

Dynamic Traceability of a Sonic Nozzle Prover System¹ (SNPS) to other Cal Benches at same company, to an outlander one, and to the National Standard

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Abstract: In calibration technique validation, reliability and the traceability of all are very important issues during operation. According to the currently applied rules the traceability or Key Comparison (KC) usually takes place every three-six months. But it's also obvious, that in the case of relocation KC needs to be performed immediately. For such KC the so-called Youden-Analysis was used, which made the collection of very acceptable results at this ambience possible.

Keywords: CalBench, Key Comparison, Youden-Analysis, twin meter package

1. Introduction

Observing calibration from a philosophical standpoint it becomes obvious that the essence of the process is reliability. In certain cases it starts falling in the philosophical category of "faith". In order to avoid such an event to occur, the application of processes may help us, serving reliability by making it measurable [2]. The use of Dynamic Traceability as Key Comparison based on Youden-Analysis in flow-meter calibration played and plays such a distinctive and definitely "positive" role in profaning technical faith, by assuring the reliability of flow-meters.

At a bigger calibration site of a household gas supplying company in Hungary the complete relocation of the site was decided. Two types of Gas Meter Calibration Systems, with other word: CalBenches were applied at this site. One was based on sonic nozzle, others on Bell Prover. All five had to be relocated due to various economical reasons.

One of them had a strictly tested control process from the time period of its operation. Its operation has started in early 1997. Because of the relocation a method was needed where the accuracy of the relocation was testable.

Our alternative (selection) for the necessary test or key comparison was the well known Dynamic Traceability or with other word Key Comparison (KC) process, based on the Youden-Analysis, which operated with reasonable results in our practice. Thus the Key Comparison (KC) tests, where we applied a tandem flow meter transfer standard or twin meter package with Youden-Analysis of variance techniques to guide the resulting data analysis became the main element of the relocation process from the point of view of quality control[4].

The above-mentioned Cal Benches, including Sonic Nozzle Prover System (SNPS) were relocated in early 2009. Five various Cal Benches were part of this KC, one of them being the National Standard.

The KC was performed at the relocated five systems, and, later extended to other five systems. Therefore the KC became an inter-company comparison including a German Company and the National Standard, too.

At the Key Comparison a Youden-Analysis was used which was further developed by NIST².

¹ System description on at Flow Measurement and Instrumentation 11(2000) pp.273-278.

² It is available from NIST, and it also was adjusted a bit according to the request of the local considerations

Also these procedures have generated data sets, which are statistically sufficient, so that high confidence can be placed in the results from the data analyses.

During the previous operation the relocated Cal Benches were also under repeated Key Comparison, [1], [4], [8] mainly the Sonic Nozzle Prover System (SNPS).

At this SNPS the etalon sonic nozzles with various throat ID were and are calibrated by Hungarian Measurement Office (MKOH) and the KCs pointed out that the tested SNPS works well (e.g. its accuracy and repeatability are in due measure similar to the earlier KCs results). Since one of these Cal Benches can operate from -20°C to $+50^{\circ}\text{C}$, the above-mentioned test was extended to a wider temperature range to the operation temperature from -20°C up to $+50^{\circ}\text{C}$, too, before and after the relocation.

The period between the two steps of the relocation was a couple of months, thus KCs (control tests) were close enough to each other.

At the same time - in the second period of the relocation - the Key Comparison tests were extended to more Cal Benches – like Hungarian National Standard (MKEH), an older one at the new place and another one which operates at a German Company). Thus it became an inter-company comparison process.

With this extension we achieved at least three results:

- Traceability to the National Standard
- Traceability to our very important partner, and, last but not last
- Proving the adequacy of the relocation.

Naturally, we have also achieved our main aim, namely the confirmation of the adequacy of the relocation.

2. Theory and Practice

For this task a well-conditioned diaphragm type by mechanically temperature compensated meters was available.

The relocation itself was a quite long process starting in early September 2008 and continuing until late April 2009.

