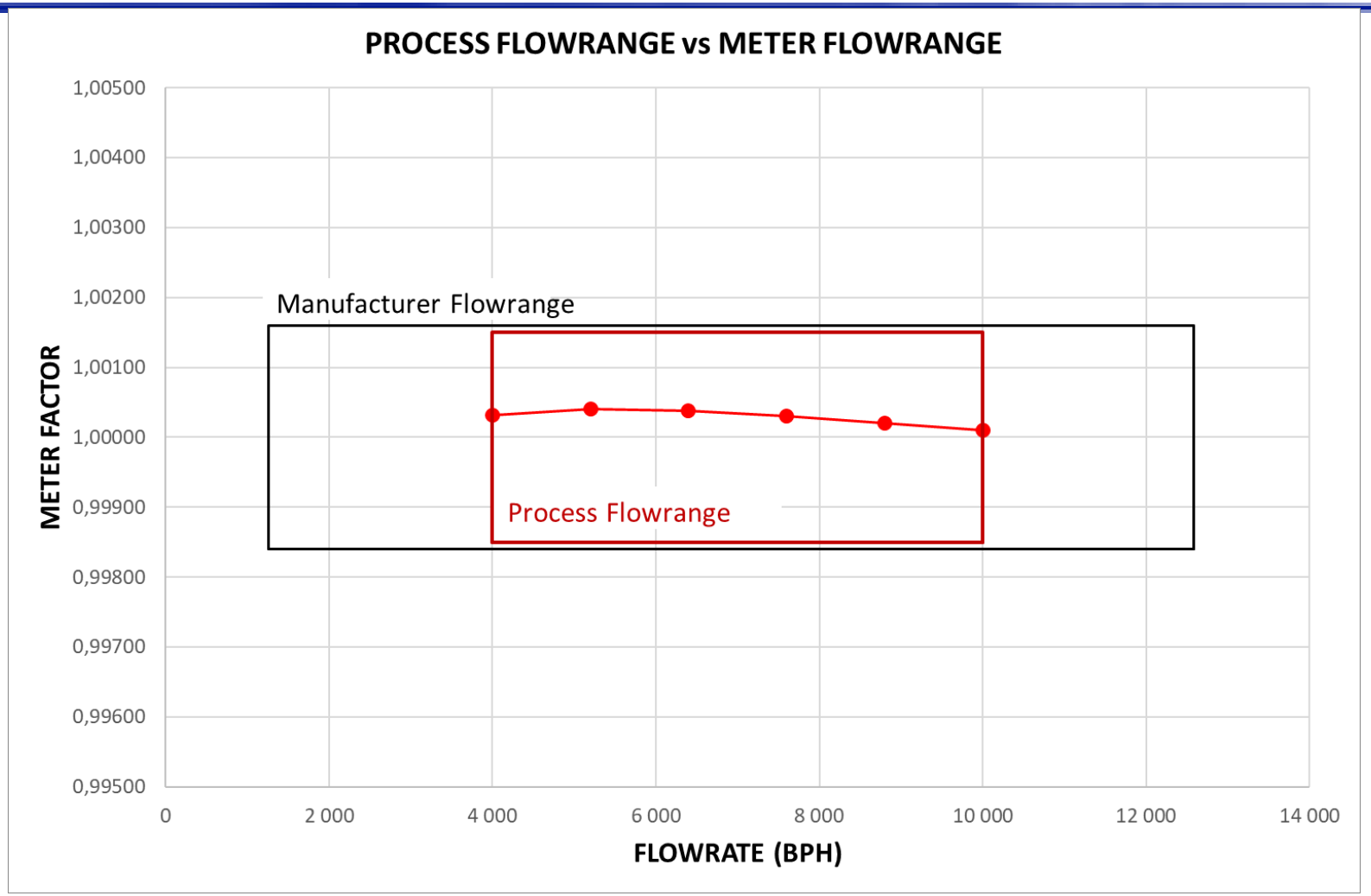
- Process envelop is mainly defined by :
  - Flowrate: min, Max, stability, continuous, start/stop
  - Temperature: min, Max, variations
  - Pressure: min, Max, regulation, stability, (cavitation), surge
  - Fluid Density: min/Max
  - Fluid Viscosity: min/Max
  - Water/Wax content …

Flowrate:

Knowing that meter performances vary from min to max flow, proving must cover the full range, even if Reynolds calibration is applied.

Note: Depending on application, the process flow range can be different from manufacturer typical range and a “zoom” can be helpful (linearization …).


PROCESS FLOWRANGE vs METER FLOWRANGE
METER FACTOR
1,00500
1,00400
1,00300
1,00200
1,00100
1,00000
0,99900
0,99800
0,99700
0,99600
0,99500
Manufacturer Flowrange
Process Flowrange
0
2 000
4 000
6 000
8 000
10 000
12 000
14 000
FLOWRATE (BPH)


PROCESS FLOWRANGE vs METER FLOWRANGE
METER FACTOR
1,00500
1,00400
1,00300
1,00200
1,00100
1,00000
0,99900
0,99800
0,99700
0,99600
0,99500
Manufacturer Flowrange
Process Flowrange
0
2 000
4 000
6 000
8 000
10 000
12 000
14 000
FLOWRATE (BPH)

If API-MPMS defines coefficients allowing correction of the effect of temperature and pressure on prover (CTSp, CPSp), the wide variety of designs of different types of meters makes it difficult to establish this type of rules to correct the effect of temperature and pressure on the meter itself.

However, manufacturers propose different solutions to minimize the impact of temperature and pressure differences observed between the calibration and operation of the meter.

IMPORTANT: The use of these factors must consider the effect induced by these temperature and/or pressure variations on fluid characteristics and their impact on meter performances.

For example, a difference in temperature between calibration and use may result in a fluid viscosity difference, whose performance effect will be 5 to 10 times greater than the possible temperature correction applied to the meter.

