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EXPERIENCES WITH ULTRASONIC METERS AT THE GASUNIE EXPORT STATIONS

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EXPERIENCES WITH ULTRASONIC METERS AT THE GASUNIE EXPORT STATIONS

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SUMMARY
Gasunie has equipped a number of its export metering stations with ultrasonic gas flow meters. These ultrasonic flow meters are used as backup meters for the primary meters, which are turbine meters. On-line comparison results with these ultrasonic flow meters and the turbine meters are assessed. Given the results it is concluded that this new type of meter gives good results in the areas of availability and spread of results.

INTRODUCTION

Background

In 1996, Gasunie sold 47.9 billion m^3 natural gas on its home market and 45.9 billion m^3 natural gas was exported to other European countries. The exported gas is measured at 13 so-called export stations at the borders. The major amount of gas is transferred via 6 large export stations. Since their renovation in the early nineties [1],[2], these major stations have been equipped with a double flow metering system in which the primary measurement is done by means of turbine meters and a backup measurement is done with either ultrasonic meters or turbine meters. Depending on the capacity of the station the metering section consists of 3 up to 7 parallel meter runs. With the primary and backup flow measurement a continuous on-line comparison has been implemented. On an hourly basis the flow at line conditions and the flow converted to base conditions are registered and compared. This result of the comparison may generate automatically alarms.

Layout of an export station

In the station the incoming gas is cleaned by means of scrubbers. After the scrubbers the gas comes via an underground header and a double bend out of plane in the actual metering section. An overview of the metering section of an export station is given in Figure 1.

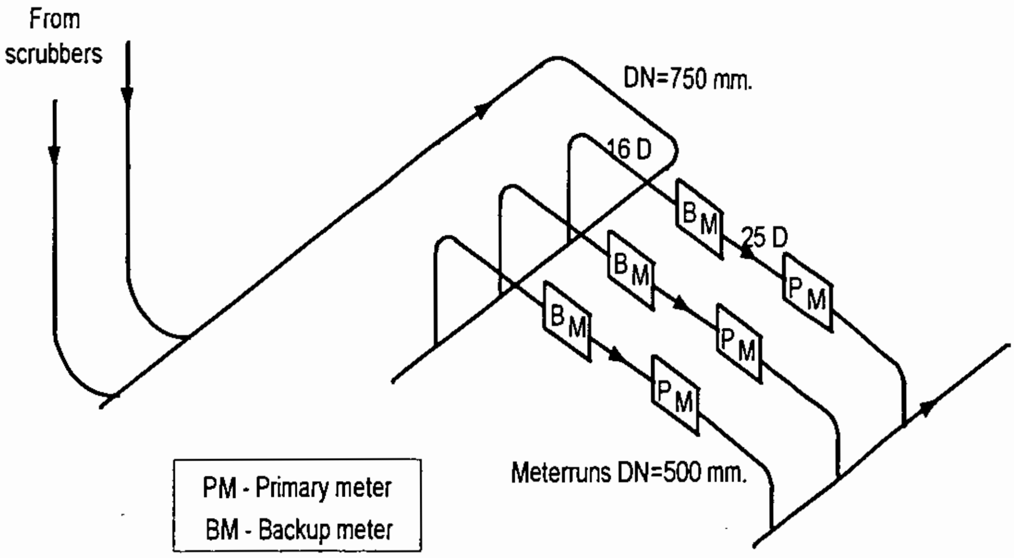

Figure 1 - Layout of the metering section of an export station

Issue

With the ultrasonic meters that were available at the time of the renovation of the export stations a number of problems were encountered. A relatively large scatter was discovered in the comparison results of the meter runs equipped with the ultrasonic meters. For a typical example refer to Figure 2.

Another problem was that the number of failures of the ultrasonic meter was too high, leading to an unacceptably low availability of the meter. Also the zero drift of the meter, which had to be corrected manually, was too high. These problems led to a research programme in which a new type of ultrasonic meter, with advanced electronics and software, was selected and tested to find out whether it could meet the requirements.

