EnCal 3000

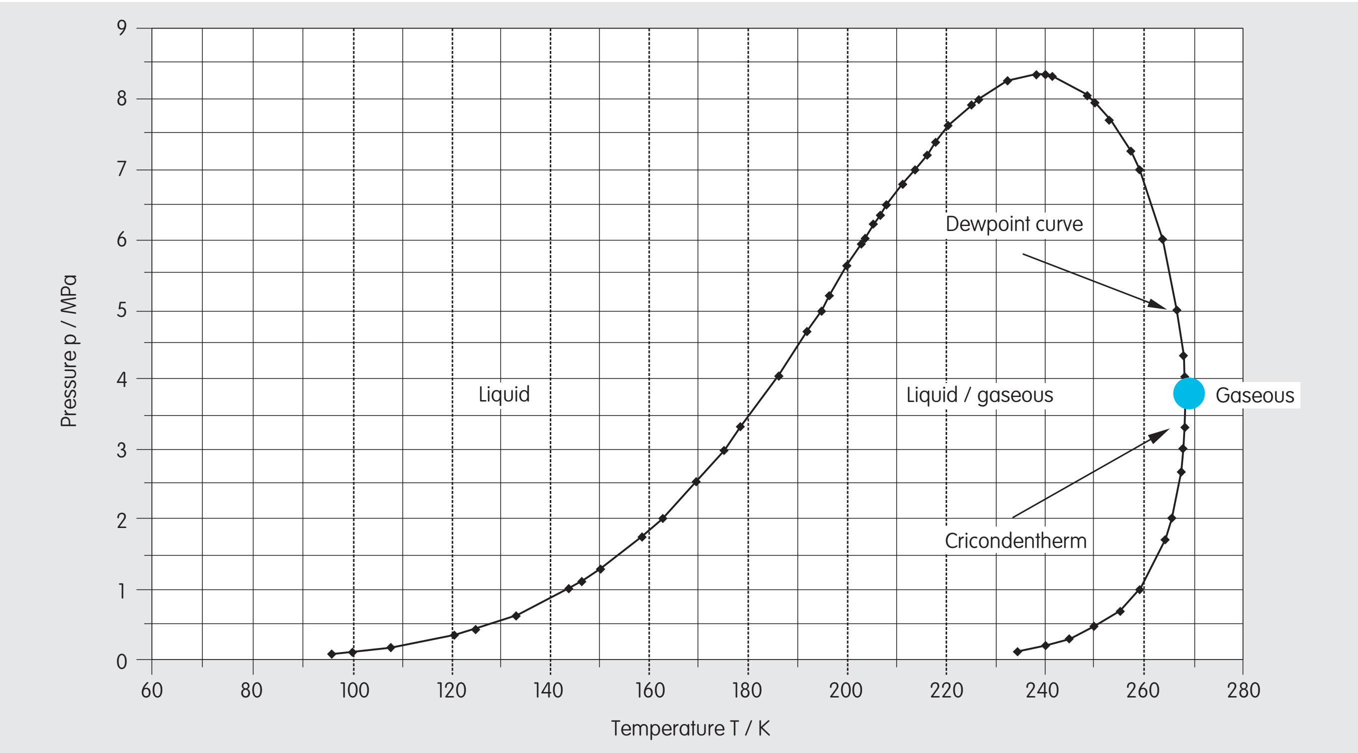
Hydrocarbon Dew Point Calculation
- C_9 analysis
- C_{12} analysis

Introduction

Process gas chromatographs are the standard tool for gas quality analysis. Classic devices provide 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. On the basis of this analysis it is possible to calculate an important gas parameter, the hydrocarbon dew point.

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.



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. 1). The hydrocarbon dew point 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 dew point 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.

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 dew point is thus often a major gas quality parameter in supply contracts.