Temperature (fluid):

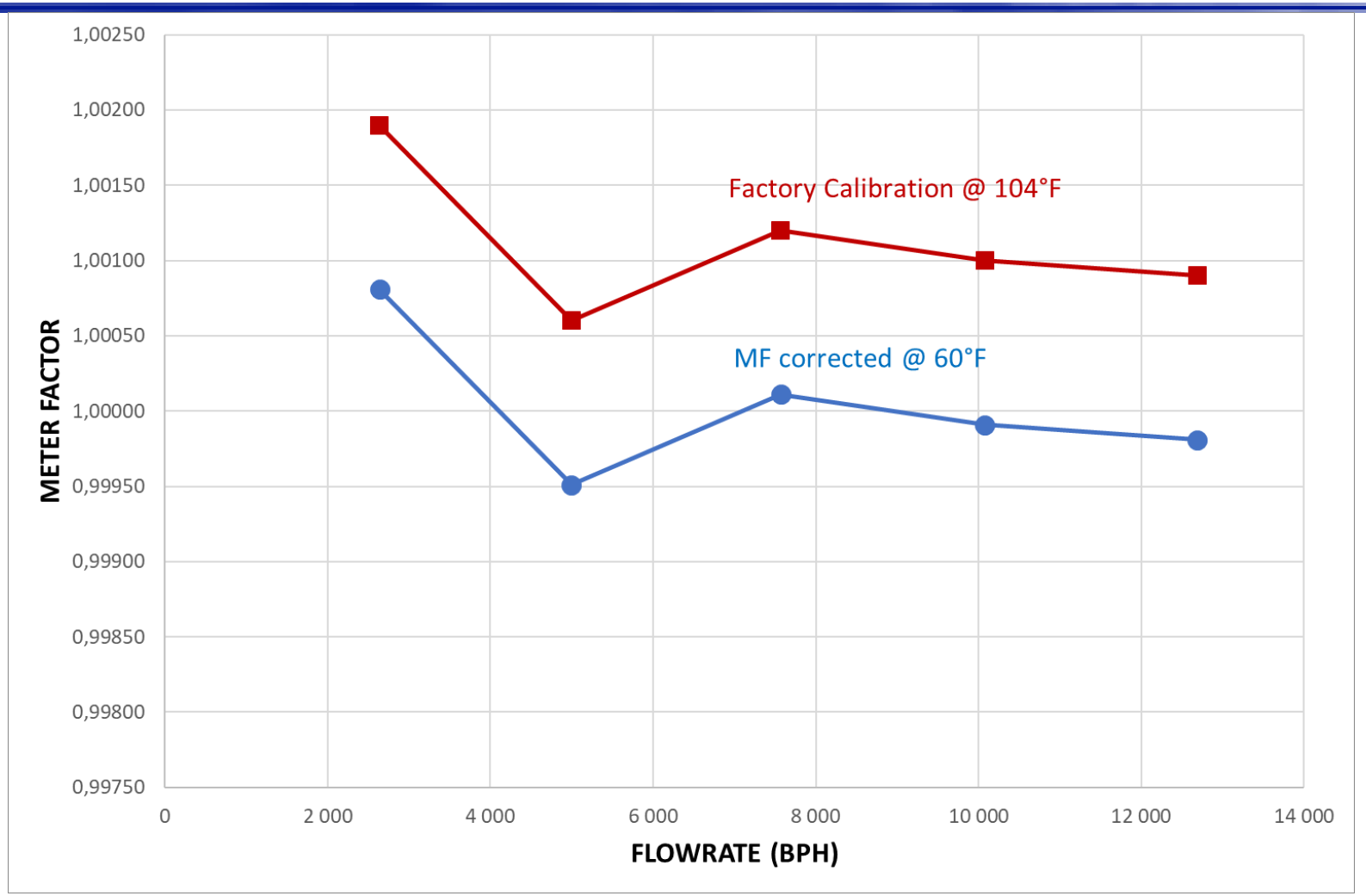
Difference between calibration and operation fluid temperature can be corrected by using CTSm coefficient, established by meter manufacturer to compensate the resulting impact of temperature difference on meter geometry changes.

- Measurement section, length and geometry (e.g. rotor pitch)
- Material stiffness …

For example, for a helical turbine meter, having a very low sensitivity to fluid viscosity variations, CTSm can be established by considering twice the linear expansion coefficient of the meter body (or cartridge) material and once the linear expansion coefficient of the rotor.

$$CTS_M = \left(1 + \alpha_{TZN}(T° - T_{ref})\right)$$

TEMPERATURE - PRESSURE

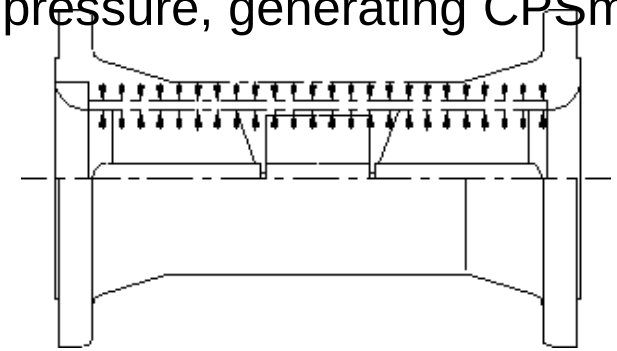


Pressure (fluid):

Difference between calibration and operation fluid pressure can be corrected by using CPSm coefficient, established by meter manufacturer to compensate the resulting impact of pressure difference on meter geometry changes.

- Measurement section, length and geometry
- Envelop stiffness …

When applicable, the double case design remain the most efficient correction factor for the effect of fluid pressure, generating CPSm = 1.00000



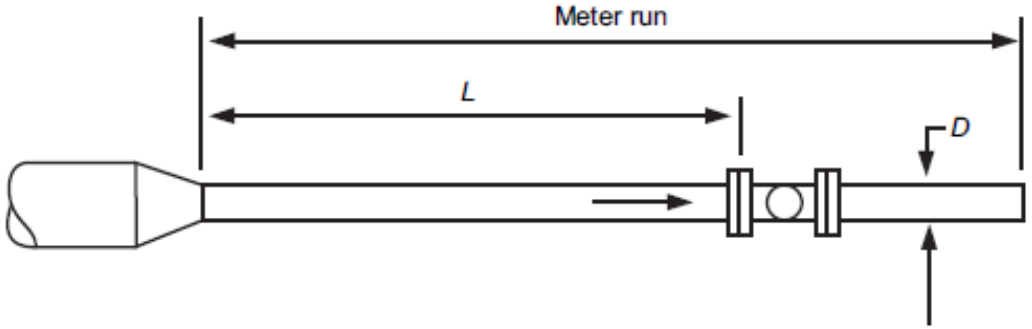
- Some meter types can be sensitive to upstream/downstream pipe geometry while other types can be sensitive to mounting stiffness, meter or pipe orientation …

- Upstream pipe configuration (*and to a lesser degree downstream pipe configuration*) can affect meter performances, therefor calibration *should be* done with representative geometry (including a flow conditioning element) and *must be* done with representative geometry without flow conditioning element.
- Typical lab configuration integrates oversized upstream/downstream pipe straight length not always in use on site …
- Additionally, recent studies shows that the position of conditioning plate can have a significant impact on linearity

