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"A new gas density meter with reduced velocity of sound effect"

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A NEW GAS DENSITY METER WITH REDUCED VELOCITY OF SOUND EFFECT

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SUMMARY

Gas Density Meters are now widely applied on major Gas Metering Stations where their performance is critical for achieving high accuracy of flow measurement. Over the past few years much valuable experience has been gained and it is now considered desirable that this should be put to good use by the introduction of a new instrument which addresses the main problem areas. These are mainly with respect to a reduction in the gas composition effect (Velocity of Sound), improved temperature response and temperature equilibrium and improved installation and maintenance features. This paper describes the new instrument and its benefits.

INTRODUCTION

A fundamental requirement of most high pressure gas metering systems is the need to know the density of the gas at flowing conditions. This can be calculated from measurements of line pressure, line temperature and gas composition by using gas equations of state or it can be measured directly using an on-line gas density meter. The choice between these two methods is mainly defined by the availability and cost of suitable instruments which will achieve the required accuracy.

Because of the importance of high accuracy, much work has been done analysing these two methods and quantifying the error sources. As far as density meters are concerned this work has now been put to good effect and has resulted in the design of a new instrument.

GENERAL REQUIREMENTS FOR GAS DENSITY METERS

The use of a gas density meter within an Orifice Metering system is illustrated in Fig 1.

The most widely applied Gas Density meters are those which employ a vibrating element which is made to resonate at its natural frequency. The resonant frequency is directly influenced by the mass of gas which is in contact with the vibrating element and therefore by its density. The vibrating element is usually in the form of a very thin metal cylinder and for it to perform its task accurately, the following conditions are important.

1. The vibrating element must be clean of dirt particles and condensate and for this reason adequate filters must be used for the sample gas. The operating conditions must be above the gas dew point.

2. The gas sample in the density meter must be representative of the gas in the pipeline. This is simply achieved by ensuring that there is a small flow of sample gas through the instrument.

3. The gas sample must be at the same pressure as the gas in the pipeline. Again this is easy to achieve by using only a small flow rate of sample gas. The selection of the sample point is however important with respect to the correct selection of the Expansibility Factor as applied to the Orifice Flow Equation.

4. The gas sample must be at the same temperature as the gas in the pipeline. This is achieved by mounting the density sensing element in a thermowell or direct in-line. The sample gas flow rate should be kept to a minimum and the installation should be adequately covered with thermal insulation.

5. The calibration of the Density Meter must use a certified procedure and for best accuracy the use of Pure Nitrogen gas is normally recommended. Secondary influences such as those caused by changes in temperature, pressure and gas composition should also be quantified.

6. The installation and application of Density Meters must be such that the above points can be checked in order to ensure that the accuracy of measurement is as required. Where necessary this may include corrections for secondary effects such as for temperature and gas composition changes. The major influence due to these changes results from the consequential change in the Velocity of Sound.

FEATURES OF EXISTING GAS DENSITY METERS

Most of the Gas Density Meters which are currently in use may be considered as "second generation" instruments and in consequence they incorporate facilities which are effective in addressing the general requirements listed above. These instruments come in two designs to cover density ranges 6 to 60 kg/m and 40 to 400 kg/m.

On the topic of calibration and when applied for Natural Gas metering, these instruments are normally calibrated using pure Nitrogen and then corrected for gas composition effects. These corrections are related to changes in Velocity of Sound between the calibration gas and the natural gas.

This Velocity of Sound effect has been well documented both from a theoretical standpoint and from experimental analysis. It is generally concluded that calibration on Nitrogen plus the application of Sound Velocity correction will result in less measurement uncertainty than calibration on other pure gases or representative gas mixtures. Typically the uncertainty of the Nitrogen calibration is better than 0.1%, and when applied to natural gases better than 0.2%.

On the topics of installation and maintenance, these instruments are normally located in thermowells, however it is often difficult to check that temperature equilibrium is being achieved. Normally an additional uncertainty of 0.1% is added for installation effects giving a total uncertainty of 0.3%.

