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PERIODICAL CONTROL AND DYNAMIC TRACEABILITY TEST OF AN SNPS[1] TO THE NATIONAL STANDARD OF GAS FLOWMETERS CALIBRATION

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Abstract
The tested Sonic Nozzle Prove ring System (SNPS) stepped into service at the Gas Works of Budapest almost five years ago. To keep its parameters in a dedicated and good condition a continuous checking process is carried out. During this checking process those tested were the SNPS main accuracy and repeatability, as well as the individual sonic nozzles (SN).
Keywords: Sonic Nozzle Provering System (SNPS), sonic nozzles (SN). Dynamic traceability, interlaboratory comparison test

Preface
A repeated round-robin test based on the Youden analysis [1],[4] has started between the calibration benches of the gas meters. The benches are various types, like sonic nozzle [5] type and Bell Prover type. This test would be extended to a wider temperature range on the operation temperature from -20°C up to +50°C, too, later this year. The current results has shown the reliable operation of the sonic nozzles.
Parallel to this dynamic traceability test – when the master is a National Standard working at the Hungarian Measurement Office – a serious and detailed test process was going on regarding the technical features of the individual sonic nozzles (SN). At a few – mainly at lower sizes (throat ID ≤ 1,5 mm) - quite meaningful changes were found on the calibrated standard flow rate. At this accuracy and repeatability test a traceabled Bell Prover was used as a master in semi-automatic operation.
The repeated tests pointed out clearly, the above-mentioned changes regarding the calibrated values, which was given in SCMPH. (The original calibrated value has slipped about 1,5-2% from the starting value at some small ID nozzles.)
The results of this checking process were also confirmed by a traceability test to the National Standard at Hungarian Measurement Office.

Theory
A quite continuous[2] dynamic traceability [2],[3] test – when the etalon sonic nozzles with various throat ID are calibrated by Hungarian Measurement Office (HMO) - can point out how the tested Sonic Nozzles Provering System (SNPS) works (e.g. its accuracy and repeatability related to the earlier interlaboratory comparison test results). The SNPS has started to operate in 1998 and it was on interlaboratory comparison testing process (using Youden Plot) in 2000, as well as in 2002.
For the mentioned Youden analysis – of course – good and repeatable meters, - with a standard deviation better than +/- 0.1% - are requested on serial connection after each other.

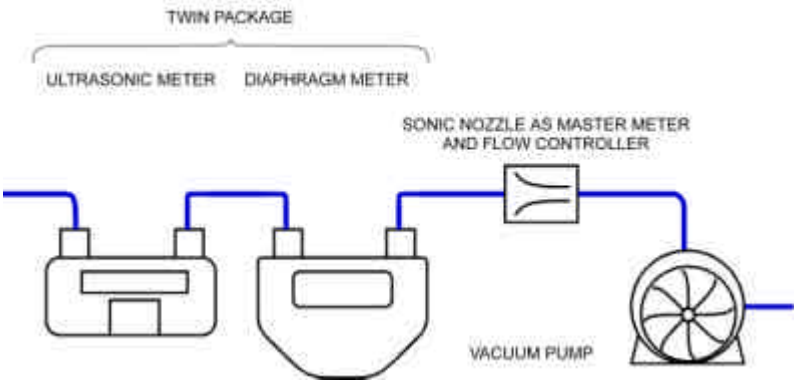

Fig.1 Arrangement of a twin meter package at SNPS

[1] Sonic Nozzle Prover System
[2] in quoted year periodicity

Practical considerations and results on interlaboratory test

For this tasks a well-conditioned[3] diaphragm or ultrasonic type of meters [6] were available. A few arrangements were tested with the following connections:

a) Ultrasonic 1 with ultrasonic 2
b) Diaphragm with ultrasonic 1

Fig.2. Serial connected household gasmeters on SNPS

c) Diaphragm with ultrasonic 2

It was a quite long process starting on November 11, 2002 and continuing to date, and probably would be finished late April 2003.
On every testing day the serial connection between the ultrasonics has changed (turn/return) and the test was carried out at

a) flowrate 1.16 [Nm^3/h] and
b) 6.06 [Nm^3/h]

with at least eleven measurements at every step.