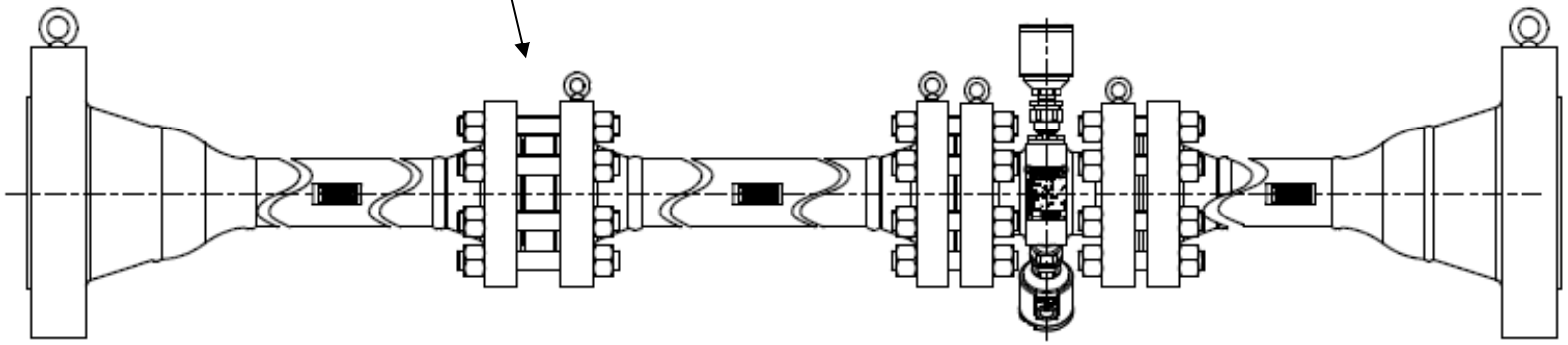
The complete meter run should be used for all remote calibrations to achieve optimal performance.

The lab …

The integrated package …



Flow conditioning Plate



⑩ Orientation of meter can have a significant impact on performances and performances stability and should be reproduced for remote calibration.

Operation

Verification

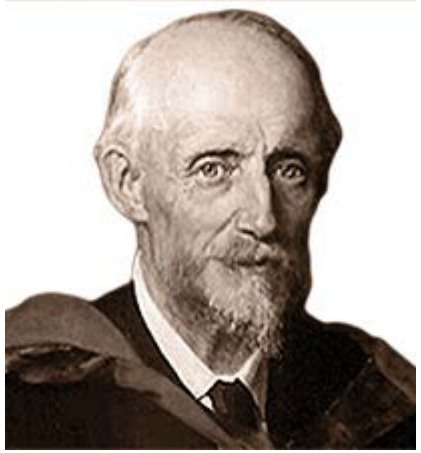
Fluid properties are the other parameters having a potential huge impact on meter performances.

Density, Viscosity, Lubricity, Speed of Sound, Vapor Pressure, Water-Wax-CO2 … content … etc … a lot of variables for different results depending on meter type.

Density impact Reynolds number (through kinematic viscosity calculation) and has a more significant impact when a mass meter is operated to measure … volumes.

Data has shown that all meters are impacted by viscosity / Reynolds number.
Flow profile, flow regime and more generally viscous friction modify meter performances and, when the verification is not done at site under real conditions, it is IMPERATIVE to explore the whole viscosity range to

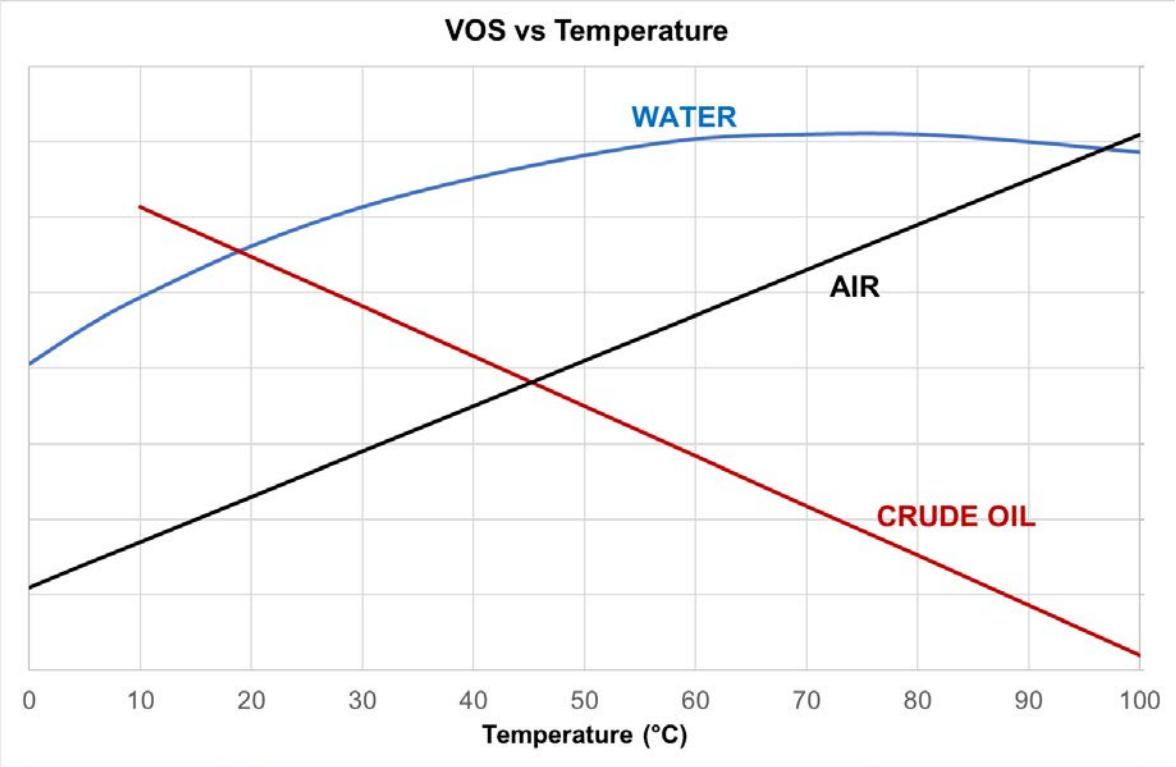
“be sure that the meter will fit the application”



Lord Osborne REYNOLDS

A lot of meters are factory calibrated on water prior to delivery, assuming that liquid characteristic differences between factory and site will have negligible effect on measurement performances …

Unfortunately, water is not an hydrocarbon, and ultimately is a strange liquid …



- In some cases, Reynold's based calibration are proposed to cover the full velocity/viscosity range.

- Law of similarity allows "adjusting" limits on one variable (flowrate or viscosity) considering that THE Reynold's range is the one!

- For example:

  - Flowrange = 3,000 to 12,000 BPH
  - Line size = 10"
  - Viscosity range = 0,5 to 70 cSt

  - Velocity range = 8,5 to 34,1 ft/s
  - Reynold's range = 9,500 to 5,300,000

- **Option #1**:

  Calibration on products having viscosity as close as possible to limits, considering that using the law of similarity it'll be possible to compensate viscosity difference by velocity.