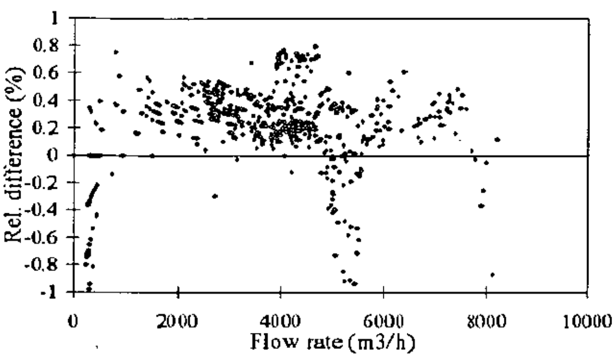

Figure 2 - Initial comparison results with an US meter of the original type

*In all graphs the relative difference between the primary and backup meter, expressed as $(V_p-V_b)/(V_b+V_p)$ * 200%, where V_p is the reading of the primary meter and V_b the reading of the backup meter totalized over an hour, is plotted against V_p. Each graph covers a period of one month.*

RESEARCH PROGRAMME

Set up of the programme

To test if the new meter could meet the requirements a two stage programme was started. In the first stage the meter was tested in Gasunie's flow laboratory and subsequently for a longer period of time field tests were carried out with meters built in on export stations.

Laboratory investigations

The 20" ultrasonic flow meter, with Q_{max}=10000 m^3/h was tested in Gasunie's Westerbork test facility. Although these test will not be discussed in this paper an overview of the major results is presented in Table 1.

Table 1 - Results from the laboratory programme

Repeatability	< 0.2 %
Linearity	< 0.5 %
Influence of swirling flow	0.2 %
Influence of exchanging transducers	<0.2 %
Range	5 - 120 % Q_{max}

The flow range is limited at the lower end to 5 % due to the fact that in the range of 2-5 % Q_{max} the dispersion in the results is too high. This is illustrated in Figure 3.

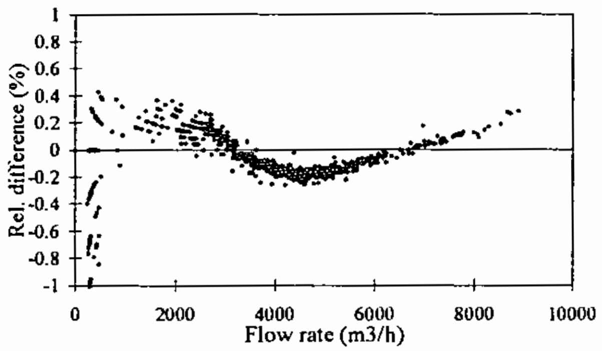

Figure 3 - Spread at low flow rate of the new type ultrasonic meter

Note:
The increasing difference at higher flow rates between turbine meter and ultrasonic meter is caused by the increasing pressure difference between the ultrasonic meter and the turbine meter. The graphs show actual flow rates.

Field test

For the field test an endurance test in the period 1994 -1995 was done. For this purpose three 20" ultrasonic meters were installed at three different export stations. During the field test swirl was detected in the meter runs of the export stations [3]. From experiments and theoretical studies [4] it is known that this type of flow disturbance is very persistent. To eliminate this swirl Laws flow conditioners [5] were installed in the pipe sections upstream of the ultrasonic meter. During the test, beside some minor problems with cabling and printed circuit boards, the meters functioned quite well. The availability in this period was > 99.9 %. No maintenance was done and the transducers were not cleaned nor exchanged. In the next section some details of the comparison results with the three meters will be discussed:

Meter 1

In the period April 1994 up to April 1995 this meter gave a typical pattern in the on-line comparison, an example of which is given in Figure 4. This was reason to re-calibrate both the turbine and the ultrasonic meter. It was discovered that the ultrasonic meter showed a difference of +0.2% and the turbine meter even of +0.4 % at low flows. The combination of these differences explains the behaviour if the comparison results. After the calibration the meter was built into another meter run on the export station. The on-line comparison now gave the result from Figure 5.

