DREAMS ABOUT LEGAL GAS METERING

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ABSTRACT

The future of gas metering is determined by past, present and future developments in the areas of metrology, economy and metering technology. This paper will show for each of these areas the current developments and development that are likely to occur or to be wished from a user perspective. This view will cover metrological, economical and technological aspects.

Generally, introduction of the concept that there are two types of information in metrology, will simplify the understanding of the background of taking measurements.

Economically, the supply of natural gas will be metered on an energy basis. New miniaturised, fast responding and cheap gas composition measurements will contribute to this market demand.

Not only the development of new and improvement of existing metering principles is important but also the measurement of flow profile, swirl, pulsations, acoustic noise, vibration and the thermodynamic properties of natural gases are important.

For the future the research area for flow meters, energy measurement, natural gas properties, disturbance testing and new metrological phenomena will remain interesting and challenging.

Keywords: Metrology, Gas meters, Energy

INTRODUCTION

Legal gas metering is the activity where gas meters are used to measure the amount of gaseous fuel or industrial gasses for custody transfer purposes, i.e. money transactions for gas supplies and fiscal purposes: taxes, levies and duties. Many counties in the world have for gas meters legal requirements that are based on the current OIML recommendations R6 1, R31 2 and R32 3. In most European countries these recommendations were implemented in their weights and measures legislation. In countries like e.g. Japan and Australia OIML recommendations are implemented via standards that are compulsory for custody transfer measurements. OIML is the International Organisation for Legal Metrology, a treaty organisation established in 1955. The countries that signed the treaty have the moral obligation to implement the OIML recommendations in their national legislation. The objective is to establish coherent metrology legislation in countries, which makes trade between countries easier. Today, OIML counts the membership of 59 countries and the corresponding membership of another 50 countries from all over the world.

The current OIML recommendations are technology oriented: diaphragm meters R31 2, rotary piston and turbine gas meters R32 3, supported by general provisions R6 1. For other technologies (e.g. ultrasonic and coriolis) there are no recommendations. Today, in the Dutch legislation only diaphragm, rotary piston and turbine meters are allowed for custody transfer. Other meter types are possible but only via a dispensation procedure, which takes approximately 6 weeks longer to complete than a regular type approval.

With technology changing at an increasing pace it will serve market interests if legislation is technology independent, a development that was recognised as one of the key issues of the new Measurement Instrument Directive (MID) 4 in the European Union. To this end the current OIML recommendations for gas meters are under revision, which has resulted in a first committee draft 5, which is technology independent. Gas meters are generally part of an entire installation and so a new recommendation for gas metering systems is being developed 6. These new recommendations necessarily form a compromise between the dreams of experts and the interests of countries participating. However, we know that these are going to be revised in the future. So today is an excellent starting point to dream about legal gas metering.

Walt Disney, famous for his creations of Mickey Mouse and Donald Duck, used for his creative work a method that was later called the Disney strategy. Any problem is viewed from three different perspectives: the dreamer, the critic and the realist. The dreamer thinks of anything that would be nice. The sky is even no limit. The critic tells why the new ideas are not possible or why they are actually bad ideas. The realist looks at what can be achieved and how problems can be solved. When changing his perspective Walt Disney actually changed seats and body posture in order to stimulate the new line of approach in his thinking.

For the purpose of this paper we will concentrate on dreaming. Criticism and realism will be postponed to a later occasion. Since gas metering is a combination of metrology, economy and technology, we will focus in our dreams on these three areas.

METROLOGY

The first field of developments to be mentioned here is metrological. Metrology is the science of taking measurements. In scientific metrology metrologists focus on the development of new standards or the improvement of existing standards. Here scientists are dreaming of a couple of new quantum phenomena that will contribute to the development of standards based on fundamental physical constants. In industrial metrology people working in research and development need measurement standards to test the equipment developed. The focus here is the development of more accurate instruments. Legal metrologists focus not only on the application of measuring methods for custody transfer purposes but also on the regulation required for fair trade, health, safety, environment and consumer protection. A concise overview of the different metrology areas can be found in *Metrology – in short* 7, a publication issued by DFM, the Danish national metrology institute.

