

Hydrocarbon dewpoint measurement with the EnCal 3000:

Efficient combination of measuring tasks in gas quality analysis

The trends in the gas industry, such as liberalisation and globalisation, place new requirements on gas measuring equipment. Gas quality analysis plays a central role in the safe and efficient trade as well as the transportation and consumption of natural gas. In addition to measuring the energy values, other gas quality parameters are also increasing in importance. For example, the hydrocarbon dewpoint is a very important value. Condensate in the gas can adversely affect the integrity of gas equipment during the transport process; when the gas is used, the condensate can present a major danger, for example for combustion gas turbines. The hydrocarbon dewpoint is generally measured using complicated, specialised measuring instruments or by sampling and laboratory analysis. A new development of the gas chromatograph EnCal 3000 from Elster now allows the hydrocarbon dewpoint to be measured in the process conveniently and at low cost while at the same time measuring the energy values.

Market for gas and gas measuring equipment

Over the last few decades the structure of the gas industry has led to massive investments in the transport and distribution infrastructure. This trend is continuing and, in addition to the construction of new

pipelines, the transportation of liquefied natural gas (LNG) in tanker ships is also growing in importance. This means that flexible global trade in natural gas is now possible. In general the investments in the infrastructure also relate to gas measuring equipment, both for the volume and also for the gas quality.

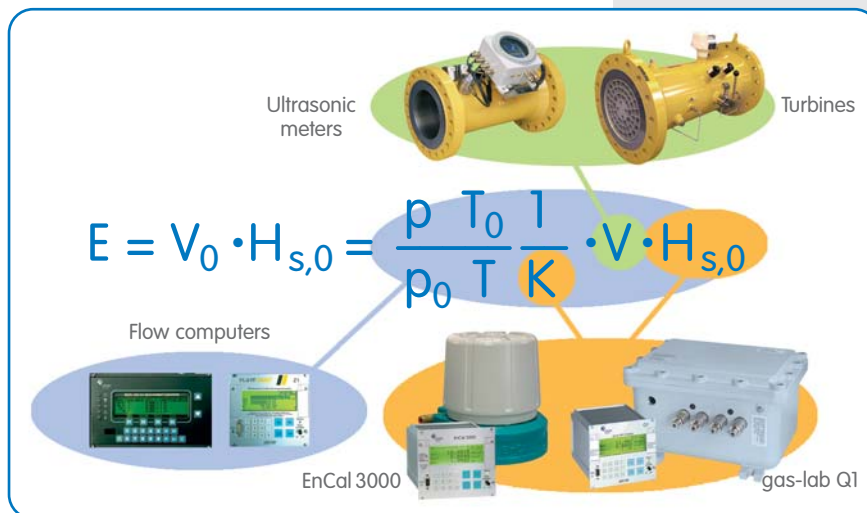


Fig. 1: Products available from the Elster Group for energy measurements



In established gas markets, too, demand for measuring equipment is growing as a result of the requirements imposed by liberalisation and unbundling. As the number of trade partners rises, the number of interfaces which must be fitted with measuring equipment also grows. As a result of international gas trade, the scope of gas quality also continues to increase. These variations must be taken into consideration for transport and distribution in ever more complex networks and also for gas utilisation.

Ultimately, global environmental and climate policy targets also play a driving role for gas measuring equipment. The reduction of emissions and the increase in the energy efficiency of gas consumption processes (for example gas turbines) require efficient measuring, control and regulation equipment.

Basic task for gas measurement and the role of the gas quality analysis

The basic challenge for gas measurement is to determine the energy since this is generally used as the utility value for the consumer and therefore provides a good basis for fiscal billing. The measuring task is described in the equation in Fig. 1.

V is the volume, T is the temperature and p is the pressure in operating conditions. The index 0 denotes the standard state, in other words, for example $p_0 = 1013.25$ mbar and $T_0 = 273.15$ K. Natural gas is a real gas. This is described by the compressibility K , which is dependent on the pressure and temperature and also on the quality of the gas. Finally, $H_{s,0}$ denotes the volumetric calorific value of the gas in standard state.

The product portfolio of the Elster Group includes a wide range of products for a whole host of measuring and calculation tasks (Fig. 1). Elster offers the process gas chromatograph EnCal 3000 and the correlative meter gas-lab Q1 for gas quality analysis. The process chromatograph supplies a high precision, detailed analysis based on substance quantities. The correlative device establishes the main gas parameters such as calorific value, density, CO_2 concentration, Wobbe index and methane number quickly and continuously. It is therefore ideal for measuring, controlling and regulating equipment.