On each testing day the serial connection between the parts of twin meter package was changed (turn/return) and the test was carried out on the dependency of the used measuring range, itemize:

- Flow-rate 0,040 [Nm^3/h]
- 1.16 [Nm^3/h] and
- 6.06 [Nm^3/h]

with at least eleven measurements at every single step, with good repeatability, sensitivity and secure data collection.

At a quite complicated calibration system like SNPS, over the KCs, besides the periodic control tests a special test is also needed because of the relocation regarding both the system operation and the etalon's features.

At the temperature compensation it would really help to maintain the features of the system if the pressure and the temperature at the nozzles were kept as close as possible to the nominal values ($p=1013\text{ mbar}$, $T=293^{\circ}\text{K}$).

3. Results/Conclusion

3.1. Dependence on the System's Point of View

During the relocation it became obvious that in a carefully organized relocation process no meaningful differences were found between the systems based on Sonic Nozzle or the ones

based on Bell Provers (BP). Even the sonic nozzle one was less sensitive to the relocation than the Bell Prover one.

Table. 1 Calculated System and Random Uncertainty at Various CalBenches

	Bell P 2000	Bell P 500	Bell P 60	SNPS	SNPS
Twin meter package.	G4 ³ - G4	G4 - G4	G4 - G4	G4 - G4	G4 – E6 ⁴
SYS[%]	0.21	0.235	0.724* ⁵	0.35	0.184
RAND[%]	0.596	0.06	0.25	0.2	0.116

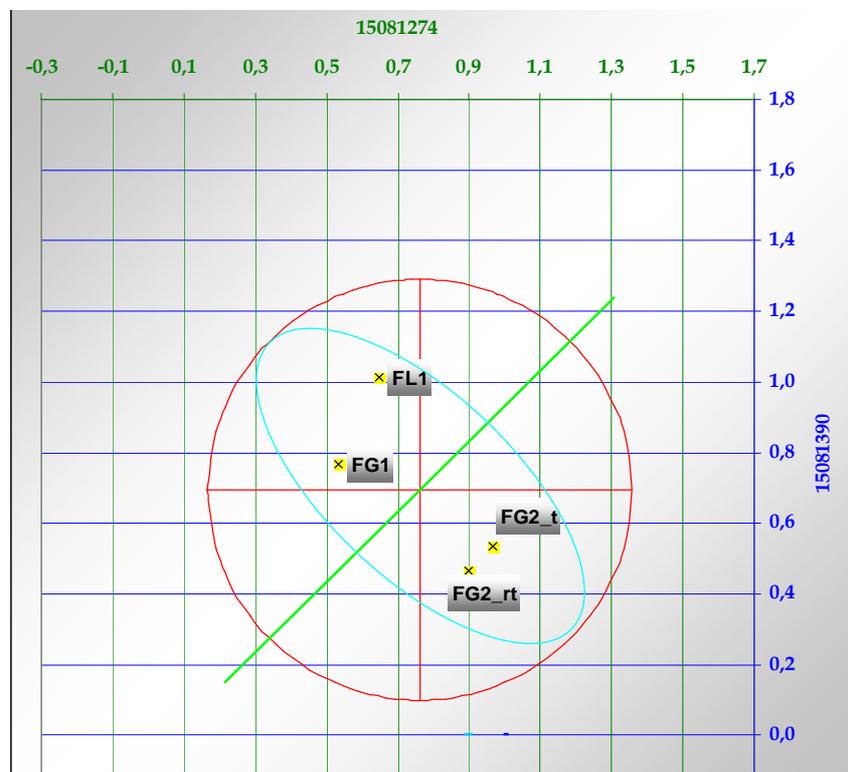
If normal design, mechanical type of gas-meters were participants of the twin meter packages, the values of the various errors are also a bit rough. From the Youden-Plots point of view it is obvious, that the area of the resulted – usually ellipsoids – graphs has a correlation to the used meters used as well as the tested lab’s technical features.

Otherwise all of the calculated parameters have to be running at about 0.1%, even at the Round–Robin tests of gas meter calibration systems. Even such types of meters used to be calibrated at the various CalBenches. Thus we can say that such types of devices are only good to the basic and rough traceability. For better results carefully selected and mainly Ultrasonic meters (E6) are requested (see: last column of Table 1.).