FEATURES OF THE NEW GAS DENSITY METER

With the wide experience gained from existing instruments it has been possible to focus on areas where further improvement can be made. This has resulted in a "third generation" instrument which is illustrated in Fig. 2 and has the following features.

1. One sensing element to cover all density ranges.

2. All calibrations for use on natural gas to be performed with pure Nitrogen at 20°C traceable to National Standards and with a typical uncertainty of 0.06%.

3. The Velocity of Sound effect is reduced by a factor of three so that, when measuring natural gases, the additional uncertainty is reduced to 0.05%.

4. Temperature response and temperature equilibrium have been improved by improving the thermal conduction from thermowell to sensor, and by reducing thermal conduction to the amplifier electronics. This reduces additional measurement uncertainty due to installation effects to typically 0.05% to give a total measurement uncertainty of typically better than 0.15%.

5. The incorporation of an internal temperature sensor (PRT) for verification of the temperature equilibrium and for use if applying a PTZ check method.

6. The internal filters can now be replaced without disturbing the pipework connections thereby simplifying this procedure if and when it is necessary.

7. These new instruments fit into existing thermowells and are therefore simple direct replacements for existing instruments.

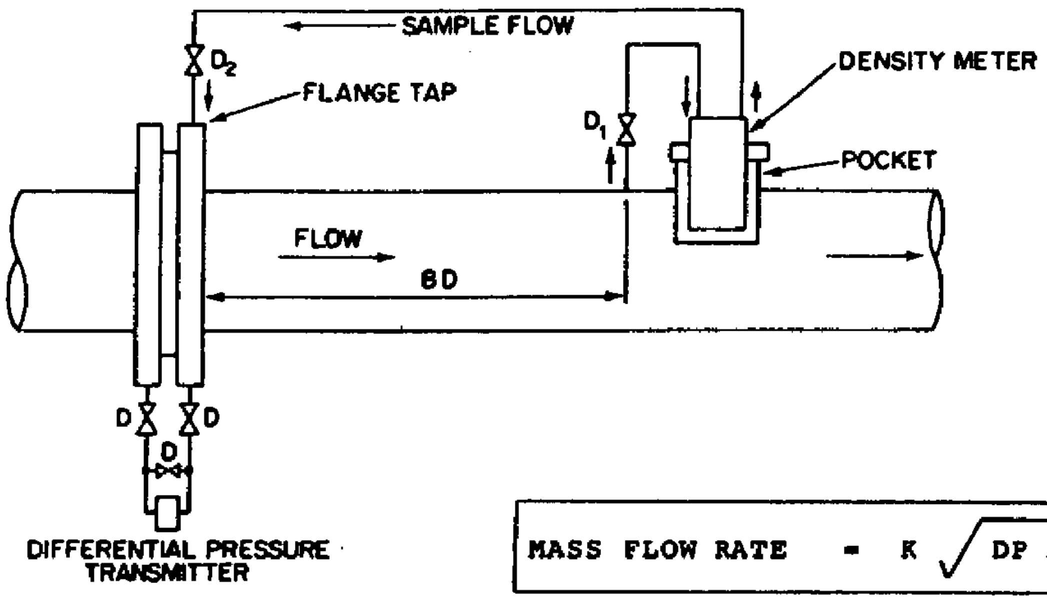
CONCLUSIONS

This new Gas Density Meter, which will shortly be available from Schlumberger Industries, is intended as a direct replacement for existing instruments and for new installation where improved accuracy is required. By reducing the Velocity of Sound effect and by improving the temperature equilibrium features, the on-line measurement uncertainty is reduced by a factor of two. In consequence this instrument offers even greater accuracy benefits over the alternative and indirect methods of determining Gas Density.

REFERENCES

* Velocity of Sound Effect on gas Density Transducers. The Theory, Measurement Results and Methods of Correction. J W Stansfeld - North Sea Flow metering Workshop 1986.