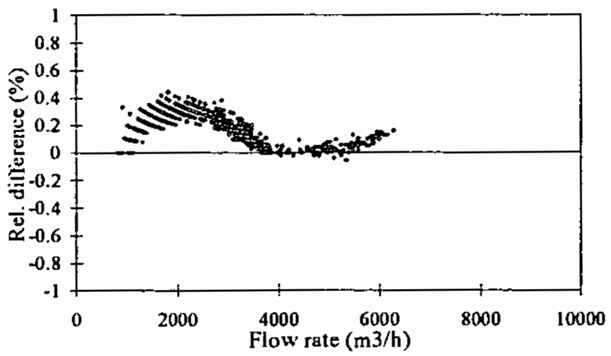

Figure 4 - Initial pattern for meter 1

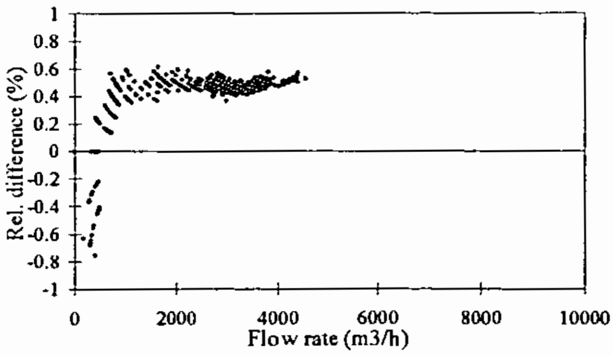

Figure 5 - Meter 1 after re-calibration

Note: For low flow rates the discretization steps caused by the meters electronics are visible

The pattern looks normal but there is a difference of 0.5 % between the primary and backup measurement. When the ultrasonic meter was built out and inspected blisters in the flow coating inside the meter were discovered. After removal of the coating and applying new coating another calibration was done. As can be observed from Figure 6 the difference between both meters is brought back to an acceptable level.

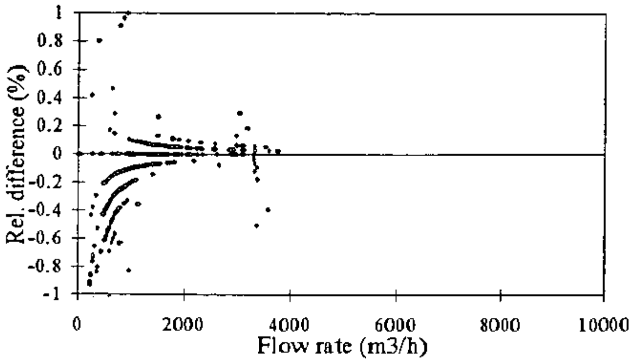

Figure 6 - Meter 1 with renewed coating

The drift of the meter in the period March 1994 - May 1995 based on the calibration results is +0.4 %, a substantial part of which can be attributed to the blisters in the coating. The spread of the on-line comparison data at $0.4*Q_{max}$ is about 0.2%.

Meter 2

This meter gave from the start a bias between the primary and backup measurement of +0.5%. as illustrated in Figure 7. The reason for this bias lies in the software that was not optimally tuned for the actual flow in the meter run. After the test period the software settings were adapted and this lead to much better results, as can be seen in Figure 8.
The spread at $0.4*Q_{max}$ in the on-line comparison is about 0.2 %.