[3] with good repeatability, sensitivity and secure data collection

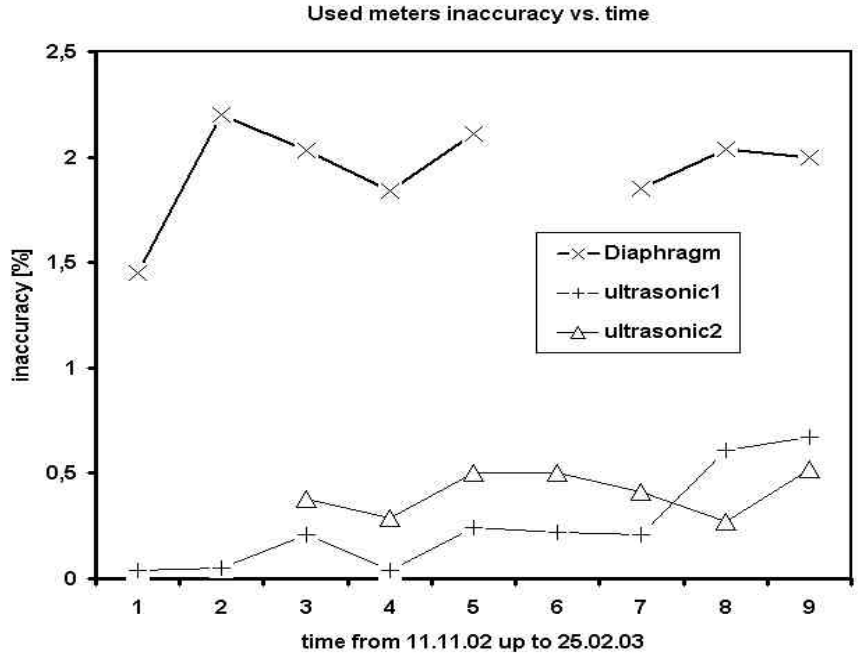

Fig.3. Inaccuracy of the members of twin meter package.

The ranking on the σ systematic point of view has shown that one of the ultrasonics serial with the diaphragm one was the best, based on summarized Youden plot of seven individual test process with the below test results:

position	variation	σ systematic %	σ random %
1st	Variation c.)	+/- 0.08%	+/- 0.14%
2nd	Variation a.)	+/- 0.17%	+/- 0.16%
3rd	Variation b.)	+/- 0.2%	+/- 0.14%

Tab.1. Ranking of various twin meter packages

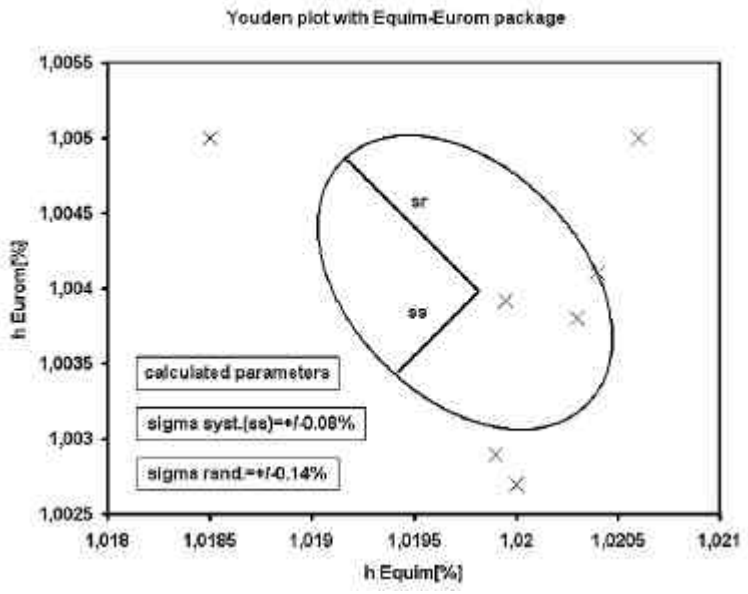

Fig. 3 The summarized Youden plot of variation c.)

During the test the applied twin meter package has shown reasonable technical features, which was confirmed at HMO[4]

	SNPS	Small Bell Prover	Nat. etalon
avg. σsys [%][5]	0.08	0.072	0.065
avg. σrand [%]	0.14	0.1	0.09

Tab.2 Summary of the technical features of the tested Lab

Sonic nozzles checking

As a part of the continuous controlling process, a few of the individual sonic nozzles were also tested. There are thirty-two (32) sonic nozzles on duty and eleven (11) out of the 32 were tested, three of the eleven several times - with a Bell Prover.

Fig.5 Bell Prover for the periodical test of the random selected Sonic nozzles at SNPS[6]

For the checking the service stage of the SNPS was used with automatic data collection using historical database. To control the automatic process parallel to this, a manual calculation was made to confirm the results of the system. The ones allowed / passed when the delta between the system's results and the hand-made one was less than +/-0.1%.
With this multichecked controlling process one SN out from the checked eleven has shown bigger delta than the requested. (The allowed delta was selected up to +/-0.5%)
It was a small one (Q nominal=0.1979 [Nm^3/h] what meant approx. 10% of the G4's middle flow rate (0.2 Q max) The test was repeated four times during a ten (10) months period and a the delta was always out of the limits.

[4] HMO: Hungarian Measurement Office
[5] Average values of min. 3, max. 7 rounds
[6] The control room has automatic air conditioning system set to +20°C.

