Paper 18

Krohne Altosonic-V, with Master Meter Approach - Rough Road to Success with Oil Ultrasonic Fiscal Meter at Snorre B

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1. INTRODUCTION

This paper is a follow-up of my presentation at the NSFMW in year 2000. Although there are issues to be evaluated still at the Snorre B fiscal oil export station, we can note a number of pitfalls to avoid from some non-ideal installation approaches.

The experience was excellent with the first two Krohne Altosonic-V ultrasonic liquid meters installed offshore, Serial Number 1 and 2 at Snorre-Vigdis Crossover, where one of the ultrasonic meters was used for master transfer in the frequent calibrations. Then applying a turbine meter for master transfer from the Compact Prover in the annual third party calibration. This led to the next step of expecting that a turbine meter could also be used for the frequent verifications of the duty ultrasonic meter at the Snorre B fiscal oil export station.

I will recapitulate the scepticism for the Snorre B fiscal oil metering installation, some of which was presented at NSFMW in 2000.

2. NON-IDEAL INSTALLATION AT SNORRE B

See Figure 1.

A Static Mixer was installed 40 D upstream of the Krohne Altosonic-V, and its swirl generation was bound to have some effect on the ultrasonic meter.

A Filter Strainer was installed 20 D upstream of the Krohne Altosonic-V, and even with clean filters the Krohne Altosonic-V Swirl Indicator showed approx 0,3 in the onshore testing at Daniel. Swirl Indicator of 0,1 is recommended for fiscal metering, and Swirl Indicator 0,3 was expected to be limit case for achieving our goal of +/- 0,02 % repeatability in the master verification. It was not concluded whether the main source for the high reading of the Swirl Indicator was the Filter Strainer or the Static Mixer.

The only prepared way of calibrating the turbine meter curvature against the Compact Prover, would require production rate cutback.

The Krohne Altosonic-V was equipped with the field version flow computer solution in an Ex Zone. Restarting would require bringing Keyboard and Display to the industrial PC flow processor installed in the field electronic box.

3. EXCELLENT SNORRE-VIGDIS CROSSOVER PERFORMANCE

For six years of operation, no maintenance is performed on the Krohne Altosonic-V meters. The piping configuration still remains as presented at the NSFMW in year 1999.

See Figure 2.

Excellent third party calibration results are achieved using a Faure Herman Helical Rotor turbine meter from the Snorre A oil export station for master transfer into volume flow calibration of the Krohne Altosonic-V meters. Transfer of traceable can volume into Compact Prover volume is performed, before calibration of this Faure Herman Helical Rotor turbine meter. Re-calibration of the turbine meter against Compact Prover is repeated with a goal of a difference inside 0,03 % for the average K-Factor, before and after the calibration with master transfer from the turbine meter to the master ultrasonic Krohne Altosonic-V meter.

Note that the turbine meter is installed between the ultrasonic meters and the Compact Prover, to eliminate possible disturbance to the volume transfer from the turbine meter to the ultrasonic meters. Furthermore, the use of flexihoses between the ultrasonic meters and the turbine meter during the re-calibration with Compact Prover, would contribute to unacceptable influence on the re-calibration of the turbine meter in this position. So fixed piping only is used for the third party calibration.

A K-Factor curvature for all annual third party in-situ calibration data for the master Krohne Altosonic-V ultrasonic meter can be plotted, so that all the points above 150 m3/hr will fit inside +/- 0,06 % from this K-Factor curvature. See Figure 3.

4. SNORRE B CALIBRATION PHILOSOPHY

The Faure Herman turbine meter for master transfer is calibrated in-situ by a third party with regular intervals, initially every two months using the portable Compact Prover, temporarily installed. The Compact Prover is wheeled directly into a fixed piping arrangement. As for the Crossover, after waterdraw of the Compact Prover volume, first the turbine meter is calibrated with the Compact Prover with a maximum spread for 5 trials; inside a goal of 0,02 % band. This is repeated with the goal for average K-Factor to be within a difference of 0,01 % from the first pre calibration average K-Factor. Then the turbine meter is used for master transfer in calibration of the duty ultrasonic meter, at the same flowrate ; thru synchronized pulse count. Immediately afterwards the turbine meter is confirmed at the same flowrate; with goal for average K-Factor to be within a difference of 0,01 % from the pre calibrations average K-Factor for the turbine meter. The turbine meter K-factor curve from the Compact Prover calibration is entered into the Snorre B master meter flow computer. The resulting duty ultrasonic meter K-factor curve is entered into the duty ultrasonic meter flow computer.

In the long operational period between Compact Prover calibrations, the duty ultrasonic Meter Factor is verified with the turbine meter approximately every 4 days, in a synchronized count of pulses. The duty ultrasonic Meter Factor determined this way is used as an alert mechanism only, for whether the period between Compact Prover calibrations should be made shorter or longer.

5. SNORRE B FILTER CLOGGING

See Figure 4.

During the startup period for Snorre B, it became obvious that Fine Filters in the Filter Strainer created unacceptable conditions for the Krohne Altosonic-V : The Swirl Indicator showed above 1,0. The pressure drop across the Filter Strainer was increasing beyond 1 Bar, and the flow profile was severely distorted, with low flow in the middle. In spite of this the master verification against the turbine meter still gave repeatable results within +/- 0,02 % for 5 out of 5 fifteen minute trials, but showed a trend of increasing K-Factor for the Krohne Altosonic-V. When the Fine Filters was removed from the Filter Basket in the Filter Strainer, as soon as we had an opportunity with production stop, the Krohne Altosonic-V K-Factor immediately decreased by more than 0,3 %, and the Swirl Indicator went back to approximate 0,3. The change in K-Factor was seen immediately from the master verification with the turbine meter, and was properly confirmed one month later in the second re-calibration against the third party Compact Prover. See Figure 5.

Our rough road to success for the ultrasonic meter performance curve, presents an important lesson : Dynamic profile disturbance can have a very strong impact on the Krohne Altosonic-V, despite all efforts to increase the tolerence for profile irregularities. When the Fine Filter, installed in the Filter Strainer 20 diameters upstream of the ultrasonic meter, was clogged with formation particles, the ultrasonic meter K-Factor performance curve determined in August 2001, was more unlinear and also with a strong shift of approximate + 0,4 % in comparison with the onshore original system performance curve. Onshore calibration will be invalidated by significant installation effects.

6. SNORRE B EXCELLENT SHORT TERM PERFORMANCE

In a two week period after removal of the Fine Filters the five master verifications final average results showed inside a band of 0,01 % for the Krohne Altosonic-V. However, using water washing only was insufficient to maintain this performance over long time. Mechanical cleaning with frequent intervals would be necessary to achieve similar results, but this was too much work for the Snorre B level of manning. The master verification remains limited to determine reliability, and to decide whether more frequent third party calibration is required. See Figure 6.

7. SNORRE B ACCEPTABLE LONG TERM PERFORMANCE

In the period from October 2001 until May 2003, five third party calibrations with Compact Prover were performed. The results were similar to those from the Snorre-Vigdis Crossover. However, the linearity spread for each third party calibration was much less for Snorre B. See Figure 7.

8. SNORRE B KROHNE ALTOSONIC-V FLOW COMPUTER

The Krohne Altosonic-V field version flow processor had to be maintained in the spring of 2002, because card components were not sufficiently reliable. A complete flow processor panel will now be installed in a safe zone for proper access when immediate action is necessary.

9. SNORRE B MASTER TURBINE METER CALIBRATION

For the third party calibrations, the Faure Herman Helical turbine meter for mmaster transfer is properly cleaned. The third party curvature for this turbine meter has been practically unchanged, but the bias has moved. Already by April 2002 it had changed 0,19 % from the first third party calibration in August 2001. However from April 2002 until September 2003, the changes has stayed within a bias of 0,07 % from the established K-Factor curvature. See Figure 8.