The test we made with this carefully selected and partly ultrasonic twin meters has shown better, almost acceptable results at the same CalBench.

The KC test (traceability) basically always included:

- A test on the old place and
- Another (second) test at the new place, after the relocation.



³ Diaphragm type household gas-meter

⁴ Ultrasonic type household gas-meter

⁵ This system has failed and doesn't fulfill the basic criteria

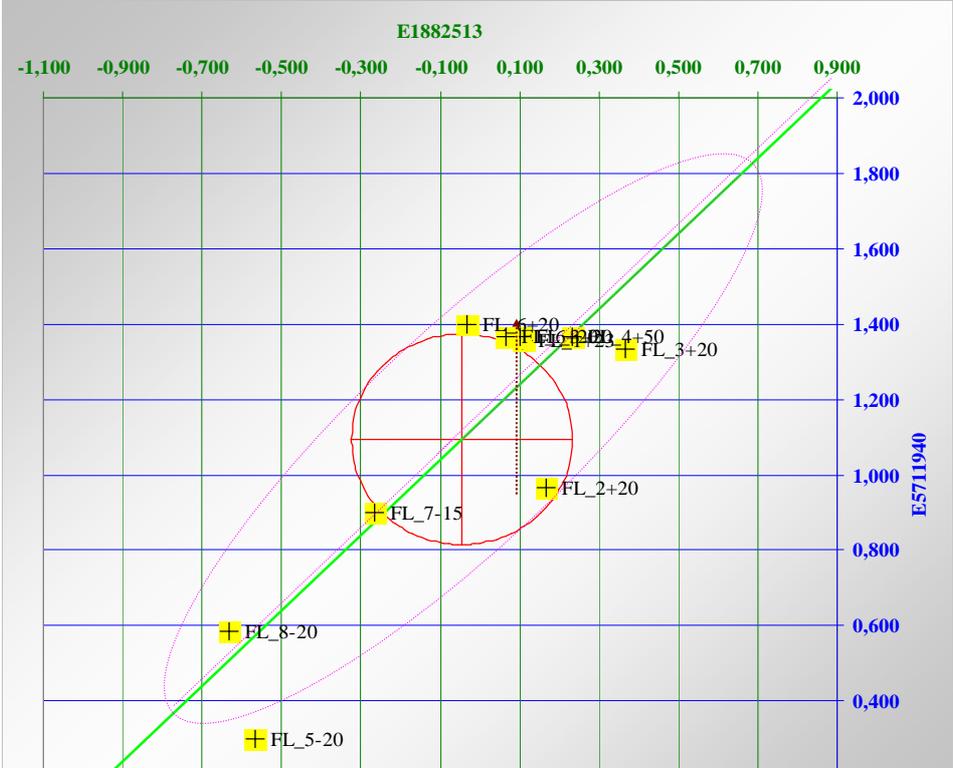
Furthermore, because of the climatic features⁶ of SNPS the KC's test was also carried out at wider temperature range: e.g. between -20°C...50°C. The SNPS to which the traceability was focused, have a part what are able to calibrate between -20°C ... +50°C.

It is also obvious that after the relocation a KC test has to be done to show how the calibration in the climatic chamber in the wider temperature ranges (-20°C ...+50°C).



Fig.3 Climatic Chamber of SNPS CalBench

The KC test has shown a quite acceptable system, even if a small temperature dependency was observed, which probably may originate from the tandem meters.



Legend: FG= old place; FL= new place; one digit number =serial number in chronology,

⁶ The SNPS has a “climatic chamber “ where various temperature could be set in the pipe as well as around the tested meters.