EnCal 3000: Hydrocarbon dew point calculation - C_9 analysis - C_{12} analysis

C_9 based HC dew point calculation

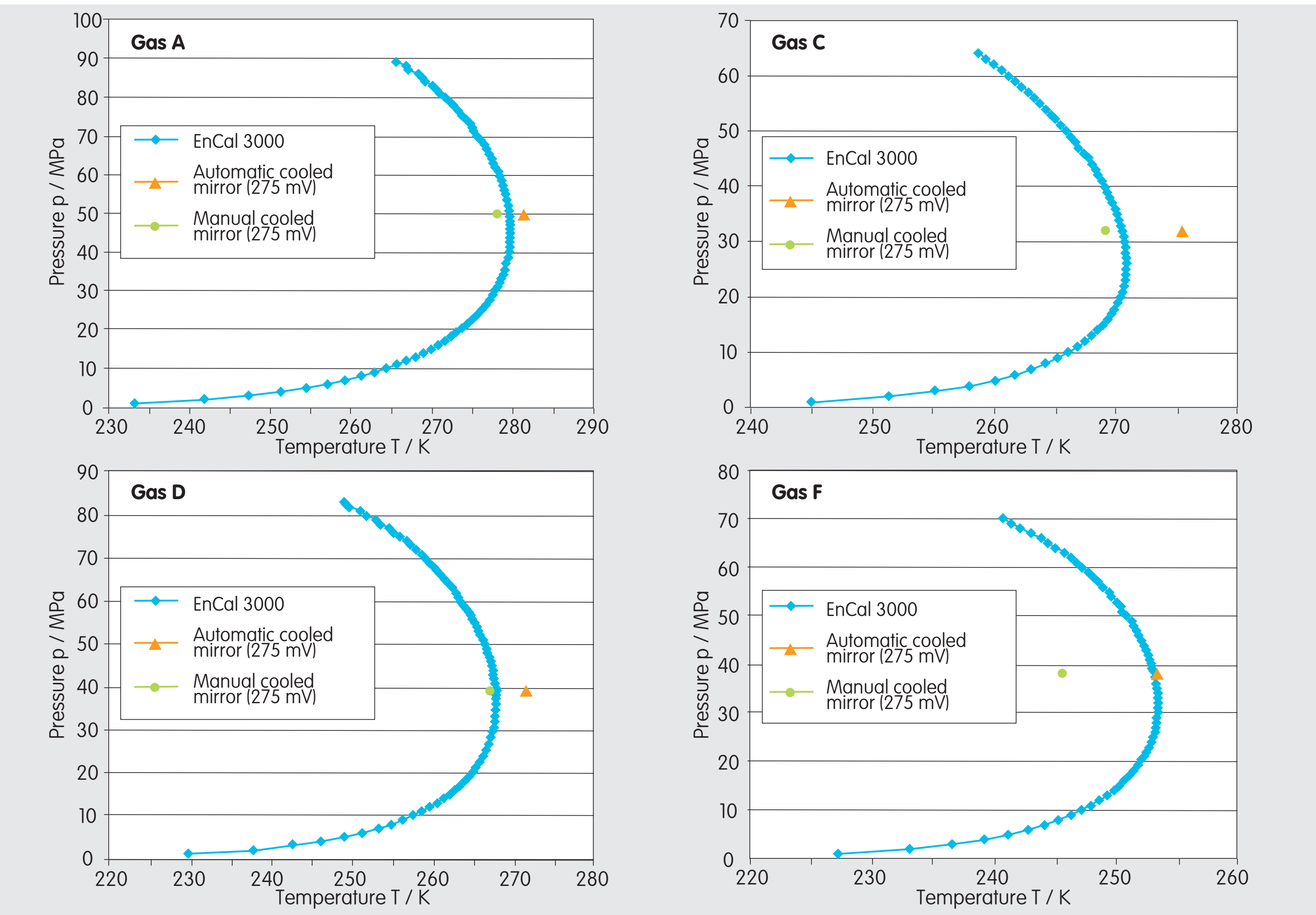
Conventional process gas chromatographs for measuring calorific values typically do not supply a suitable analysis for calculating the dew point since the hydrocarbons above hexane cannot be determined with sufficient detail or accuracy. Available solutions with FID based gas chromatographs require Hydrogen and purged Ex housings which results in high cost systems. With the Encal 3000, based on the latest MEMS technology, we can now offer solutions which are much more economic.

The process gas chromatograph EnCal 3000 now offers a detailed and high precision analysis up to n-Nonane (C_9). On the basis of this increased analytical performance of the EnCal 3000, Elster has developed an algorithm for calculating the dew point, which has been derived from ISO 23874 and to which additional data modeling has been assigned. To determine the dew point, the EnCal 3000 requires an appropriate separation column for the C_9 analysis and an external process computer. This enables the system to complete a C_9 analysis within a cycle time of five minutes, and this analysis can then be used to calculate the calorific value and the hydrocarbon dew point. Compared to a conventional measuring system consisting of a C_6 gas chromatograph and a separate dew point measurement with a cooled mirror, the apparatus requirement and therefore the investment and maintenance costs are drastically reduced.

Validation

A comparison with direct mirror dew point meters was carried out to validate the hydrocarbon dew point measurement of the EnCal 3000. The comparison measurements were carried out at the laboratories of EffecTech (Uttoxeter, UK), one of the participants in the NPL study, using the original natural gas samples used in the study. The diagrams below show the dew point curves calculated from the gas chromatograph analyses and using the algorithm used by the EnCal3000. The results for these typical natural gas samples are between the values found by the manual and automatic mirror dew point meters. They are therefore within the systematic differences between the various established quasi-standard measuring methods. The validation shows that the hydrocarbon dew point measuring method using the EnCal 3000 can provide a comparable alternative to the established standard measuring methods using a dew point mirror.