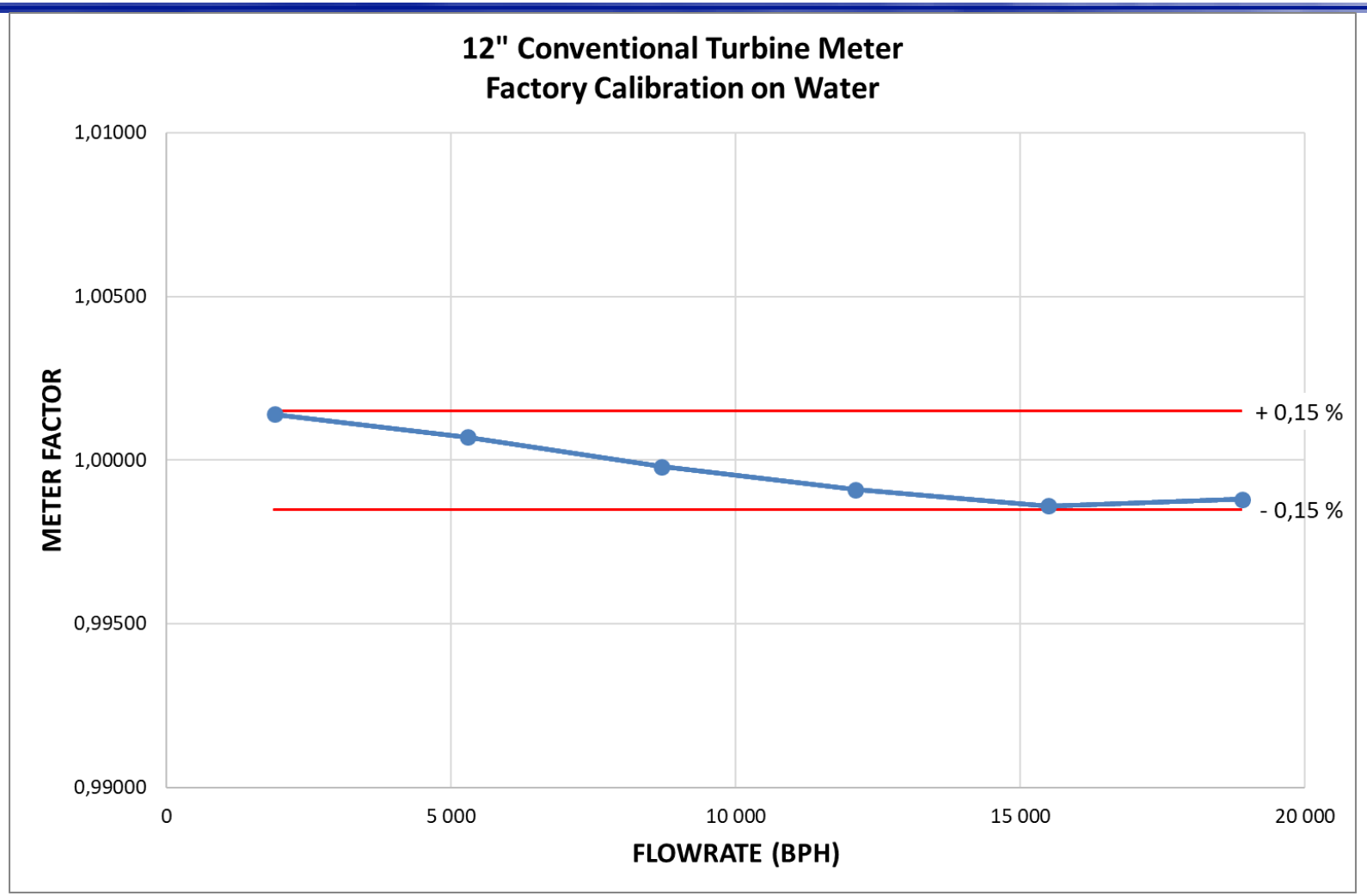
$$Re = \frac{V \times Ø}{\nu} \Rightarrow V = \frac{Re \times \nu}{Ø}$$