The turbine meter calibration over a wider range was made economically acceptable by installing a control valve in the master bypass, so that some of the production can be routed outside the master section for the third party calibration of the turbine meter against a Compact Prover.

10. SNORRE B MASTER VERIFICATION AGAINST FAURE HERMAN FH8500

In May 2003, the Faure Herman 18 beam FH8500 ultrasonic fiscal oil meter prototype was introduced into the master section. This was done immediately after the third party calibration of the turbine meter, and calibration transfer by performing master verification for the Krohne Altosonic-V. Note that the FH8500 was calibrated by master transfer at Faure Herman in a very similar piping arrangement; with a 90degree elbow upstream of the minimum 10 diameters. In both cases flow conditioning was not performed. At Snorre B the first major disturbance was the Filter Strainer installed 70 diameters upstream. A shift of more than 0,5 % was seen from the calibration at Faure Herman, to the master verification at Snorre B. This shift was removed by entering a lower K-Factor for the FH8500. By continuous comparison with the Krohne Altosonic-V we could confirm that neither FH8500, nor Krohne Altosonic-V ultrasonic flow meters had developed any erroneous performance. See Figure 9.

Repeatability of +/- 0,02 % in the master verification was slightly more difficult to achieve, than with the turbine meter. But daily volume comparison was satisfactory without any cleaning of the FH8500. See Figure 10. Similar level of difference were achieved in the master verification results. The change in comparison level that can be seen, happened immediately after a synchronized master verification. Build-up in the FH8500 during the closed in period, can not be ruled out as a possible reason for the shift.

11. SNORRE B FLOW PROFILE IMPROVEMENTS

In order to improve the linearity of the Krohne Altosonic-V, the Filter Strainer was completely removed, and replaced by a spool piece with a Profile Adjustor Plate installed immediately upstream of the spool piece. This was done during the shutdown at Snorre B in August 2003. See Figure 11 and 12. This resulted in a Swirl Indicator one decade lower; below 0,03, which proves a perfect profile for the Krohne flow meter, just as we had hoped for. From this; improved linearity for the K-Factor curve was expected. More of a surprise to us was a shift in the K-Factor for the Krohne Altosonic-V at higher flowrates, found early in September and confirmed from the third party calibration with a Compact Prover in mid September. The transfer from the turbine meter into the Krohne flow meter was performed at production rate only. See Figure 13. It remains to be confirmed that the curvature for the Krohne Altosonic-V K-Factor is now really almost perfectly flat, as was found in the original calibration in 1999 against the Krohne certified water tower.

12. EFFECT ON ULTRASONIC FLOW METERS FROM WALL LAYERS

Some shifts for an ultrasonic oil meter will be caused by the effect of a wall layer, such as barite, wax or scale. If we assume that this wall layer is evenly distributed, this effect can be evaluated from a geometrical viewpoint, when the profile distribution is not significantly changed due to the less significant change in the real Reynolds number.

With a wall layer present, the central beam will produce too high a flowrate. If the wall layer is 0,1 % of the pipe inner radius, the inner pipe diameter will be 0,1 % shorter. However the flowrate in the remaining flowing area will be more than 0,2 % higher; resulting in approximately 0,1 % over reading for the central beam.

Similarly beams out of center can be evaluated. I define the angle as the angle α out of center from the central beam. See Figure 14. Disregarding the minor effect of Reynolds number change, the single beam error effect ratio is :

Equation 1

$$\varepsilon_{SBeam} = \frac{\sqrt{(1-\Delta)^{2} - \sin^{2}\alpha}}{\cos\alpha \cdot (1-\Delta)^{2}} - 1$$

Note in particular that a beam over a 90 degree segment (α is 45 degrees) will be almost insensitive to an evenly distributed layer. However, some offset will be present with very thick layers.

A beam over a 120 degree segment (α is 30 degrees) with a 0,1 % radius layer thickness, will result in approximate 0,07 % over reading. A beam over a 60 degree segment (α is 60 degrees) with a 0,1 % radius layer thickness, will result in approximate 0,2 % under reading. A multibeam ultrasonic flow meter with well selected beam flow-weighing balance, could therefore result in high tolerance to wall layers. None of the existing ultrasonic liquid flow meters have focused on reducing scale sensitivity. The Krohne Altosonic-V has 1 central beam, 2 of 120 degree segment beams, and 2 of 60 degree segment beams. The Faure Herman FH8500 has 6 central beams and 12 of 120 degree segment beams.

13. RECOMMENDATION FOR FUTURE FISCAL ULTRASONIC OIL METER SYSTEMS

Our clear recommendation for future master meter based USM systems, is to use another ultrasonic meter as the periodic verification master meter; the same way that it is done at Snorre Vigdis Crossover. To avoid duplicated errors, a different model Master USM from the Duty USM could be used. A turbine meter is still required as a master transfer meter for the Compact Prover, but should be removed and replaced with a spool piece for the long time in between. See Figure 15. Note that fiscal oil measurement without in-situ calibration can not be recommended.

