KEY COMPARISONS AND THE ULTIMATE TRANSFER STANDARD

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Abstract

The Working Group for Fluid Flow (WGFF) (a part of CIPM) has established the key comparisons for measurement of flow and volume covering volume, water, oil and gas flow measurement. This paper discusses the methodology of key comparison performed within flow and volume measurement and present the ultimate transfer standard package consisting of two different measuring principles. This opens the possibility to obtain Youden plots to distinguish between uncertainty contribution from the transfer standards and the facility. By putting the main part of the work in choosing and characterizing the transfer standards and minimizing the paper work, future Key Comparisons will benefit.

Key Comparisons on Volume and Flow

Background

During the last decades we have spent a lot of time, effort and money on trying to prove that we can measure liquid flow rate/dynamic volume correctly. As a national laboratory, the ultimate goal is to verify the uncertainty claims in the CMC-tables (Calibration and Measurement Capability) published by BIPM. On this level the inter comparisons are named "Key Comparisons". Sometimes we have succeeded but too often we "failed". By failure, I don't mean that we had problems with result itself. The main problem was the objects we used as transfer standards.

The main goal

When planning an inter comparison the main goal has to be clear. It ranges from comparing static volume of liquid, comparing calibrating equipment for meters (volume standards, weighing, ball prover, piston prover, master meter, LDV….), comparing calibration methods (standing/flying start stop, different installation and test rigs….), to comparing test methods used in pattern testing/verification (not included in Key Comparisons). In the ideal world, you perform inter comparisons in all steps. For each step the uncertainty gets larger.

Inter comparison in steps

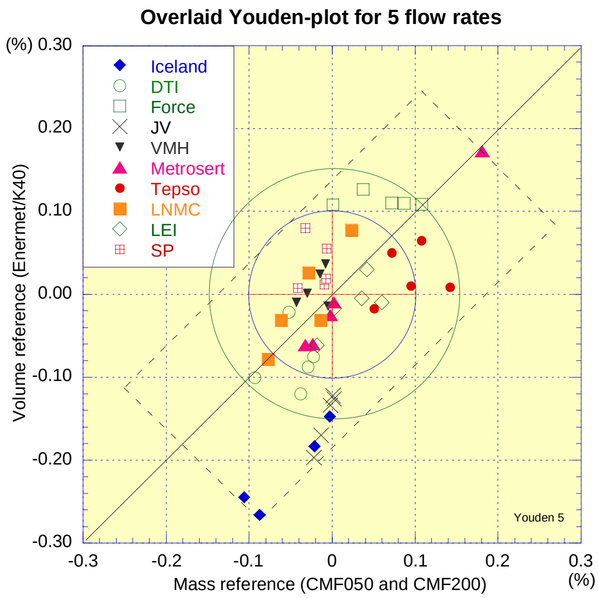
The first step, comparing static volume measurement has been successful, using carefully constructed containers with excellent resolution. When comparing calibration equipment and methods for meters, it is a far greater challenge to find good enough transfer standards.

The second step on the ladder is to compare dynamic volumes in the most accurate way, to make sure a volume "on the run" is determined correctly. To do this the most important feature of the transfer standard is repeatability and reproducibility. The meter should be insensitive to liquid properties and installation effects. By using long test time/large test volume the repeatability is improved. Screw meters works fine, but not on water. Coriolis meters works, also ultrasonic and mag meters (not on petroleum) with inlet pipes creating a fixed flow profile. Turbines are excluded, at least in water.

When the dynamic volume itself is secured, the third step is the dynamic volume under less stable conditions. These conditions include varying flow rate, diverters, buffer volume and small test volumes such as piston provers. A transfer standard for this has to be as repeatable as possible, but more important, it has to be fast. This excludes ultrasonic and mag meters. Turbines, screw meters and some Coriolis meters works.

Reality, a compromise

Usually inter comparisons cover both the second and the third step, a compromise. For a successful inter comparison, you have to select a transfer standard with the right properties for this purpose. If the inter comparison starts as a compromise, it is hard to achieve a really great result. To strengthen the setup, at least two meters with different behavior are combined in the package. Displaying the result in a Youden plot, opens the possibility to distinguish between uncertainty contribution from the transfer standards and the facility.