In the past decades metrology has undergone a paradigm shift leading to the publication in 1993 of the Guide to the expression of Uncertainty in Measurement 8 (GUM). The major implication of the GUM is that uncertainties are part of the measurement results. Instead of saying the length of the table is 1.80 m, we represent the length of the table by (1.80 ± 0.01) m, 0.01 m being the measurement uncertainty.

Also terminology has changed. Terms like *true value* and *error* have lost their practical significance in metrology. Instead of *error* the word *deviation* is used and *true value* is changed to *value*. The best-known estimate of the *value* of a quantity is the reference value obtained from a standard, which is used to determine the deviation of an instrument reading. *Maximum permissible error* is now better replaced by *tolerance*.

Terminology is an important aspect of the language in which we communicate measurement results. In metrology there are currently two dictionaries that contain terminology and definitions that are currently agreed on in metrology. The *Vocabulaire International de Métrologie* VIM 9 is general to metrology; the other is the *Vocabulaire International de Métrologie Légale* VIML 10, which is specific to legal metrology. In these vocabularies a number of terms exist that are not defined in a quantitative way: accuracy, inaccuracy, precision, repeatability, reproducibility.

Some terms actually demonstrate the opposite of their intention. E.g. if we look by repetitive measurements for *repeatability* or *reproducibility* we will find that the instrument show small fluctuations in reading that makes it not entirely repeatable or reproducible. In fact our search for repeatability leads to the opposite. Consequently, *repeatability* and *reproducibility* are nowadays treated as uncertainty sources.

In this information era it is an idea to divide all terms into two categories. One group of terms represent *available information*. Here we have *measured value*, *reference value* and *deviation*. The other group of terms refer to *missing information*, i.e. *measurement uncertainty*. Here we can put all terminology that result in measurement uncertainty: *repeatability*, *reproducibility*, *drift* and *uncertainty*. Now it is also clear that if you do not correct for a known deviation this will result in an additional uncertainty. Terms like *accuracy* and *inaccuracy* have a bit of both categories, which make them confusing. On one hand accuracy expresses a small deviation, on the other hand an accurate instrument also has a low uncertainty. The term inaccuracy has the same ambiguity.

The concept of uncertainty as a measure of missing information has proven to be very useful instrument to help people to master the basic concepts of metrology. Illustration of this idea with examples can be found in a paper by the author 11.

Uncertainties cannot be avoided and that means that these play a role when taking measurement based decisions 12. Examples are speeding tickets for people that drive too fast and approval of instruments with respect to legal tolerances. The probability that a decision is taken correctly is called *confidence level*. The probability of taking an erroneous decision is called *risk*, which is 1 – confidence level. If the instrument deviation equals the tolerance the probability of taking a correct decision is 50%. So the point of standardisation in legal metrology is the minimum confidence level (e.g. 95%) required for metrological decisions.

ECONOMY

Apart from any metrological and technological developments, the gas markets are liberalized in some countries. As a result the trade and transport responsibilities are separated into different companies. Gas transportation and gas distribution companies will not own the gas and get only a fee for transporting the gas to the end user. As a result the gas balance of these companies will get more attention, requiring more accurate gas meters.

Another consequence of the liberalised market is that gas will be supplied from many more different sources than today. As each source has a different gas quality with different calorific value there will be a tendency to bill the supplied gas on an energy basis. However, normal gas appliances like stoves and central heating boilers are not capable of handling entirely different gas qualities. A stove manufactured for a calorific value of 35 MJ/m^3 will get damaged if gas of 42 MJ/m^3 is used. So a constant gas quality is of importance to domestic users of natural gas. The solution here is an intelligent pressure regulator that reduces the gas pressure on the appliances if a higher quality of gas is supplied. This will be possible after the development of a new and miniaturised measurement method for determining the gas composition, which will be also useful for gas metering on an energy basis.

The prices of energy are expected to rise in the near future and this will stimulate a market demand for more accurate meters, new measurement principles, gas meters that meter on an energy basis, automatic reading or telemetry through the internet, gas meters with multiple tariff registers.

However there is another development that will require new metrological methods. The person that manufactures a product or provides services has to demonstrate that his products or services comply with regulations, standards and consumer specifications. Quality systems have been accepted as a means to control design, production, and final product inspection.