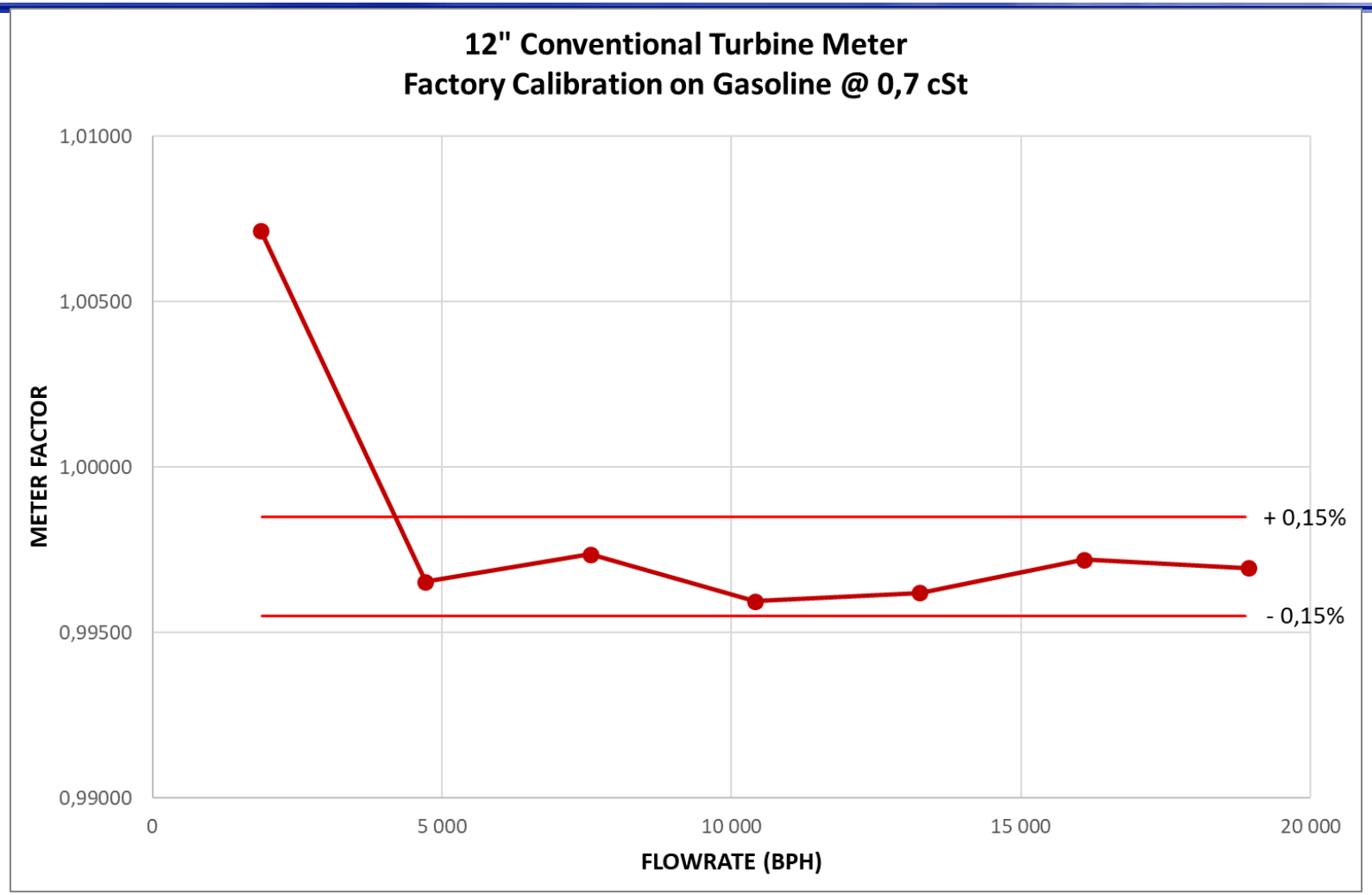
- **Option #2:**

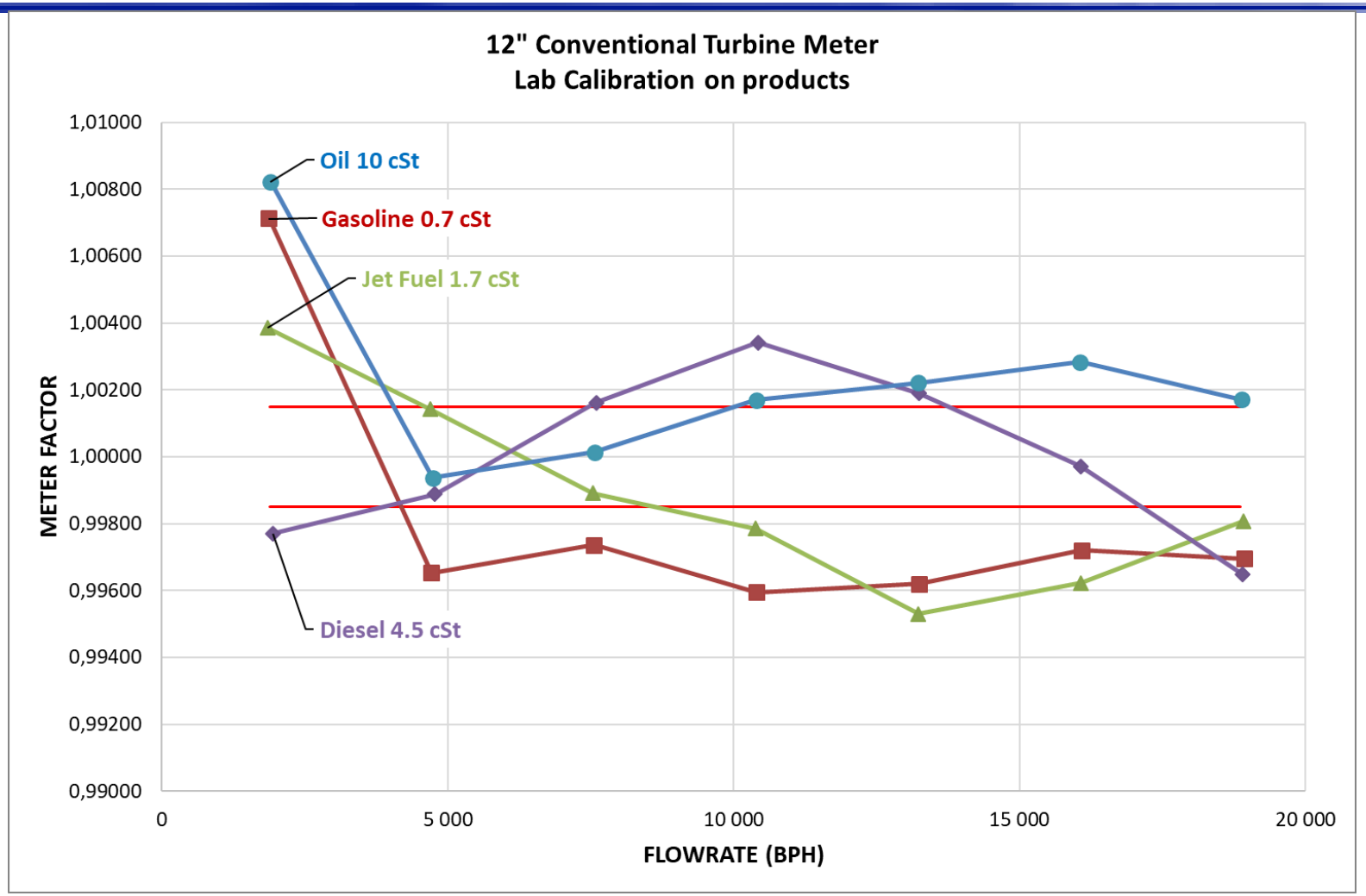
  Calibration on water

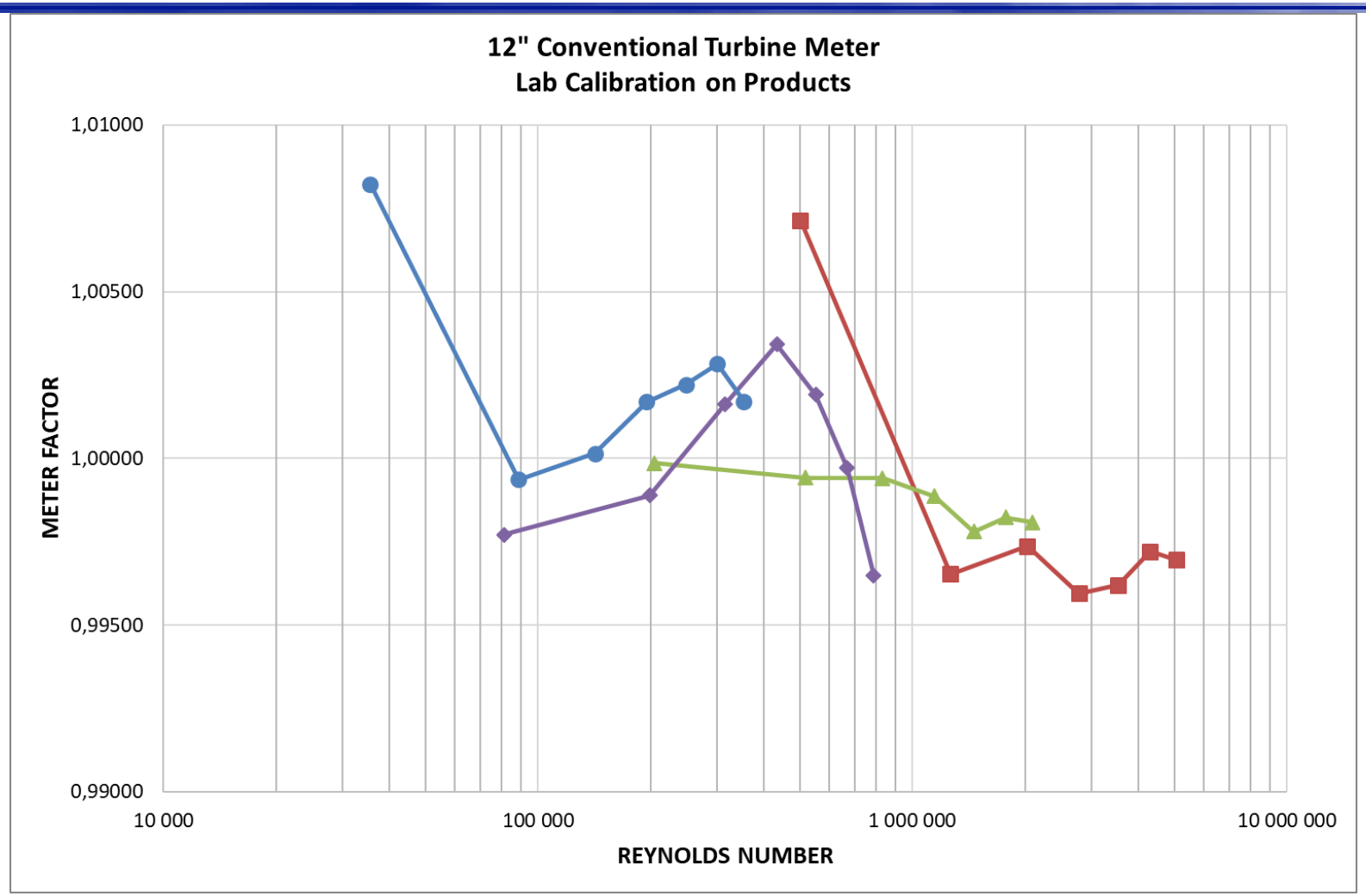