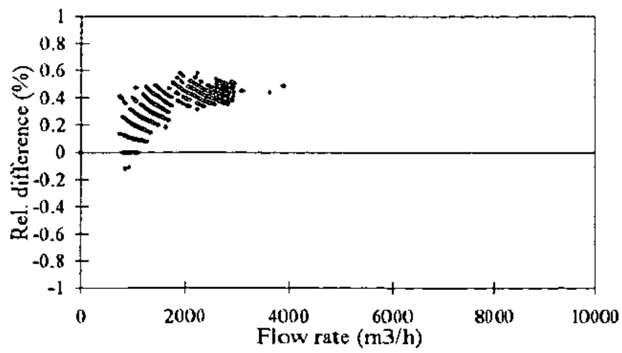

Figure 7 - Meter 2 before software tuning

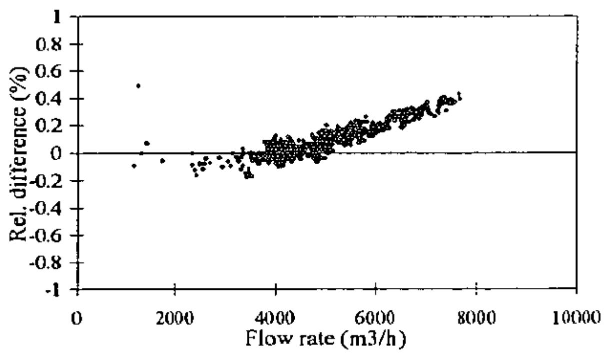

Figure 8 - Meter 2 after software tuning

Meter 3

The pattern in Figure 9 which was observed in the first period in the on-line comparison was again due to the turbine meter. After replacement of the turbine meter a behaviour as plotted in

Figure 10 was found. In the period March 1995- September 1995 a spread in the on-line comparison at $0.4*Q_{max}$ of 0.1 % was found.

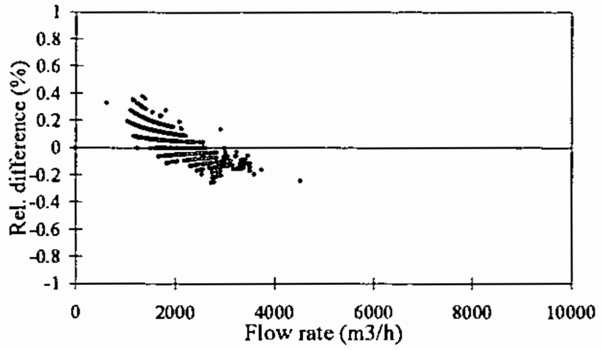

Figure 9 - Initial results of meter 3

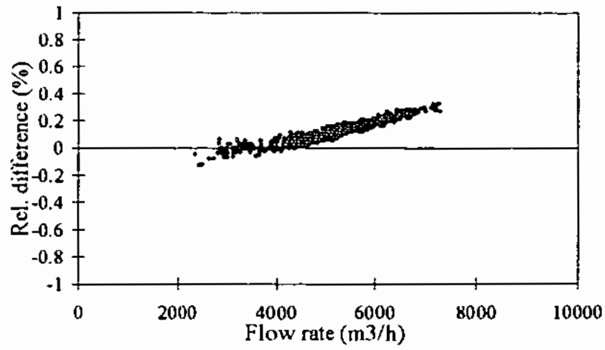

Figure 10 - Meter 3 after turbine meter replacement

Intermediate period

In the period after the end of field test the meters have been kept in operation. In Table 2 the figures for the spread of the results based on the on-line comparison are given.

Table 2 - Summary of the results in the period after the field test

METER	PERIOD	SPREAD AT $0.4*Q_{MAX}$	Refer to
1	January 1996 - October 1996	0.2%	Figure 11
2	September 1995 - October 1996	0.2%	Figure 12
3	September 1995 - September 1996	0.1%	Figure 13

The figures 11, 12 and 13 give an impression of the results of the comparison of the meters in this period.