Both devices have been awarded PTB type approvals for completing official measurements.

Extended tasks in gas quality analysis

In addition to this primary task of gas quality analysis to establish the energy values, there are other gas parameters which are important for ensuring that gas can be transported and consumed safely and efficiently. In addition to the calorific value, density and Wobbe index, these particularly relate to individual substances and substance groups such as oxygen O_2 , hydrogen H_2 , carbon dioxide CO_2 , sulphur, particularly H_2S , and also the condensation of water and hydrocarbons. These extended gas parameters are often determined using specialist measuring instruments or by sampling and laboratory analysis.

Process gas chromatographs are the standard tool for gas quality analysis. Classic devices supply an analysis of the main gas components for the calorific value measurement and volume correction process. Current, high performance devices, however, now also make it possible to measure the parameters of an extended gas analysis in the process. For example, the EnCal 3000 can complete a highly sensitive analysis of the hydrocarbons up to nC9. On the basis of this analysis it is possible to calculate an important gas parameter, the hydrocarbon dewpoint. The following reports on this application.

Hydrocarbon condensation and hydrocarbon dewpoint

Natural gas essentially consists of methane, higher hydrocarbons, nitrogen and carbon dioxide. The higher hydrocarbons, in particular, are prone to condense when exposed to the pressures and temperatures which are typically used in the process. The phase properties of a gas are shown in a so-called phase diagram as a function of temperature and pressure (Fig. 2).

The hydrocarbon dewpoint at a given pressure represents the temperature at which the hydrocarbons of the natural gas start to condense out of the gas phase. The maximum dewpoint temperature is known as the cricondentherm and for many typical natural gas types, it will be in a pressure range between around 25 and 45 bar.

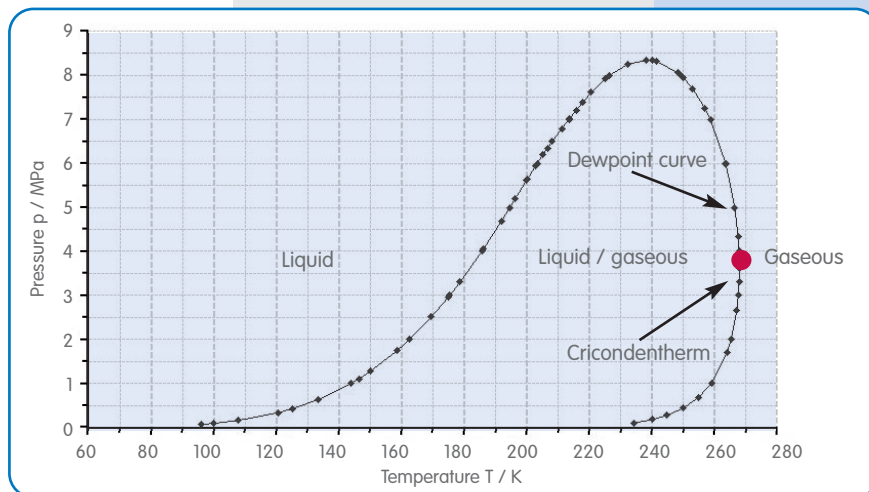


Fig. 2: Phase diagram of a typical natural gas. The envelope curve includes the 2-phase area and therefore separates the areas of the liquid and gaseous phases. If the gas state crosses the dewpoint curve coming from the gaseous phase into the 2-phase area, the result will be hydrocarbon condensate. The dewpoint temperature depends on the pressure. It initially increases at low pressures and falls again at higher pressures (retrograde condensation). The maximum dewpoint temperature is called the cricondentherm.

Practical importance of hydrocarbon condensation

Hydrocarbon condensation is very important for safety when transporting gas. Condensate may adversely affect the function and integrity of gas equipment, particularly regulators, valves and measuring systems.

Hydrocarbon condensate can also cause problems when using gas, primarily when used in combustion gas turbines. Condensate can accumulate in the gas transport system and in certain operating conditions this will lead to the condensate being transported in surges. This, in turn, produces temporary overheating and can result in the machine suffering damage. But even low, uniform concentrations of condensate can adversely affect the operation of a gas turbine by causing ignition delays or post-ignitions during the combustion process. Premature spontaneous ignition can also occur in turbines with a fuel premixing system.