Youden plot for inter comparison on water at 50 ºC [1]

Setting up the inter comparison

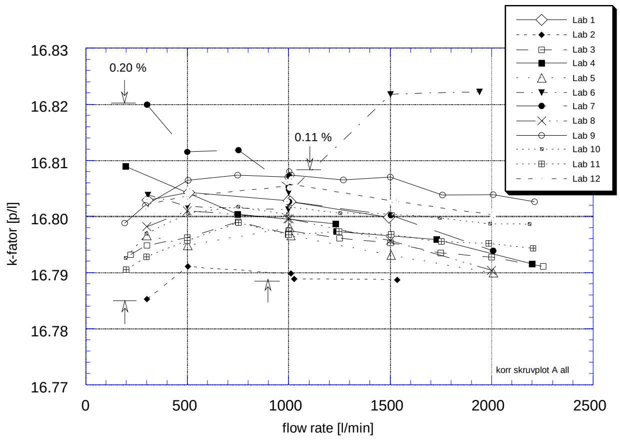
Test plan

The test plan should specify flow rates (maximum 5), temperature (within 0,5 ºC), liquid, viscosity (specify a limited range), number of repetitions (5 or 10), and restrictions in test method. The reference values must cover the test point ranges. If influence from installation is part of the test plan, installation set up is specified. The result is reported in a standard protocol, including uncertainty, no raw data! The evaluation includes Youden plot for each flow rate and calculation of En-value/degree of equivalence. That's it!!!!! The main part of arranging a successful inter comparison is in choosing transfer standards and establishing good reference values, not in paper work! Now to selecting transfer standards……

Selecting transfer standards

Precautions for volumetric meters

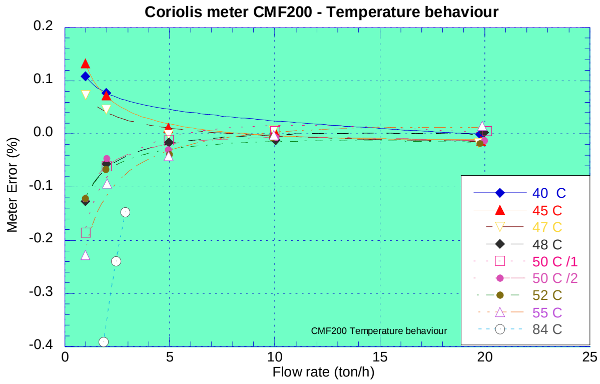
For petroleum products the main parameter for volumetric meters is viscosity. Since laboratories have different liquids, all result has to be transformed into a common viscosity. The meter body volume is temperature dependent in a relatively predictable way, which can be corrected for. The screw meter is fast and very repeatable, the first choice for petroleum!



A screw meter as transfer standard for petroleum, result adjusted to common temperature and viscosity

The week spot of Coriolis meters

Coriolis meters are the meter type with most potential. It can be used as a transfer standard both in water and petroleum, and by setting the time constant to zero, it is fast. The week spot is the zero point that is sensitive to both installation and temperature. The installation can be taken care for by installing the meter in a fixed rig, which is transported without dismantling. The zero point is left untouched throughout the inter comparison. By not using the meter at low flow rate the temperature problem can be reduced. Very high viscosity and large temperature difference between liquid and environment create problems. The meters are large and heavy in larger sizes, and bulky. The first choice for water and the second choice for petroleum!



A Coriolis meter as transfer standard for water at 50 ºC, zero point sensitive to temperature [1]

The benefit of mag meters

The mag meter is relatively insensitive to temperature, come in all sizes and has a very large flow range. It is sensitive to flow profiles but small and not heavy. Getting dry inside may create problems. The time constant is a problem not improving with new models. This is usually the second choice for water.

Precautions for ultrasonic meters

Ultrasonic meters have one big disadvantage; the time constant. Otherwise they can run is both water and petroleum. Depending on the number of "beams" it can be sensitive to flow profiles. For bigger pipe sizes this is a candidate for petroleum and maybe for water.

Why using turbines at all?

Turbines are sensitive to "everything". Still they are used as transfer standards. The major benefits are repeatability and quick respons. They are sensitive to temperature and viscosity, but using Reynolds number, results can be transformed to a common ground. They are sensitive to installation effects.

Conclusion

Without a good transfer standard, do not start an inter comparison. Use the experience from "every day life" in the laboratory to pinpoint a meter model to be used as a transfer standard. Ask the manufacturer for several individuals, and pick the best. Convince the manufacturer that a successful inter comparison is the best advertising.

References

[1] P. Lau, K Stolt, Intercomparison on water-/heatmeters at 50 ºC and 1-20 m^3/h EUROMET Project No. 863, Borås 2007.