Figure 1

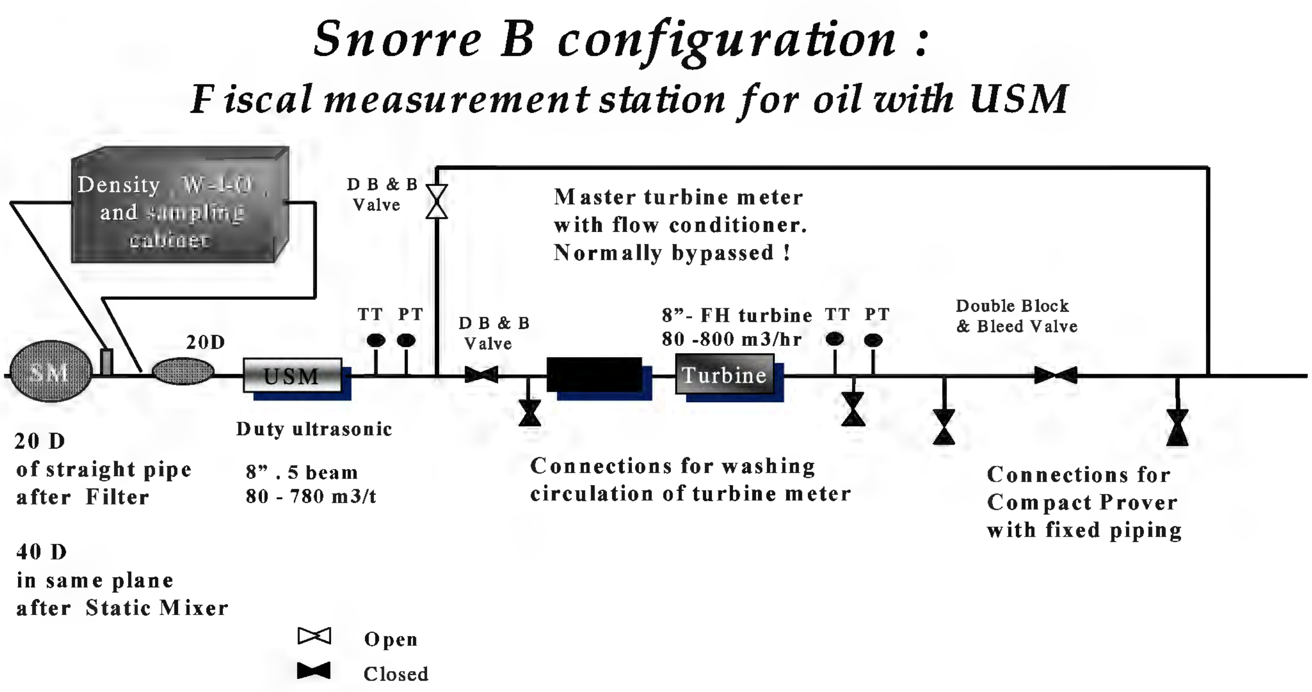


Figure 2

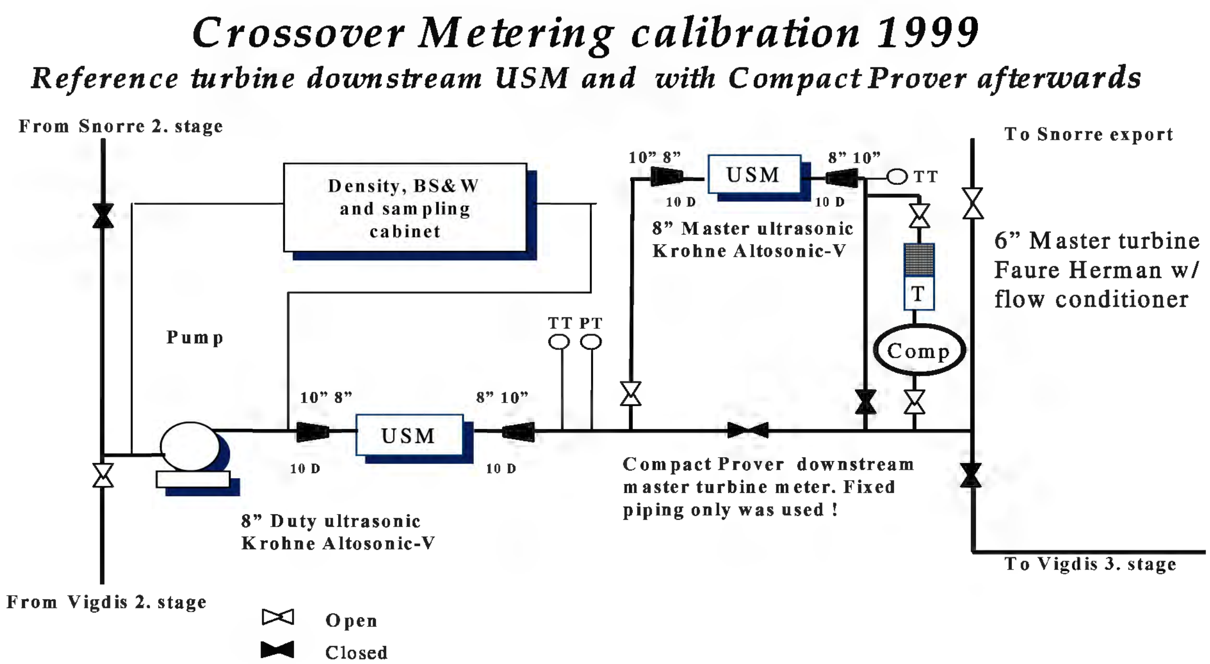


Figure 3

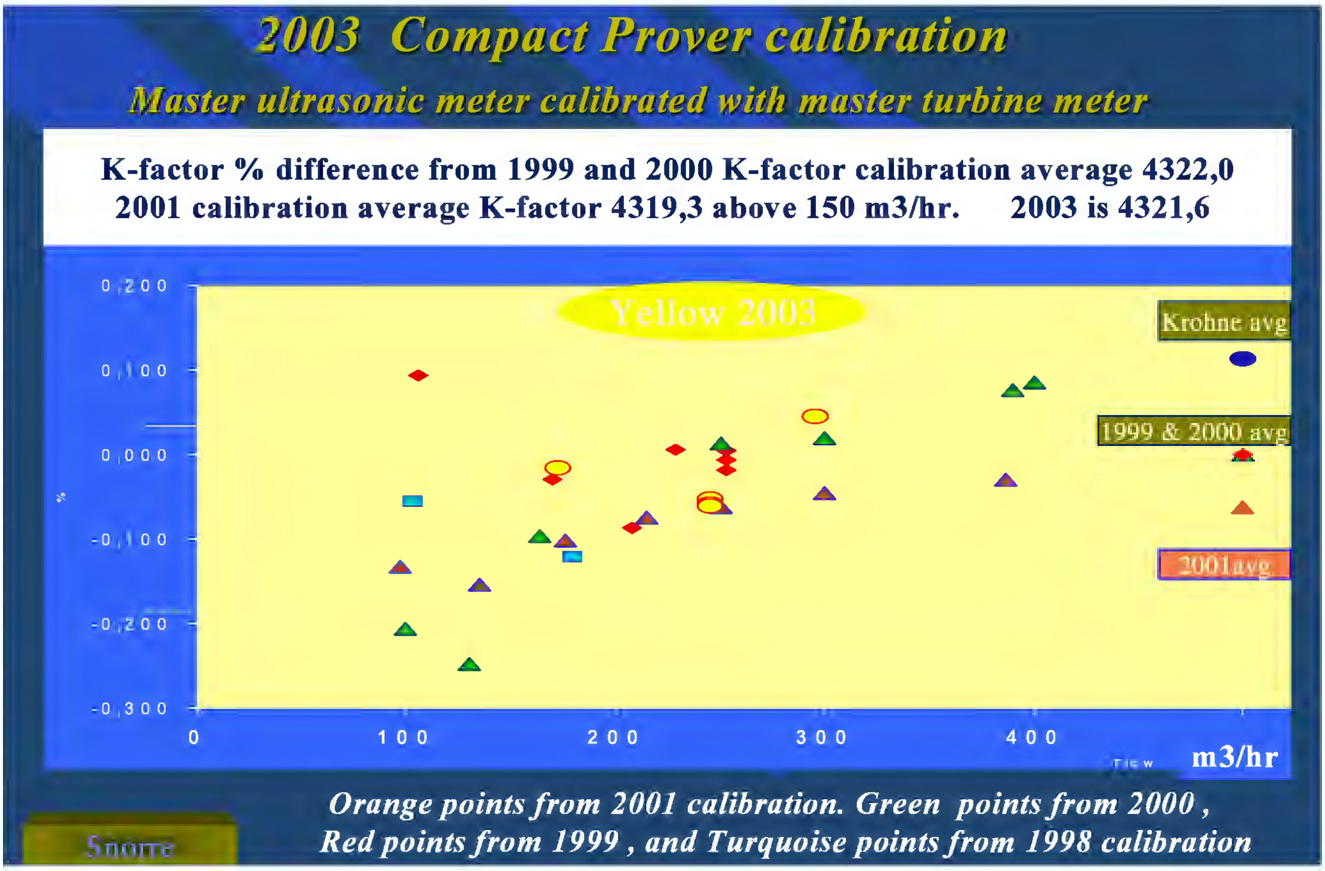


Figure 4 Filter Clogging

Figure 5 **Flow Shift From Clogged Filters**

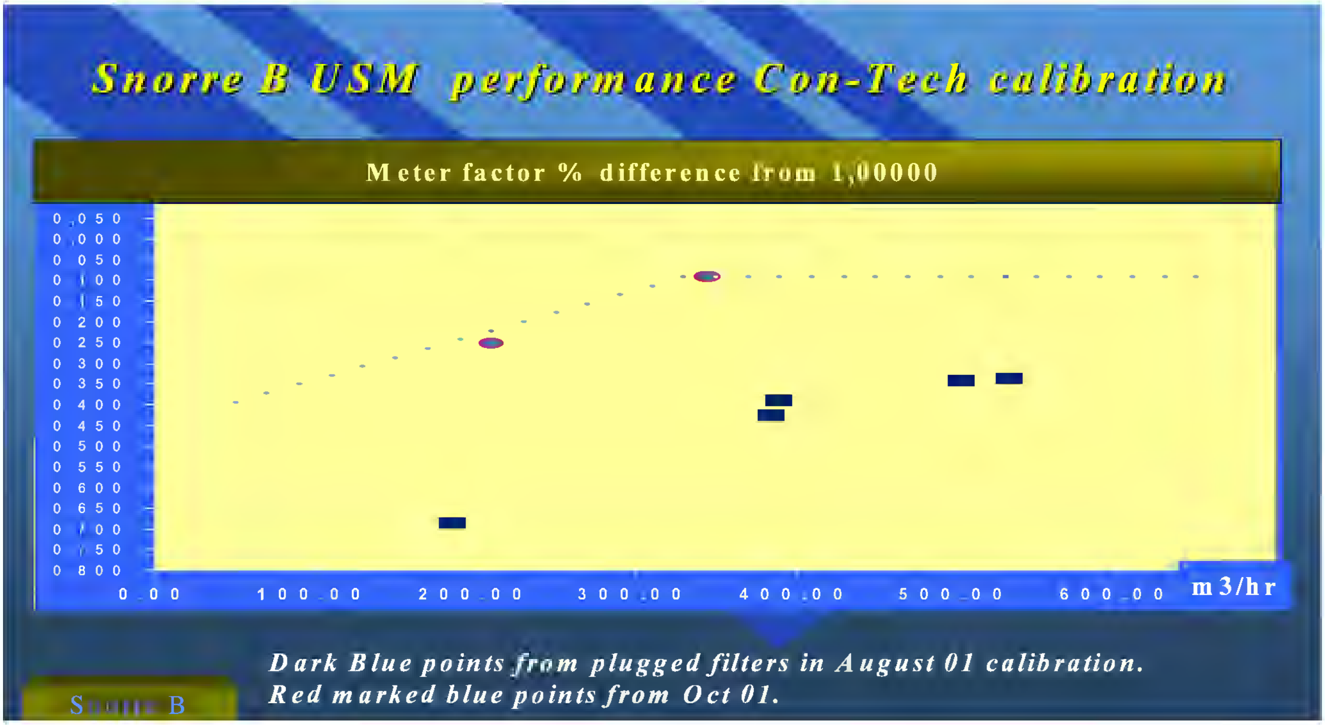