Therefore there are sufficient reasons for all parties in the production, transport and consumption chain to specify the potential for hydrocarbon condensation of the natural gas. The hydrocarbon dewpoint is thus often a major gas quality parameter in supply contracts.

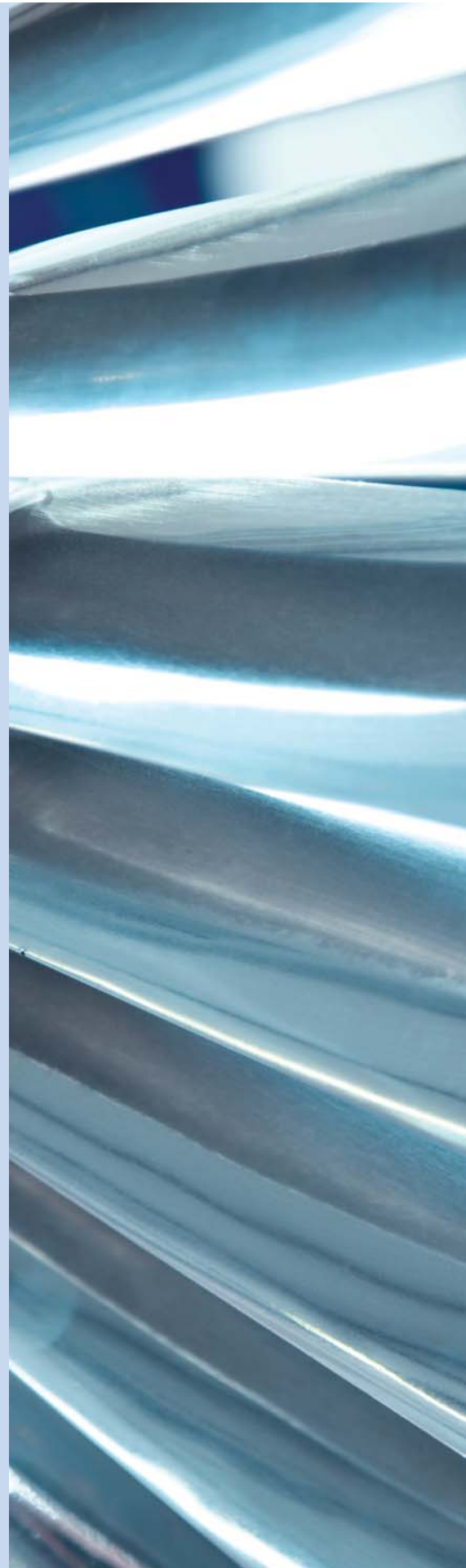
For this reason, hydrocarbon condensation is also specified in a range of technical regulations. The DVGW regulations require that the condensation point of hydrocarbons at the relevant pipeline pressure is less than the ground temperature [1]. The EASEE-gas Committee has specified a limit of -2°C for the pressure range from 1 to 70 bar for the hydrocarbon dewpoint [2].

However, specifications require that this be checked by means of measurement. Elster has therefore developed an option for establishing the hydrocarbon dewpoint from an extended gas analysis for its process gas chromatograph EnCal 3000.

Methods for measuring the hydrocarbon dewpoint

Direct method: condensation on a cooled mirror

One fundamental method is to find the hydrocarbon dewpoint using a cooled mirror. The principle of this method is based on the formation of a film of condensate on the surface of an illuminated, cooled mirror. The sample gas flows over a mirror at a defined pressure (typically 27 bar). The mirror is cooled until a film of condensate forms at the dewpoint. The threshold point is detected in the reflected light so that the dewpoint can be identified.



The basic measuring principle has been implemented in both manual and automatic mirror dewpoint meters. The measurement results of various types are certainly subject to systematic variations. The reproducibility of the results from the manual dewpoint meters is also dependent on the skill and experience of the operator. Mirror dewpoint meters have become established as the standard for hydrocarbon dewpoint measurements.

Indirect method: calculation using the gas analysis

The dewpoint can also be calculated indirectly from the gas analysis using state equations. The benefits of this method compared to direct dewpoint measurements is the fact that it is possible to calculate the complete phase properties of the gas. This means that the dewpoint for a range of pressures or even for the current pipeline pressure can be found. The requirement for this method, however, is a very detailed and high precision analysis of the gas up to the high hydrocarbon orders. This means that the indirect method of finding the dewpoint from the gas analysis generally involves discontinuous sampling and analysis using laboratory gas chromatographs.