  To respect min Reynolds n^r (9,500), flowing velocity would be **0,1 ft/s**

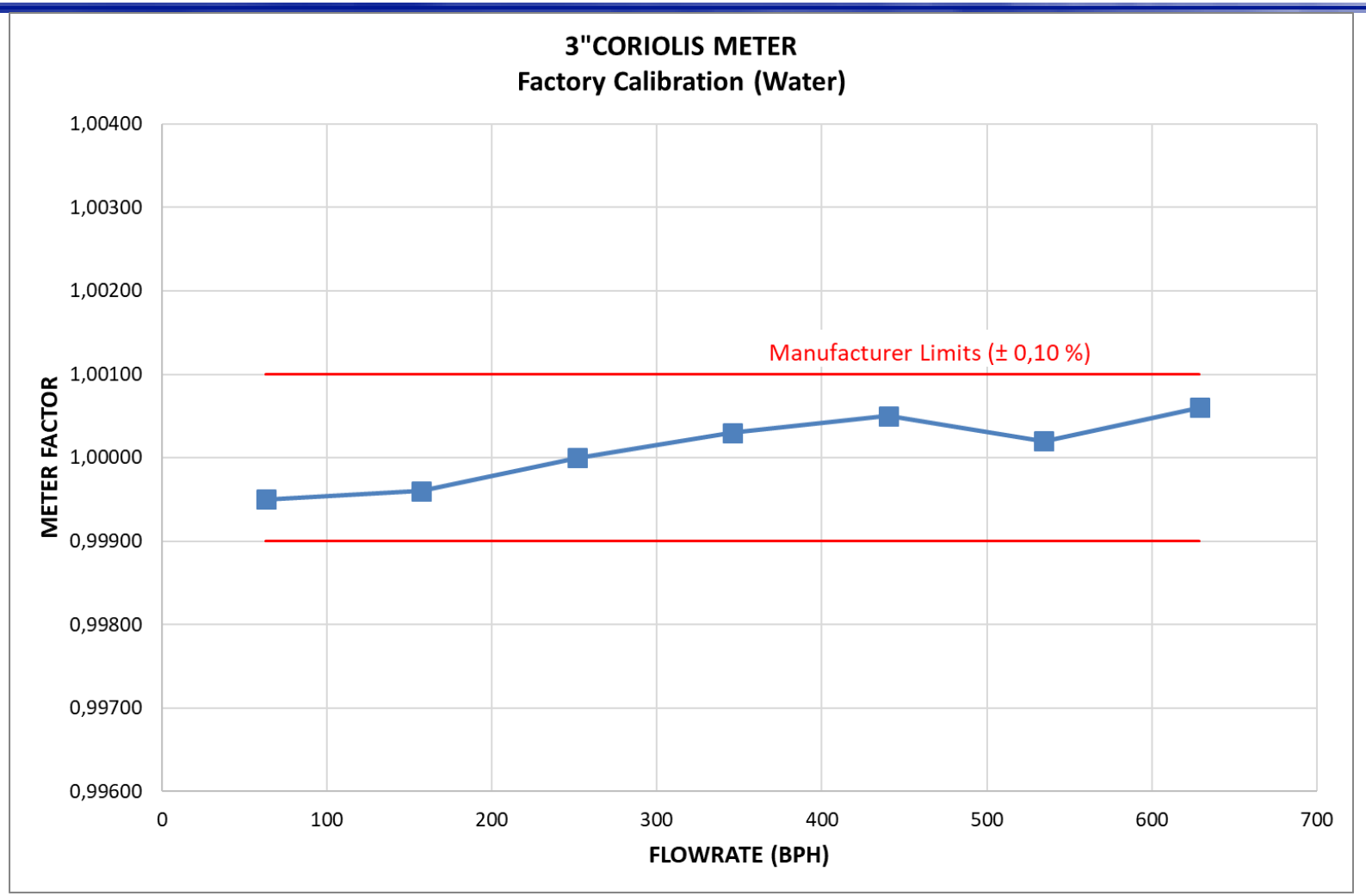
  To respect Max Reynolds n^r (5,300,000), flowing velocity would be **68,2 ft/s**