Product malfunction will lead more and more to liability lawsuits, which involves high costs of lawyers and possible compensation payments. These payments have increased in the past decades and there is no indication that this tendency will change in the next years. Especially, the new economies will implement legislation on liability according to principles that are used in other countries. The manufacturer wants to know the risk he runs. Statistical and metrological methods will be further developed to assist the manufacturer to maintain his risk at a preset level.

Manufacturers will act on a global market with local needs. Language support will be of vital importance, not only for documentation but also in interpreting error messages that are transmitted in case of instrument malfunction or maintenance requests.

The consumers that are offered a free choice of gas supplier may become owner of the gas meter in which case they will become much more interested in possible meter deviations and measurement uncertainty. Consumers will appreciate more and more clear invoices based on transparent measurement systems that measure gas quantities traceably in energy units.

TECHNOLOGY

The last decade has shown rapid technological developments in the field of gas metering. Compared to the existing diaphragm, rotary piston and turbine gas meters a range of new metering technologies has been developed. Ultrasonic meters and coriolis meters are now used for custody transfer purposes, the latter one measuring gas quantities in mass units. New metering principles are being developed that have potential for custody transfer measurements and existing mechanical measurement principles will be upgraded with electronics to add diagnostic and telemetric functions. Velocity based gas meters, like the turbine gas meter and the ultrasonic meter will be able to compensate asymmetric velocity profiles and even swirl. Clamp-on meters have been developed that are able to measure the flow rate from the vortex noise of the gas flowing in the pipeline 13.

Recently, manufacturers try to develop compact equipment to measure gas in energy units. Although the response time of miniaturised gas chromatographs is much better than the existing process gas chromatographs 14, further miniaturisation is to be expected with almost real time determination of the gas composition. From the gas composition the calorific value of the natural gas can be determined using the ISO 6976 algorithm 15.

The technological and metrological challenges associated with these developments are plenty. As many gas meters are sensitive to flow disturbances, velocity profiles, pulsations and acoustic disturbances adequate tests need to be developed and standardised. Currently, only standardised tests exist for flow disturbances 3, 5. Laser Doppler velocity profile measurements for these disturbance tests under high-pressure conditions is described in 16. Objective of this study is to find flow conditioning methods. These methods can be used to provoke in a straight pipe the velocity profile and swirl typical to two out of plane 90° bends. Such devices will actually reduce the cost of full-scale tests of large diameter gas meters under high-pressure conditions. Ultrasonic Doppler methods are already used for instant determination of velocity profiles in liquids 17.

The influence of pulsating flows 18 and pipe vibrations 19 was investigated by TNO in The Netherlands. These test are not yet performed on a routine basis as part of the product certification of flow meters, but this is likely to change in the future.

A special chapter in technology is the determination of thermodynamic properties of natural gases. Today there are several standards to calculate the real gas factors of natural gases from the full gas composition 20 or some components and the calorific value 21. Also for the speed of sound a standard is available 22. However despite the many computer programs that determine from the gas composition, pressure and temperature the viscosity, the isentropic coefficient, etcetera, the traceability is still poorly documented. Especially, for differential pressure devices the accuracy of the measurement is depending on the uncertainty of the calculated values of thermodynamic properties.

CONCLUSION

At the end of this overview of the metrological, economical and technological aspect our dreams are summarised as follows.

As new insights in metrology become clearer to metrologists, developers and users of instruments, this will give an impulse to improvement of instrumentation and the quality of products improve. The introduction of the concept of available information (deviation, measured value) and missing information (uncertainty) helps people to find their way in the terminology that exists in metrology today.

In a competitive liberalised market consumers will be more aware of value for money. As a result there will be a market demand for metering the energy of gas supplied. Also gas meter accuracy will get more attention, certainly if the prices of energy increase.

Technologically gas meters will be developed that are based on new metering principles. Also energy meters will be developed. Instrumentation to measure the gas composition will become much smaller in size, faster in response and cheaper. For the prototype testing of new gas meters standardised tests will be developed for pulsations, vibrations and acoustic noise. Disturbances test of flow profile and swirl generation can be performed with devices that can be installed in straight pipe lengths, thus avoiding the costs of full-scale tests with large diameter gas meter under high-pressure conditions. Thermodynamic properties of natural gases need to be known in a traceable way in order to improve metering accuracy.

The research on gas metering and adjacent areas will be certainly very interesting for the future.

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