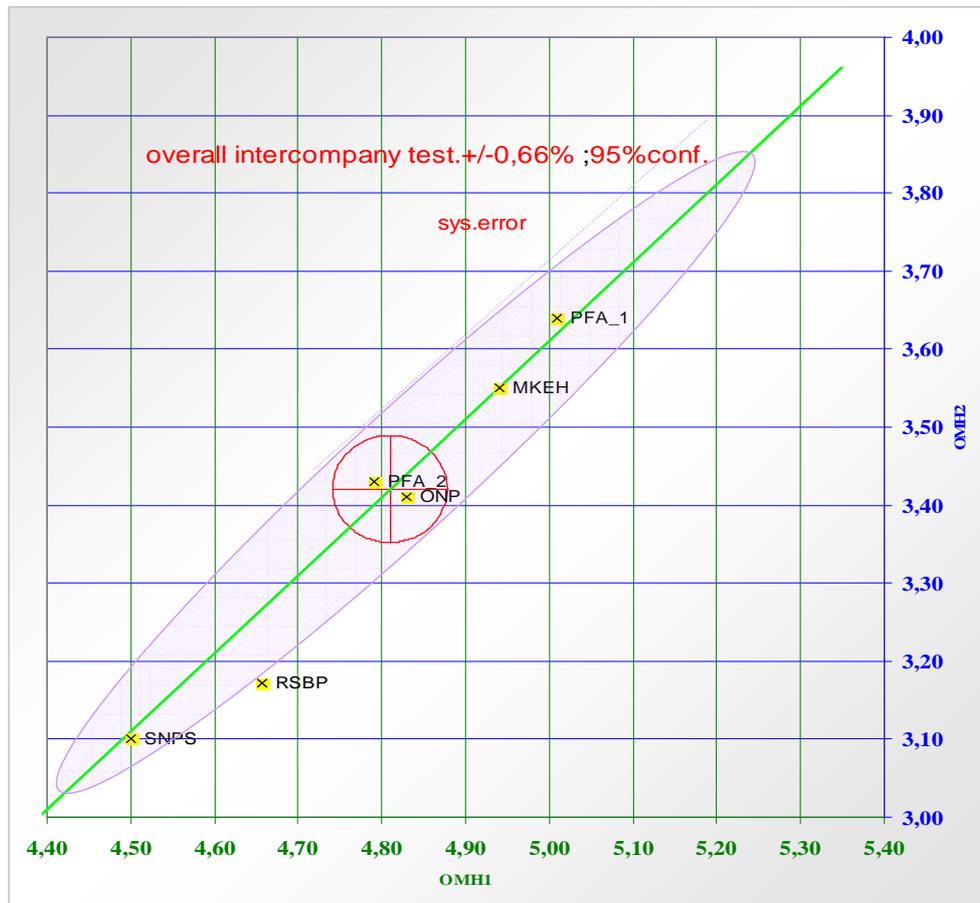
three digit number = value of temperature (Dimension %)

Youden std = 0,114
 master/random error = 0,279
 Circle Center = Mean
 whole system = 1,065 "95% confidence"
 whole system = 0,869 "90% confidence"

Fig. 4 Youden-Plot of SNPS in Wide Temperature Range

3.3. Intercompany Key Comparison

Inter-company comparison of five various Cal Benches



Legend: PFA=Partner From Abroad; MKEH=National Standard; RSBP=Relocated Small Bell Prover; ONP=Older at New Place; SNPS= Sonic Nozzle Prover System (All values are in percent)

Youden std = 0,028
 Circle Radius = 0,069 "95% confidence"
 Circle Center = Median
 overall system = 0,659 "95% confidence"
 overall system = 0,538 "90% confidence"

Fig. 5 Youden-Plot of SNPS in Wide Temperature Range

4. Conclusions

- The KC test with twin meter packages have similar results with various types of CalBenches
- With random selected meters the
 - Random errors running at about 0.2%
 - Systematic errors running at about 0.3...0.4 %
- The above results can be better by min. 0.1...0.15% with Ultrasonic masters.
- In the case of climatic chamber a Temperature dependency was observed at mechanically compensated masters. The Youden-Plot -which has got results from a strictly controlled test process at 50°C; 20°C; -10°C; -20°C shows a quite acceptable system, even if a small temperature dependency is also observed.
- The inter-company KC is very important because of traceability.
- No doubt, that using a twin meter package gives more reliable values vs. the single master system. Therefore, it is strongly suggested to use this method in the near future. Hopefully, the EUMET practice will also move to this direction.

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