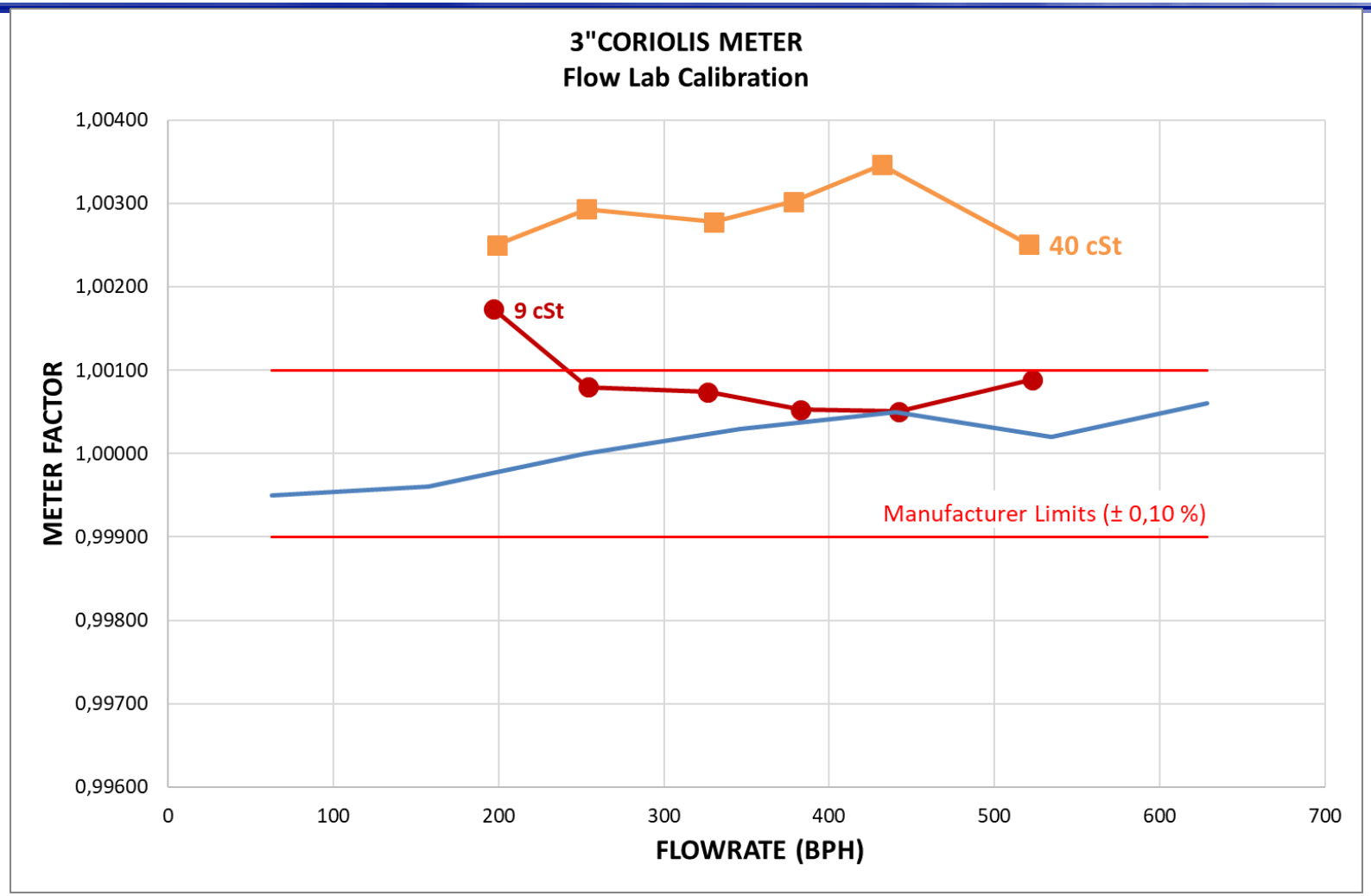

12" Conventional Turbine Meter
Factory Calibration on Water
1,01000
1,00500
1,00000
0,99500
0,99000
METER FACTOR
+ 0,15 %
- 0,15 %
0
5 000
10 000
15 000
20 000
FLOWRATE (BPH)

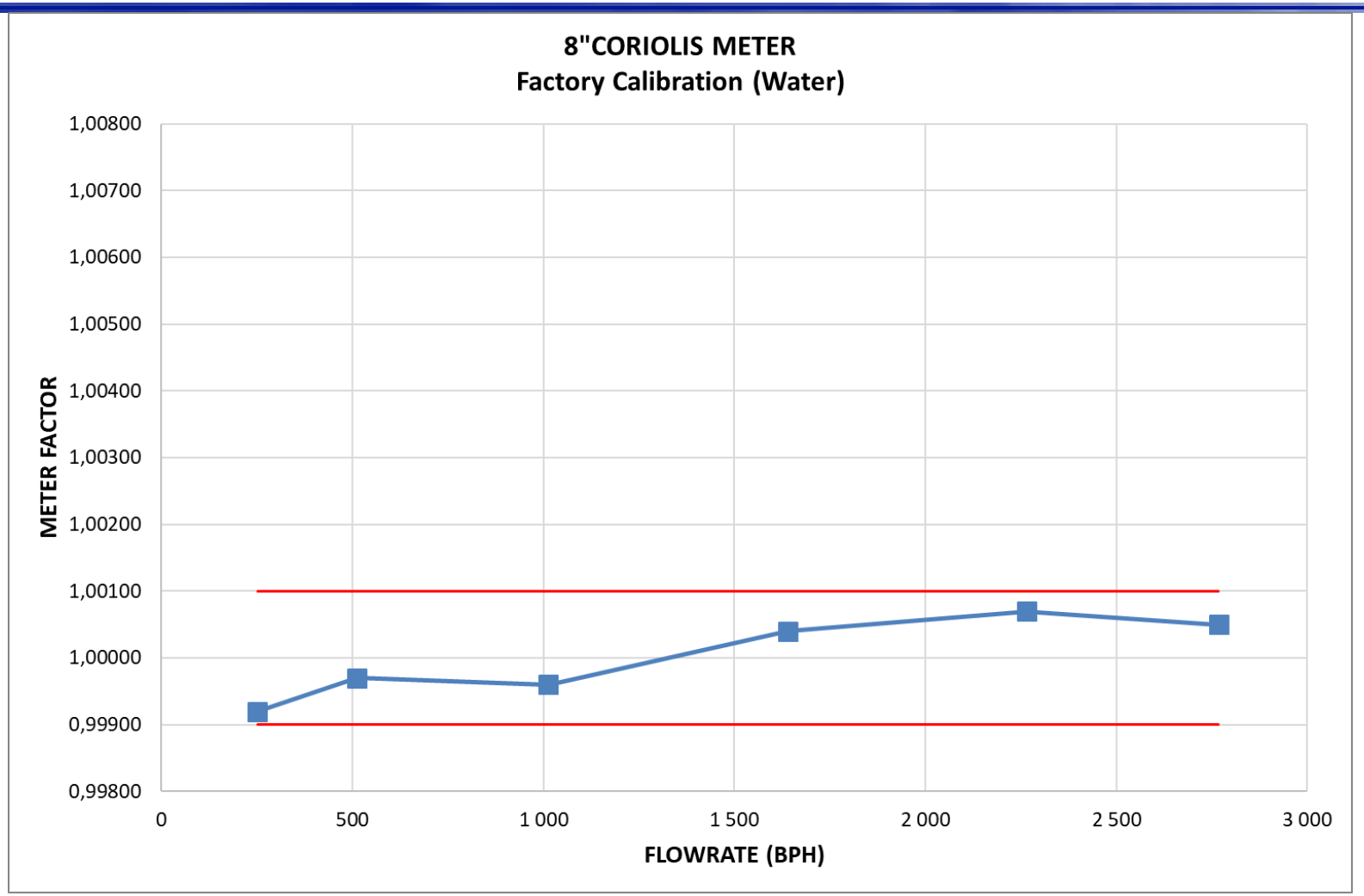

12" Conventional Turbine Meter
Factory Calibration on Gasoline @ 0,7 cSt
1,01000
1,00500
1,00000
0,99500
0,99000
METER FACTOR
+ 0,15%
- 0,15%
0
5 000
10 000
15 000
20 000
FLOWRATE (BPH)