Figure 6 **Master Verification With Turbine Meter**

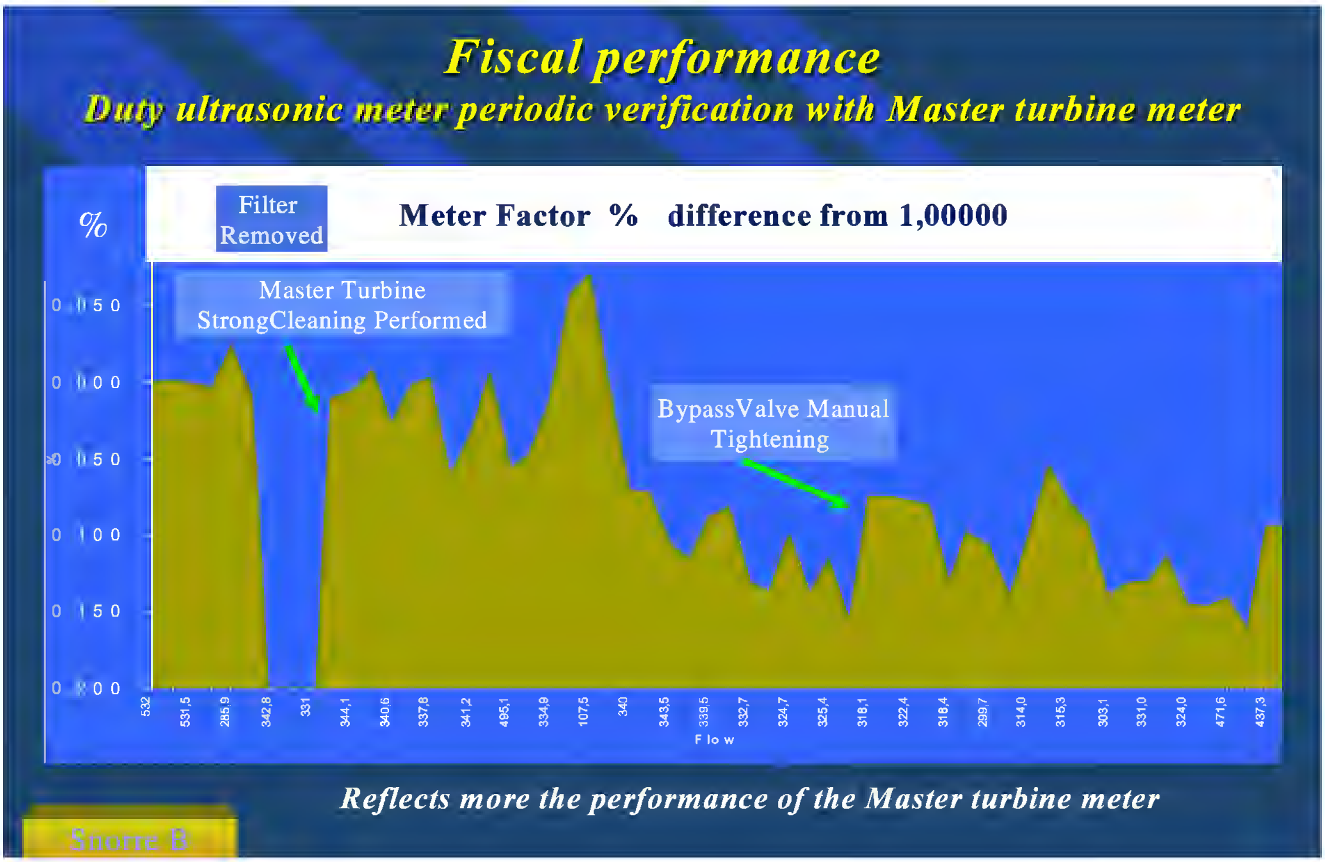


Figure 7

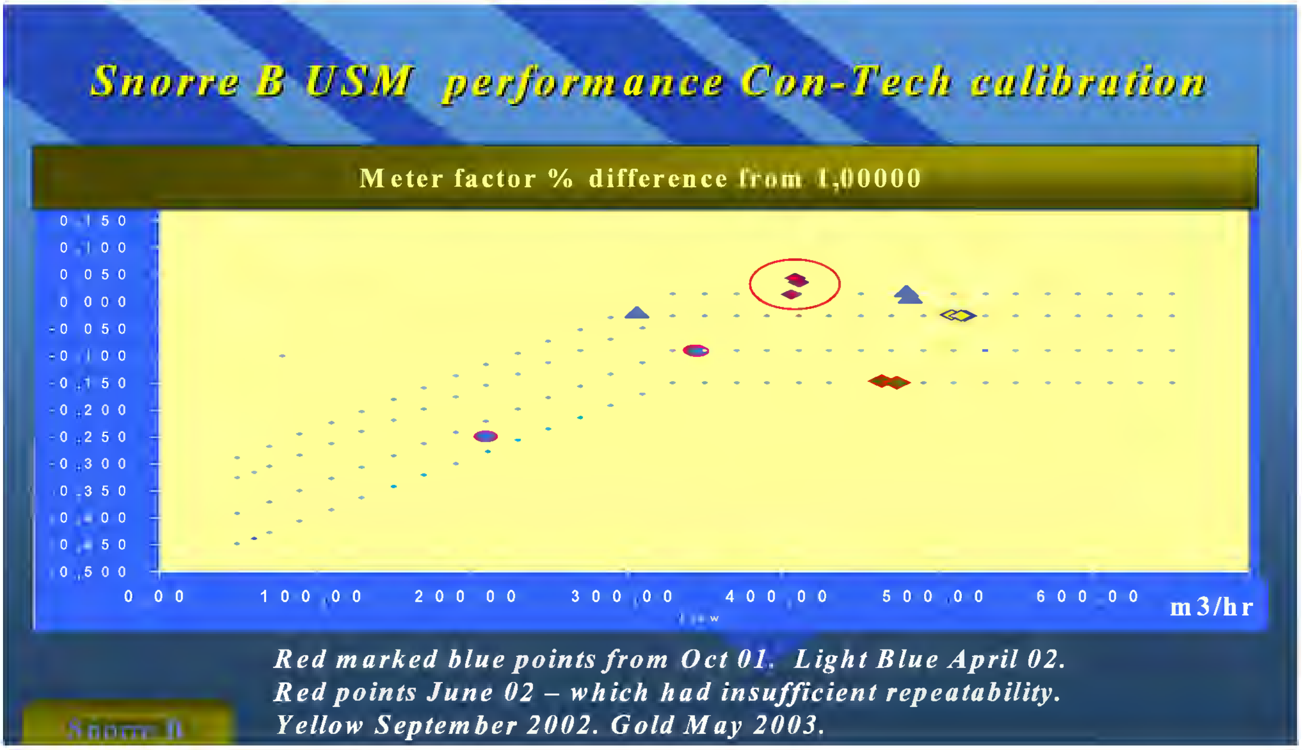


Figure 8

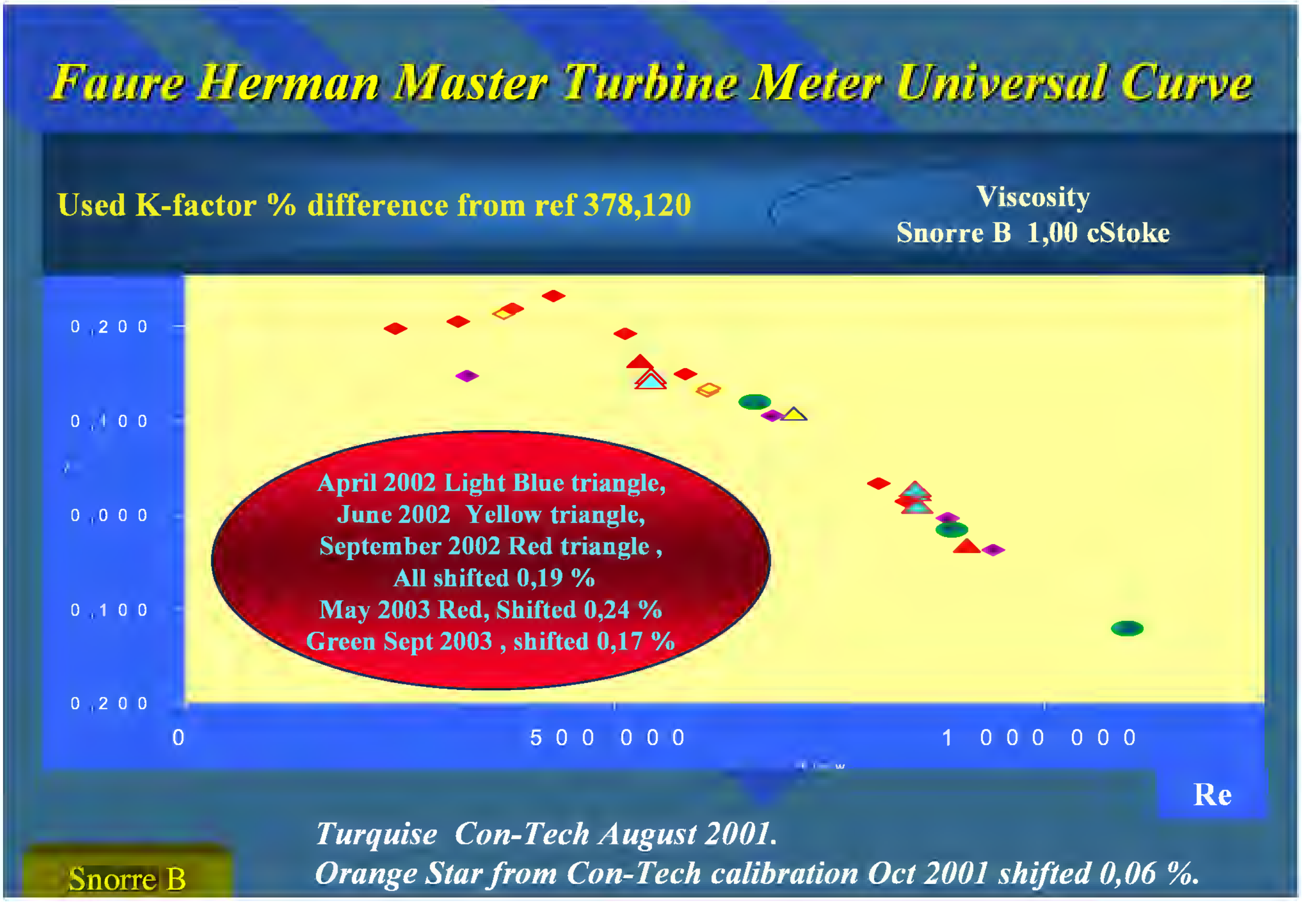


Figure 9 Krohne Altosonic-V and Faure Herman FH8500 Tracking

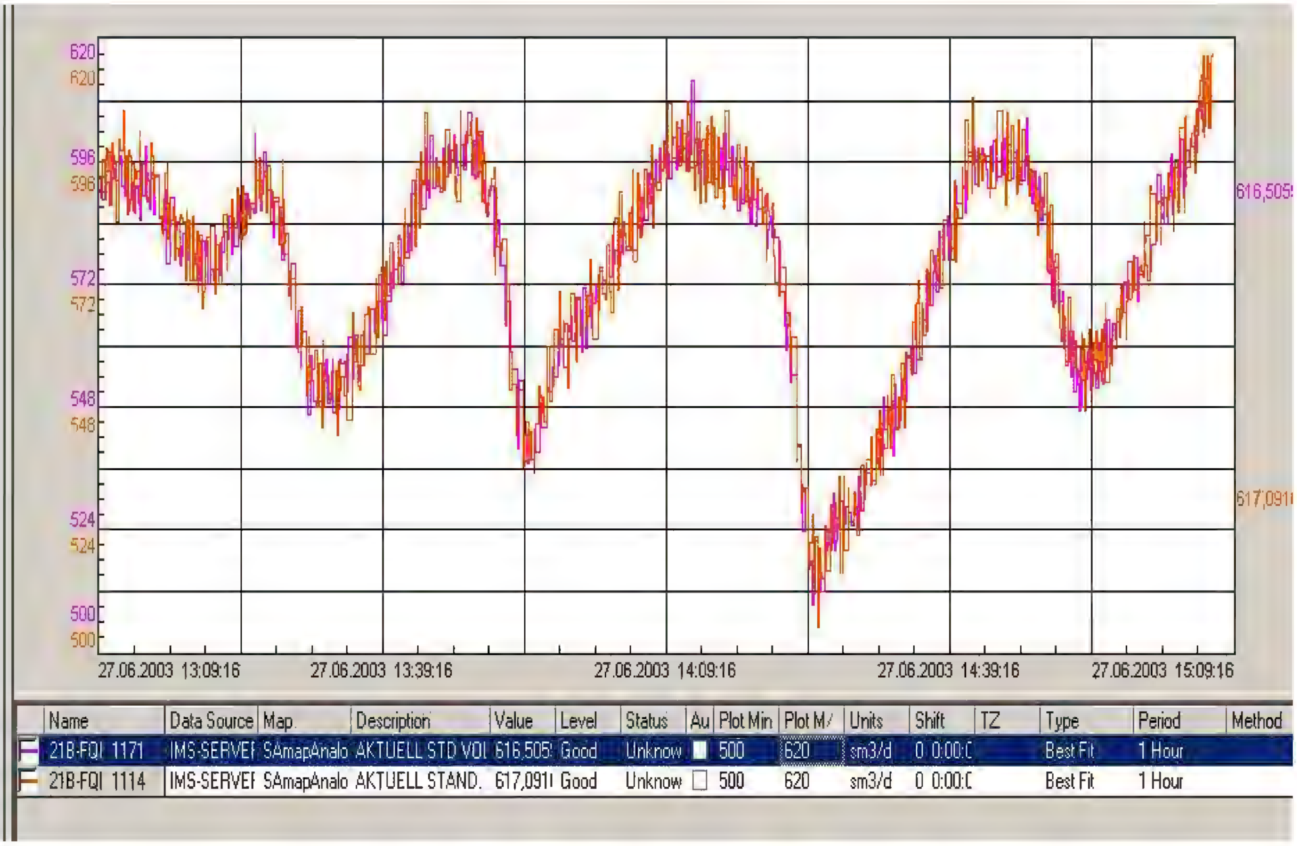