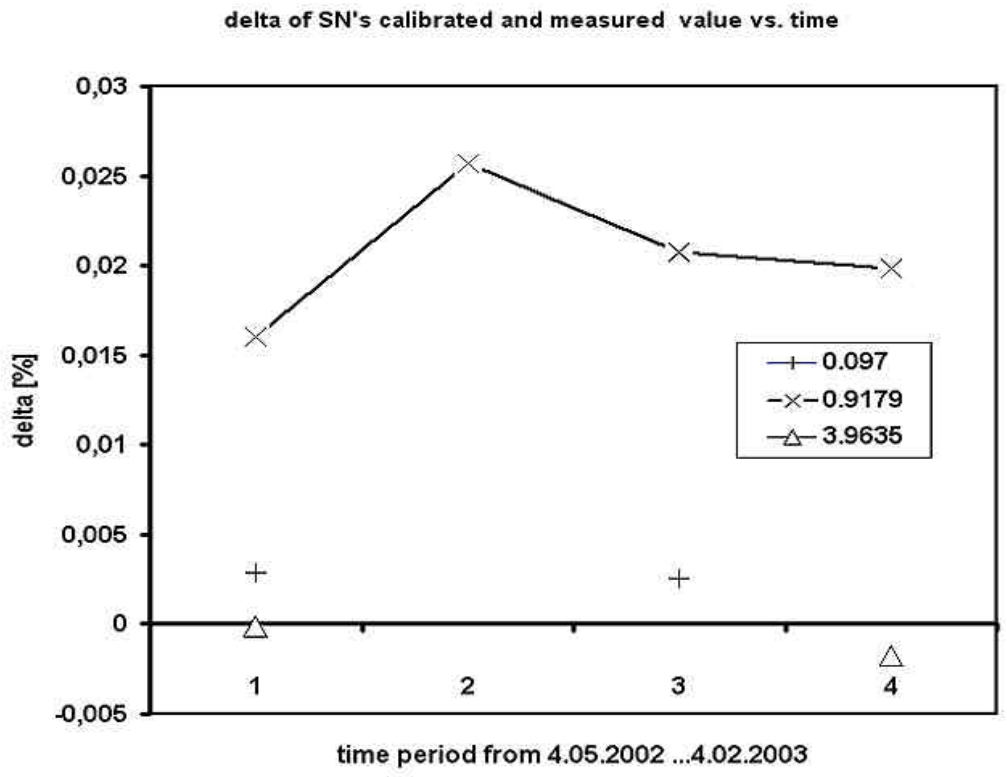

Fig.6 Delta of SN's calibrated and measured value during a period 4.05.02 …4.02.03

As seen in the above graph, a quite big delta was found, which does not show a strong correlation to the throat ID. There was a smaller SN with a tenth of Q (0.097 [Nm^3/h] and this smaller one was good. The above mentioned one (Q nominal = 0.1979 [Nm^3/h] has shown one more slow growth related to the time. Perhaps the wearing should be the reason for its bigger delta. In any case it has to be recalibrated to the National etalon. Until then it will be out of duty.

Conclusion

At a quite complicated calibration system like SNPS, a periodic control test is absolutely needed regarding both the syste m operation and the etalon's features.
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 mbar, T= 293°K).
The period between the control test should not to be more than a quarter of a year.
From Fig.6 it's more than possible that there is an – although slow, but continuous - wearing on the nozzles, mainly if they are not made out of ceramics. Because of that all the operated SNs test is needed every second year.
It is also obvious that in the near future a quite similar test would start in wider temperature range (like –20°C …+50°C).

References:

[1] W.J. Youden: Graphical Diagnoses of Interlaboratory Test Results Journal of Industrial Quality Control May 15, 1959, pp. 133-137

[2] G.E. Mattingly: Dynamic Traceability of Flow Measurements Symposium on Flow Measurement and Control Industry, Tokyo, Japan November 13-16, 1979

[3] A.S. Kun: Coriolis Mass Flow Meters at the Flow Meter's Calibration FLOMEKO 93's Preprints pp. 416-420, Seoul 1993

[4] M.Takamoto et al: Intercomparison tests of gas flow rate standard
FLOMEKO 93's Preprints pp. 533-540, Seoul 1993

[5] M.T.Pereira et al: Flow metering with modified sonic nozzle
FLOMEKO 93's Preprints pp. 142-147, Seoul 1993

[6] H.H.Dijstelbergen at all: A New Reference Meter for Gasmeter Calibration
FLOMEKO 93's Proceedings pp. 37-42, Lund 1998

[7] A.S. Kun et al: Dynamic Traceability for Gasmeter Calibration Stations using ultrasonic and diaphragmatic reference meters as a twin package
FLOMEKO 2000, CD-ROM G 11