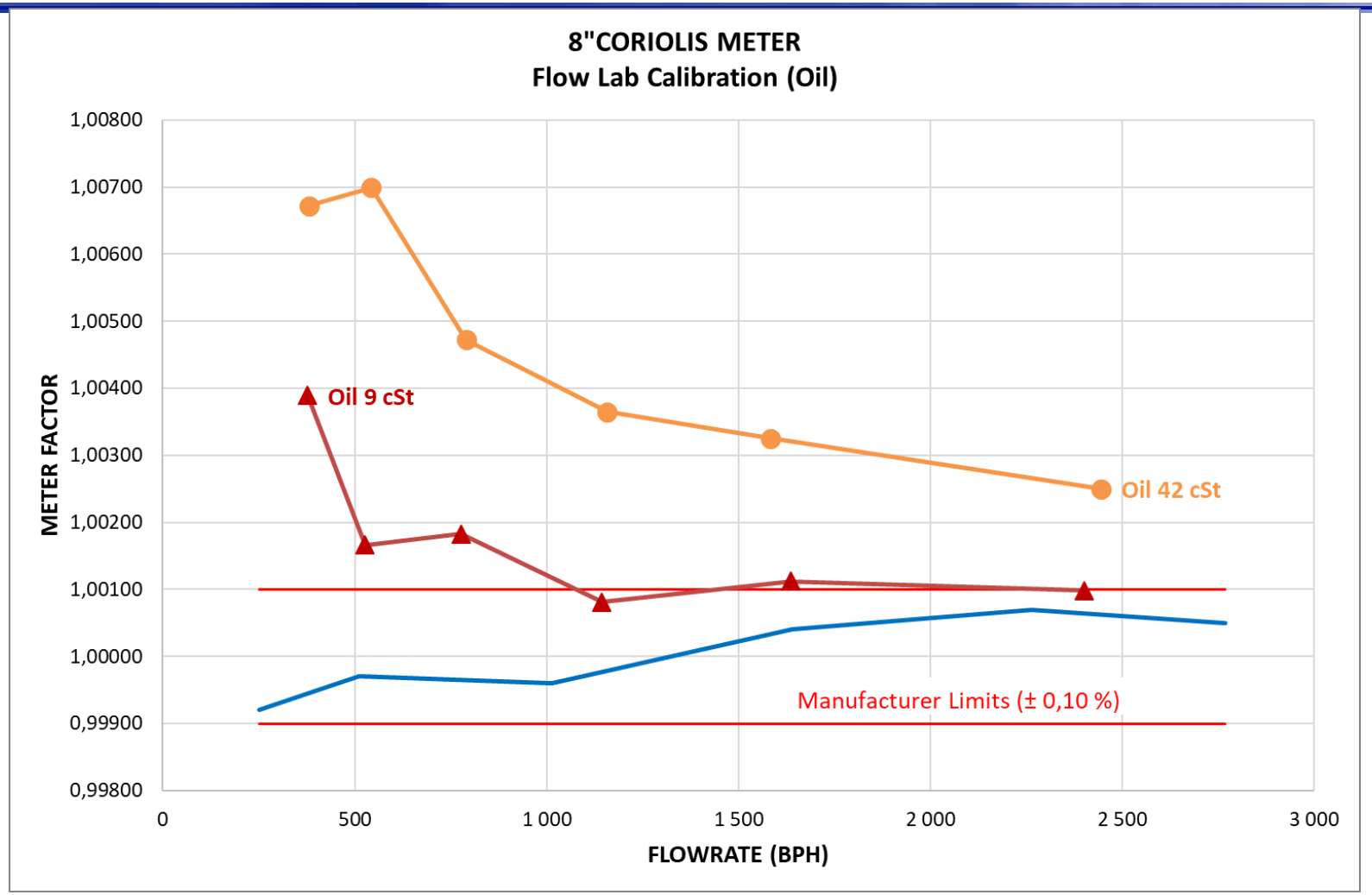

12" Conventional Turbine Meter
Lab Calibration on products
1,01000
1,00800
1,00600
1,00400
1,00200
1,00000
0,99800
0,99600
0,99400
0,99200
0,99000
METER FACTOR
Oil 10 cSt
Gasoline 0.7 cSt
Jet Fuel 1.7 cSt
Diesel 4.5 cSt
0
5 000
10 000
15 000
20 000
FLOWRATE (BPH)


12" Conventional Turbine Meter
Lab Calibration on Products
1,01000
1,00500
1,00000
0,99500
0,99000
METER FACTOR
10 000
100 000
1 000 000
10 000 000
REYNOLDS NUMBER


3"CORIOLIS METER
Factory Calibration (Water)
METER FACTOR
1,00400
1,00300
1,00200
1,00100
1,00000
0,99900
0,99800
0,99700
0,99600
Manufacturer Limits (± 0,10 %)
0
100
200
300
400
500
600
700
FLOWRATE (BPH)


3"CORIOLIS METER
Flow Lab Calibration
METER FACTOR
1,00400
1,00300
1,00200
1,00100
1,00000
0,99900
0,99800
0,99700
0,99600
0
100
200
300
400
500
600
700
FLOWRATE (BPH)
40 cSt
9 cSt
Manufacturer Limits (± 0,10 %)


8"CORIOLIS METER
Factory Calibration (Water)
METER FACTOR
1,00800
1,00700
1,00600
1,00500
1,00400
1,00300
1,00200
1,00100
1,00000
0,99900
0,99800
0
500
1 000
1 500
2 000
2 500
3 000
FLOWRATE (BPH)


8"CORIOLIS METER
Flow Lab Calibration (Oil)
METER FACTOR
1,00800
1,00700
1,00600
1,00500
1,00400
1,00300
1,00200
1,00100
1,00000
0,99900
0,99800
0
500
1 000
1 500
2 000
2 500
3 000
FLOWRATE (BPH)
Oil 9 cSt
Oil 42 cSt
Manufacturer Limits (± 0,10 %)

Water is highly recommended for … irrigation and ice cubes

Not for hydrocarbon meter calibration.

ANY QUESTIONS ?

THANK YOU