Figure 10

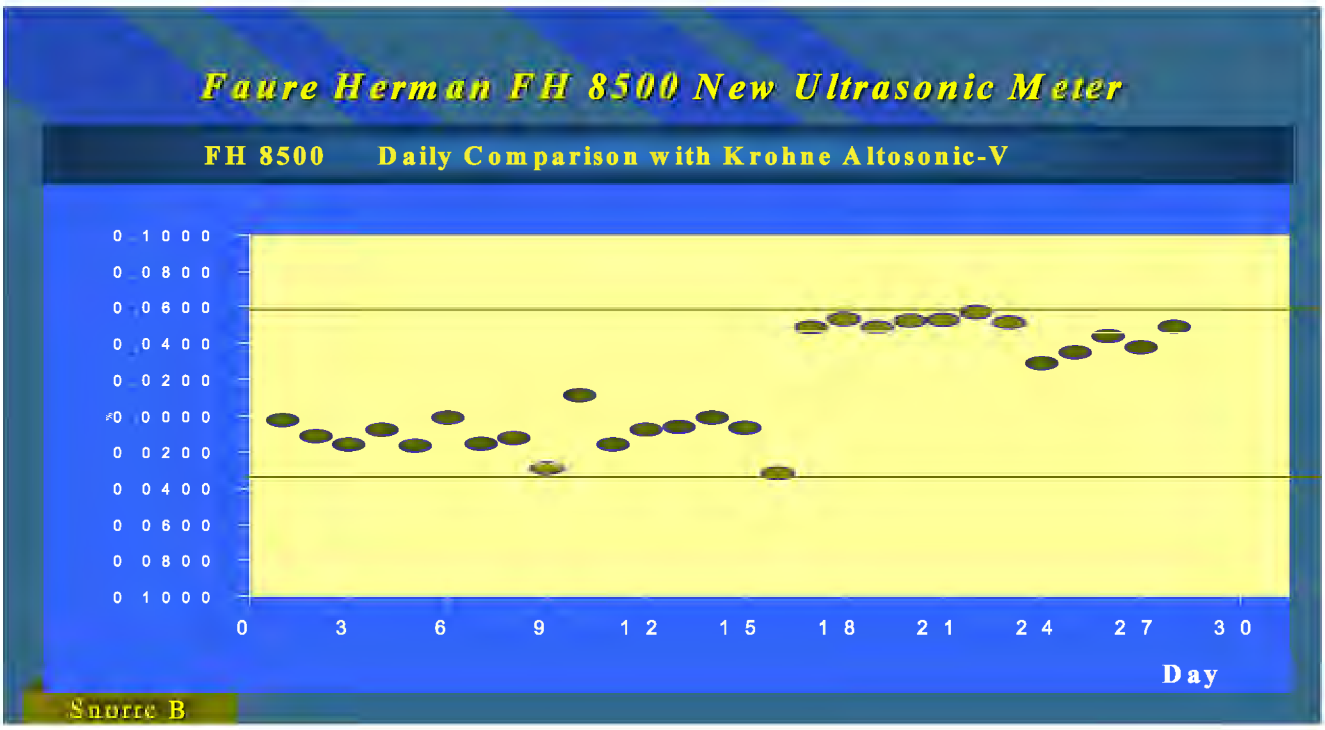


Figure 11

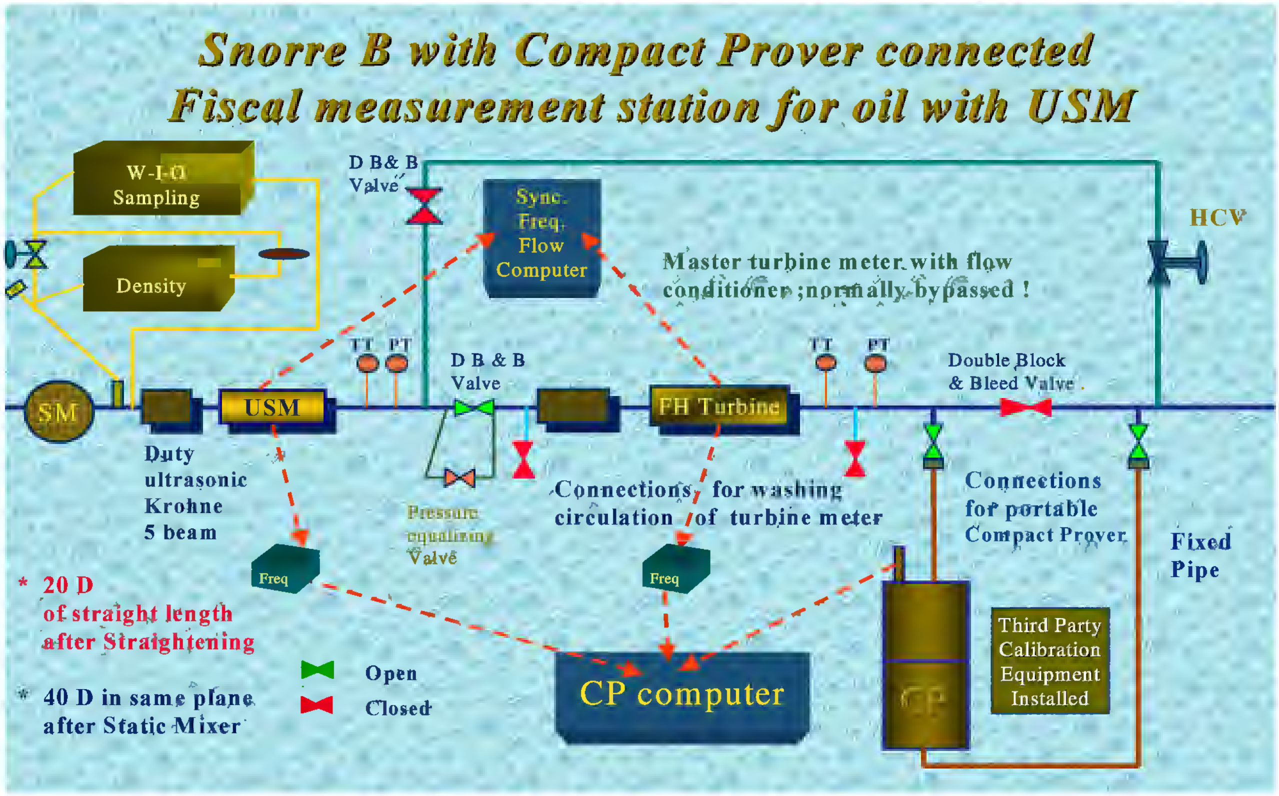


Figure 12

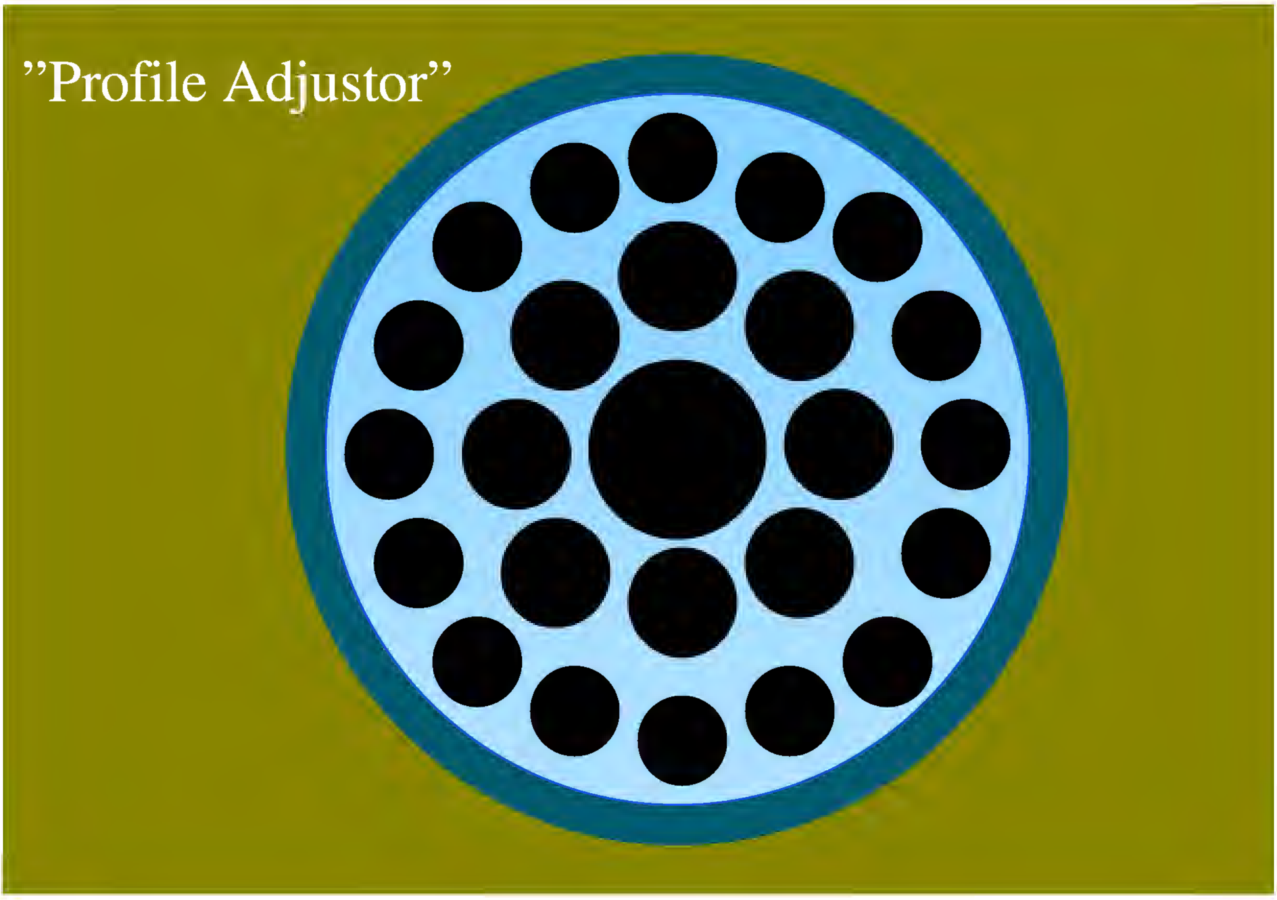


Figure 13 Shift After Removal Of Filter Strainer And Profile Adjustor Installed

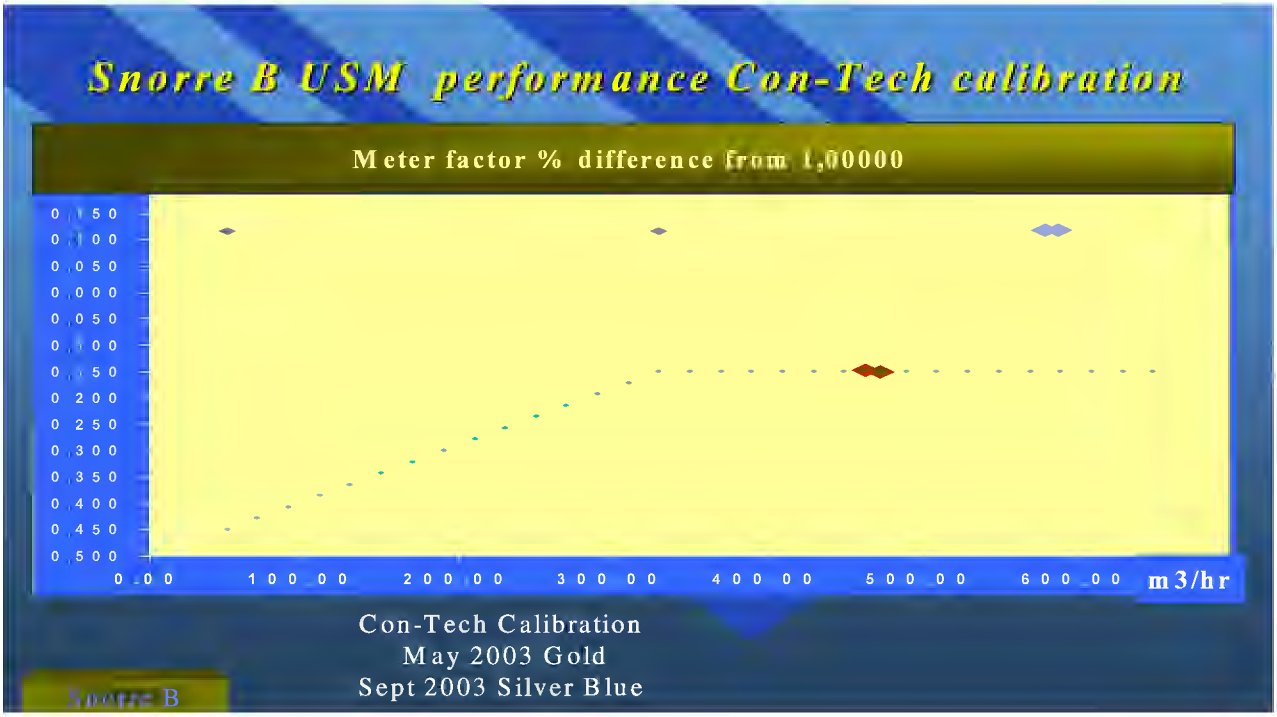