ISO 23874 [3] describes the requirements for the gas chromatograph analysis and the algorithm for preparing the chromatograph data for completing the calculation in the state equations. This standard describes the following main steps:

- Standard analysis of the main components of natural gas: nitrogen N₂, carbon dioxide CO₂ and hydrocarbons from C1 to nC5
- Analysis of the higher hydrocarbons over nC5 to nC12 using boiling point separation
- Individual analysis of the benzene, cyclohexane, methylcyclohexane and toluene components
- Analysis of the unidentified components, generally alkane isomers and modelling their substance properties such as boiling point, from the retention time
- Grouping the unidentified components with the corresponding n-alkane to form an equivalent fraction and modelling the effective substance properties of this fraction.

In a study by the National Physics Laboratory (UK), various direct and indirect methods for measuring the hydrocarbon dewpoint were investigated [4]. The study produced a distribution of the various measuring methods in a range of around 10°C. This means that, on the one hand, the study shows that the determination of the "true" dewpoint is technically demanding and that a specification of the dewpoint measurement should always also define the analytical method to be used. On the other hand, the study also shows, however, that the indirect determination of the hydrocarbon dewpoint using a GC analysis can be a real alternative to the established direct method using a dewpoint mirror.

Hydrocarbon dewpoint measurement with the process gas chromatograph EnCal 3000

Conventional process gas chromatographs for measuring calorific values typically do not supply a suitable analysis for calculating the dewpoint since the hydrocarbons above hexane cannot be determined with sufficient detail or accuracy. The process gas chromatograph EnCal 3000 now offers a detailed and high precision analysis up to n-nonane (C9). On the basis of this increased analytical performance of the

Compared to a conventional measuring system consisting of a C6 gas chromatograph and a separate dewpoint measurement with a cooled mirror, the apparatus requirement and therefore the investment and maintenance costs are drastically reduced.

Validation

A comparison with direct mirror dewpoint meters was carried out to validate the hydrocarbon dewpoint measurement of the EnCal 3000. The comparison measurements were carried out at the laboratories of Effectech (Uttroeter, UK), one of the participants in the NPL study, using the original natural gas samples used in the study (Fig. 4).

The diagrams show the dewpoint curves calculated from the gas chromatograph analyses and using the algorithm used by the EnCal 3000. The results for these typi-



Fig. 3: Process gas chromatograph EnCal 3000 with process computer for calculating the hydrocarbon dewpoint

EnCal 3000, Elster has developed an algorithm for calculating the dewpoint, which has been derived from ISO 23874 and to which additional data modelling has been assigned.

To determine the dewpoint, the EnCal 3000 requires an appropriate separation column for the C9 analysis and an external process computer (Fig. 3). This enables the system to complete a C9 analysis within a cycle time of five minutes, and this analysis can then be used to calculate the calorific value and the hydrocarbon dewpoint.

cal natural gas samples are between the values found by the manual and automatic mirror dewpoint meters. They are therefore within the systematic differences between the various established quasi-standard measuring methods. The validation shows that the hydrocarbon dewpoint measuring method using the EnCal 3000 can provide a comparable alternative to the established standard measuring methods using a dewpoint mirror.