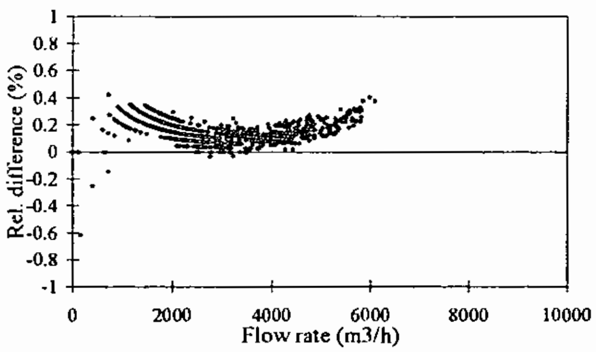

Figure 11 - Results of meter 1

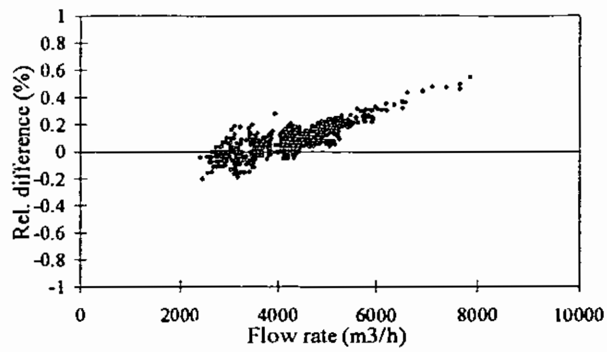

Figure 12 - Results of meter 2

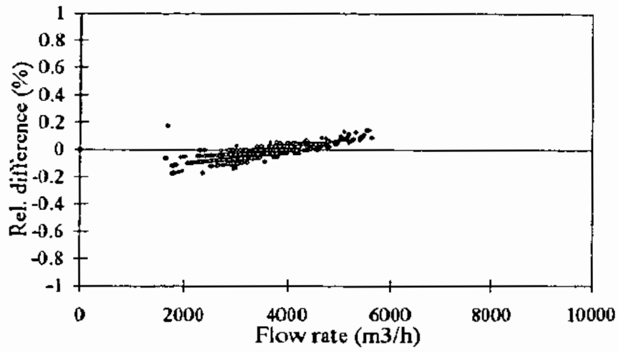

Figure 13 - Results of meter 3

FINAL SITUATION

Based on the results of the field test it was decided to select the tested ultrasonic meter as backup meter for the Gasunie export stations which were to be equipped with ultrasonic meters. The meters used in the field test were upgraded so that they are functionally equal to the new meters and installed in an export station. New meters were bought for the other meter runs and are to be installed now. No results are available yet from this period.

CONCLUSION

Based on the experiences with the three meters that were used in the field test the following conclusions may be drawn:

- The new type ultrasonic flow meter gives better results in the areas of availability and spread then ultrasonic flow meters of the previous generation.
- The number of defects is reduced to 1 -2 per year.
- The difference between the results of the turbine meter and the ultrasonic meter is about 0.2% in the range 0.2 -1.0 Q_{max}. For lower flows this number increases.
- Installation of a Laws flow conditioner lead to more stable results. The effect of flow conditioners on ultrasonic flow meters has to be further investigated.
- The ultrasonic meters serve excellent to monitor the quality of the turbine meter.
- Tests have demonstrated that components can be exchanged without significant influence on the meter performance.

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2 Van der Kam, P.M.A., Dam,A.M. and Van Dellen,K. "Gasunie selects turbine meters for renovated export metering stations", Oil & Gas Journal, December issue, 1990.
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4 Steenbergen, W., Voskamp, J., Krishna Prasad, K. "The decay of swirl in turbulent pipe flows" 7^{th} Int. Conference on Flow measurement. FLOMEKO, Glasgow 1994.
5 Laws, E.M., "Flow conditioning - a new development ." Flow measurement and instrumentation 1990 Vol. 1

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.