Figure 14 Geometric Influence On Beam From Wall Layer

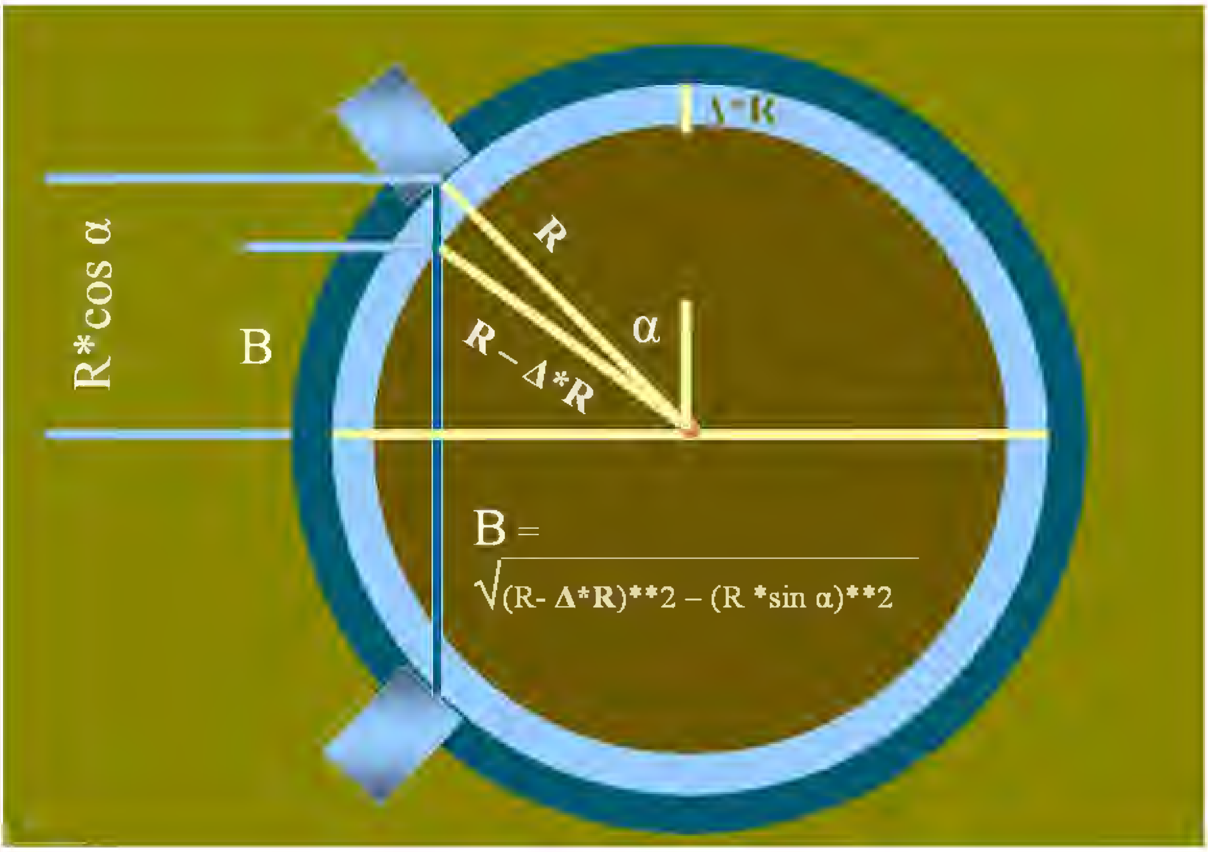
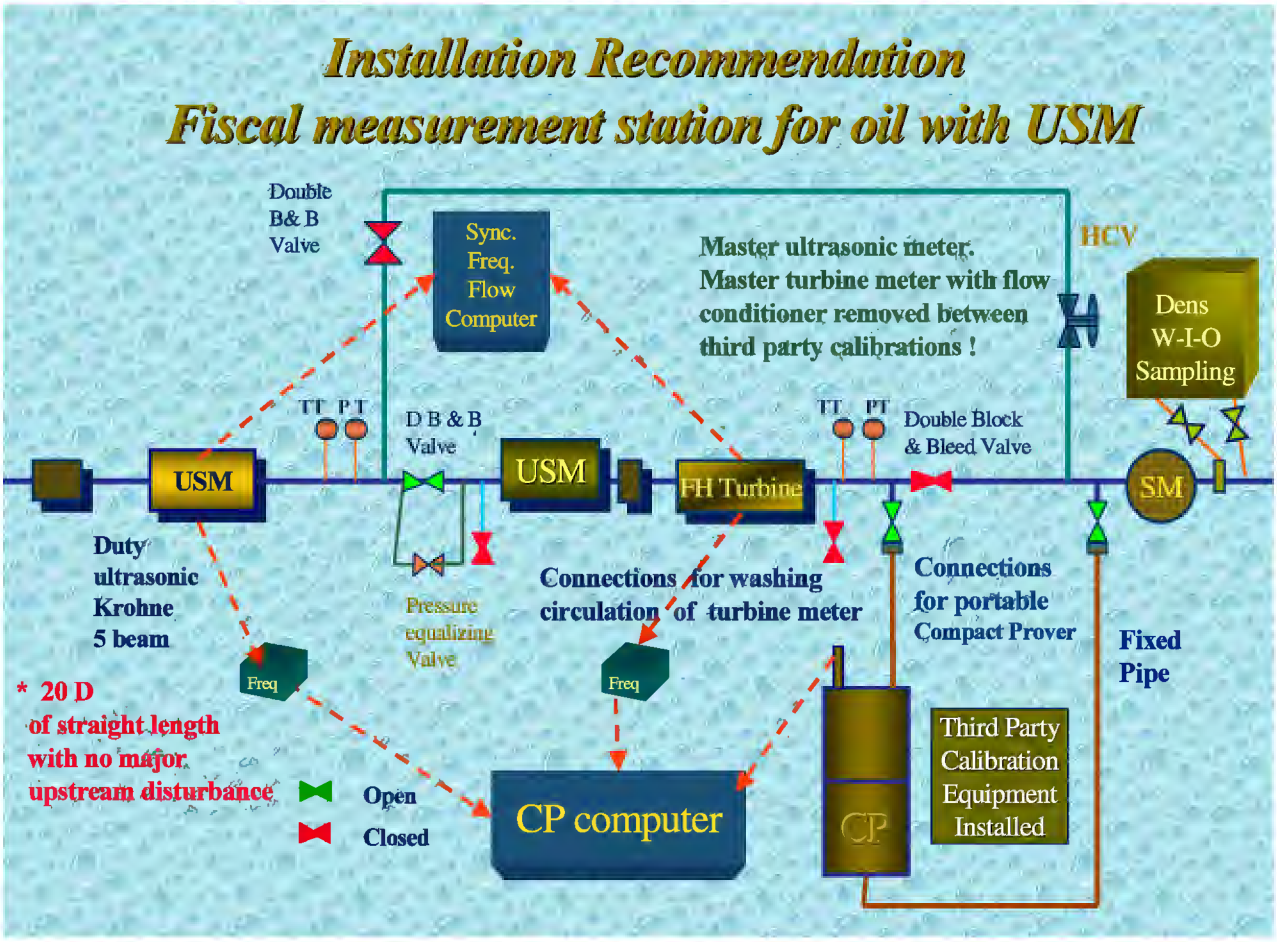


Figure 15



Installation Recommendation
Fiscal measurement station for oil with USM
Double B& B Valve
Sync. Freq. Flow Computer
Master ultrasonic meter. Master turbine meter with flow conditioner removed between third party calibrations !
HCV
Dens W-I-O Sampling
TT PT
D B & B Valve
USM
USM
FH Turbine
TT PT
Double Block & Bleed Valve
SM
Duty ultrasonic Krohne 5 beam
Pressure equalizing Valve
Connections for washing circulation of turbine meter
Connections for portable Compact Prover
Fixed Pipe
Freq
Freq
* 20 D of straight length with no major upstream disturbance
Open
Closed
CP computer
CP
Third Party Calibration Equipment Installed

References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.