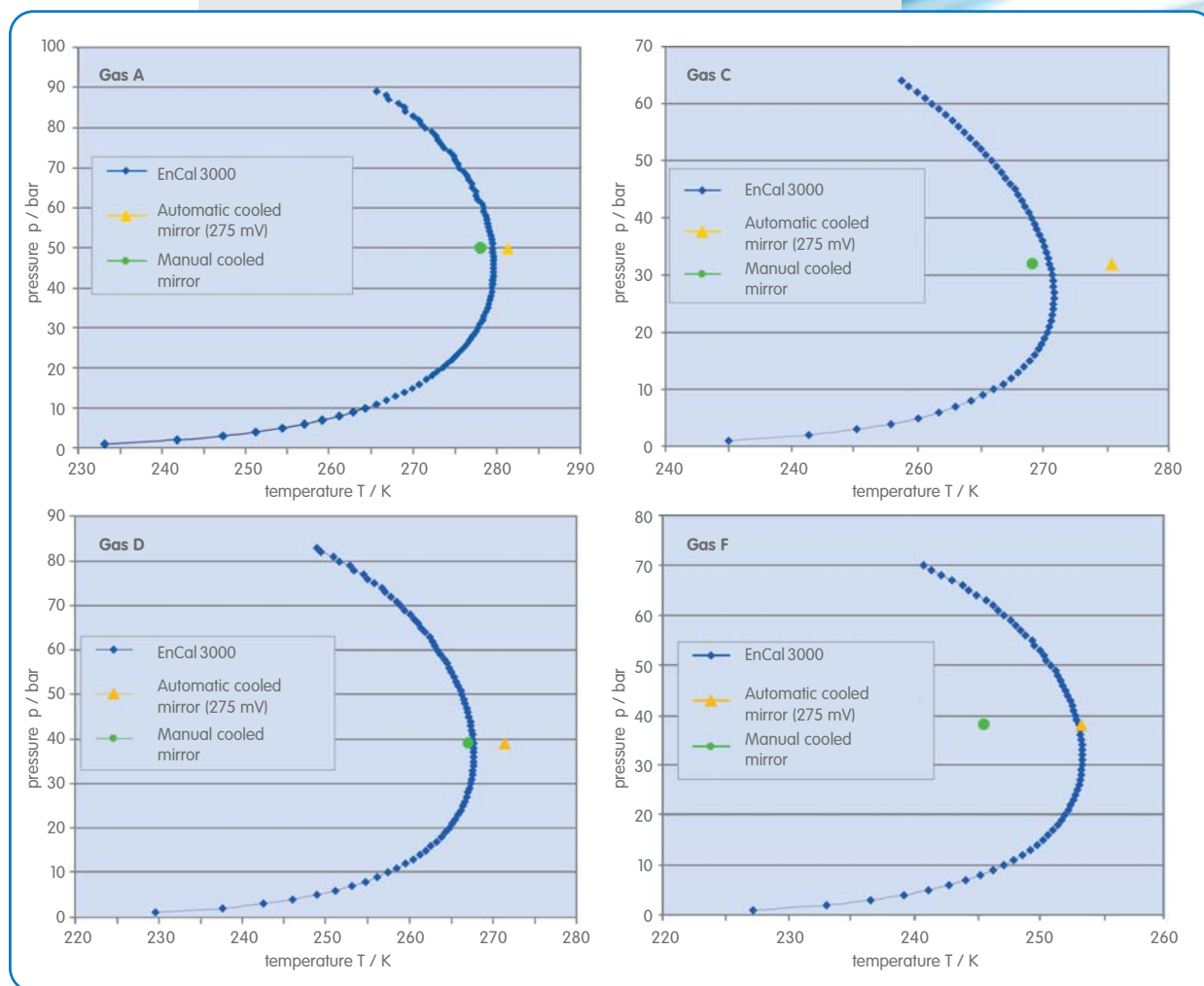


Fig. 4: Comparison of the dewpoint measurement with various methods on real gas samples: direct measurements using manual and automatic mirror dewpoint meters. Indirect dewpoint measurement from the gas chromatograph analysis of the EnCal 3000 (internal measurements and study by the National Physics Laboratory [4]).

Summary

Gas quality analysis plays an important role in determining energy values. However, additional gas quality parameters are important for transporting, storing and using gas, but in the past they have required a wide range of highly specialised measuring methods. One of the main parameters in this respect is the hydrocarbon dewpoint. A current development of the process gas chromatograph EnCal 3000 now makes it possible to determine this complex gas quality parameter conveniently using an extended gas analysis and subsequent calculation using state equations. The hydrocarbon dewpoint is measured in combination with the energy measurement and therefore offers attractive potential savings in terms of investment and maintenance costs.

Dr. Joachim Kastner

j.kastner@elster-instromet.com

Addy Baksteen

a.baksteen@elster-instromet.com

Bernd Brendemühl

b.brendemuehl@elster-instromet.com

References

- [1] DVGW Codes of Practice G260, G262
- [2] <http://www.easee-gas.org/>
- [3] ISO 23874:2006(E) Natural Gas – Gas chromatographic requirements for hydrocarbon dewpoint calculation
- [4] NPL Report AS 3, May 2007, Comparison of methods for the measurement of hydrocarbon dewpoint of natural gas