* Petroleum Measurement Manual Part VII, Density - Sect.2. Continuous Density Measurement. Institute of Petroleum, London - November 1983.



$$\text{MASS FLOW RATE} = K\sqrt{\text{DP} \times \text{DENSITY}}$$

Fig 1 ORIFICE GAS METERING SYSTEM

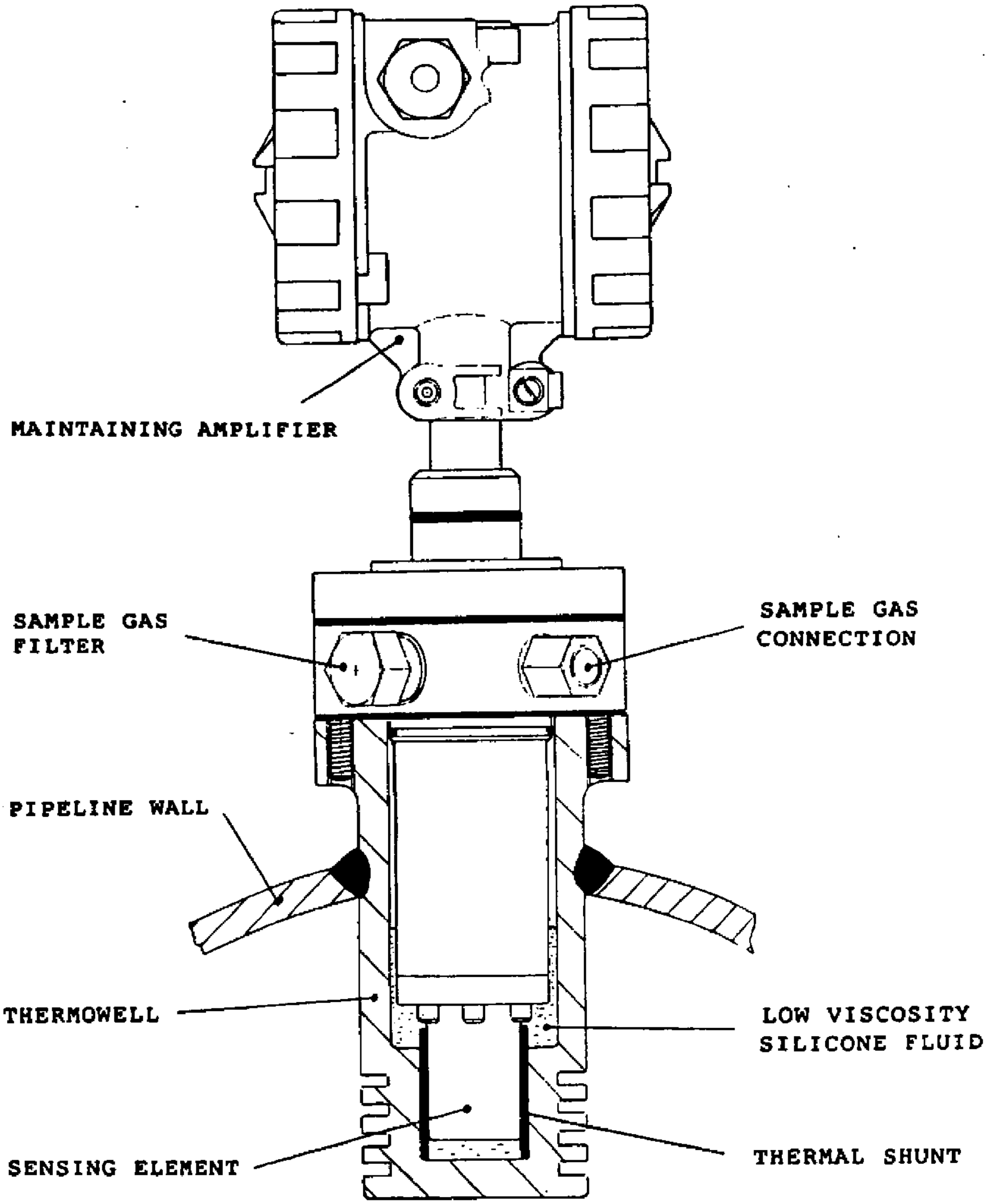


Fig 2 GAS DENSITY TRANSDUCER Type 7812