Methode comparison (C_9 calculation vs. mirror dew point meters)



Hydrocarbon Dewpoint Analysis EnCal 3000 (C_{9+})

Carrier gas:
Helium, 50l x 200 bar / a

Calibration gas:
- N_2, CO_2
- Alkanes: C_1, C_2, C_3, iC_4, nC_4, $neoC_5$, nC_5, nC_6, nC_7, nC_8, nC_9
- Cyclic components: Benzene, Cyclohexane, Methylcyclohexane Toluene

Extended GC analysis within 5 minutes:
- N_2, CO_2
- Alkanes: C_1, C_2, C_3, iC_4, nC_4, $neoC_5$, iC_5 nC_5, C_6, C_7, C_8, C_9 incl. isomers < nC_9
- Cyclic components: Benzene, Cyclohexane, Methylcyclohexane Toluene

Calibration:
- Automatic, daily
- Fully traceable

Calculation:
- Modelling of unknown components
- Modelling of C_{10}, C_{11}, C_{12} by concentration breakdown
- Peng-Robinson or Redlich-Kwong-Suave EoS
- Reference pressure: Live or fixed values

C_{12} based HC dew point calculation

For some applications customers prefer a full C_{12} analysis as a basis for the Hydrocarbon dew point calculation. Even more detailed analysis results are then obtained and in case of calamities which may result in sudden increase of the C_{11} and/or C_{12} concentration this will be noticed and the user will be warned that such a calamity has taken place. This application requires a combination of two gas chromatographs.

EnCal 3000 (1):

This analyser uses two channels which each contain an injector a column and a TCD detector. Channel 1 will identify and measure the components: N_2, CO_2, C_1, C_2, Channel 2 will identify and measure: C_3, iC_4, nC_4, $neoC_5$, iC_5, nC_5, C_6, C_7, C_8, including isomers < nC_8. Furthermore the following cyclic components are identified and directly measured: Benzene, Cyclohexane, Methylcyclohexane and Toluene. The cycle time for this analysis is 4 minutes and the heating value calculation will be based on the measured concentrations and data of all these components.

EnCal 3000 (2):

This analyser will only contain 1 channel which is used to measure C_9 up to C_{12}. This analysis will take 4 minutes as well.

Calibration

Both gas chromatographs will be calibrated automatically and daily with a special calibration gas based on the typically used 11 components for natural gas energy metering: N_2, CO_2, C_1, C_2, C_3, iC_4, nC_4, $neoC_5$, iC_5, nC_5, nC_6. In addition there will be further n-alkanes nC_7, nC_8, nC_9, nC_{10} and some additional cyclic components needed for accurate hydrocarbon dew point calculation: Benzene, Cyclohexane, Methylcyclohexane, Toluene

The analyser EnCal 3000 (2) will calculate response factors for nC_9 and nC_{10} by direct calibration. The response factors for C_{11} and C_{12} are determined by relative calibration from the nC_{10} component. Since there are no calibration gases available on the market with a true traceability for C_{11} and C_{12}, it is better to base the response factors on the response factor of nC_{10} which is obtained via a traceable calibration. In addition C_{11} and C_{12} are delicate to handle without sampling errors, which might exceed the approximation done by the relative calibration with nC_{10}.

Since the full calibration of the whole analyzer system will take place daily and automatically this should be a preferred method compared to costly and time consuming manual calibration procedures.

EnCal 3000: Hydrocarbon dew point calculation - C_9 analysis - C_{12} analysis

Calculations

The data retrieved from both EnCal 3000 devices will be transferred via TCP/IP protocol to the EnCal 3000 control unit. In this control unit the HC dew point calculation will be done according to the desired calculation method RKS (Redlich-Kwong Soave) or PR (Peng-Robinson).

C_{10}, C_{11} and C_{12}:
In most gases the C_{10}, C_{11} and C_{12} concentration is so low that it does not influence the Hydrocarbon condensation significantly. These low concentrations are below the detection limit of the EnCal 3000 (2). Hence the algorithm will derive the C_{10}, C_{11} and C_{12} by concentration breakdown calculation, in case they are not detected by the EnCal 3000 (2). In cases where significant levels of C_{10}, C_{11} or C_{12} are present they will be detected and if so the measured values will be used rather then the derived values.

Features

- The complete analysis up to C_{12} and the HC dew point calculation are completed within a total of 4 minutes. This in contradiction to systems where only the C_{6+} analysis is refreshed every 4 minutes and the C_{12} analysis takes much longer (up to 12 minutes or longer)

- Fully traceable calibration whereas a calibration gas containing nC_{11} and nC_{12} components can not be traceable.

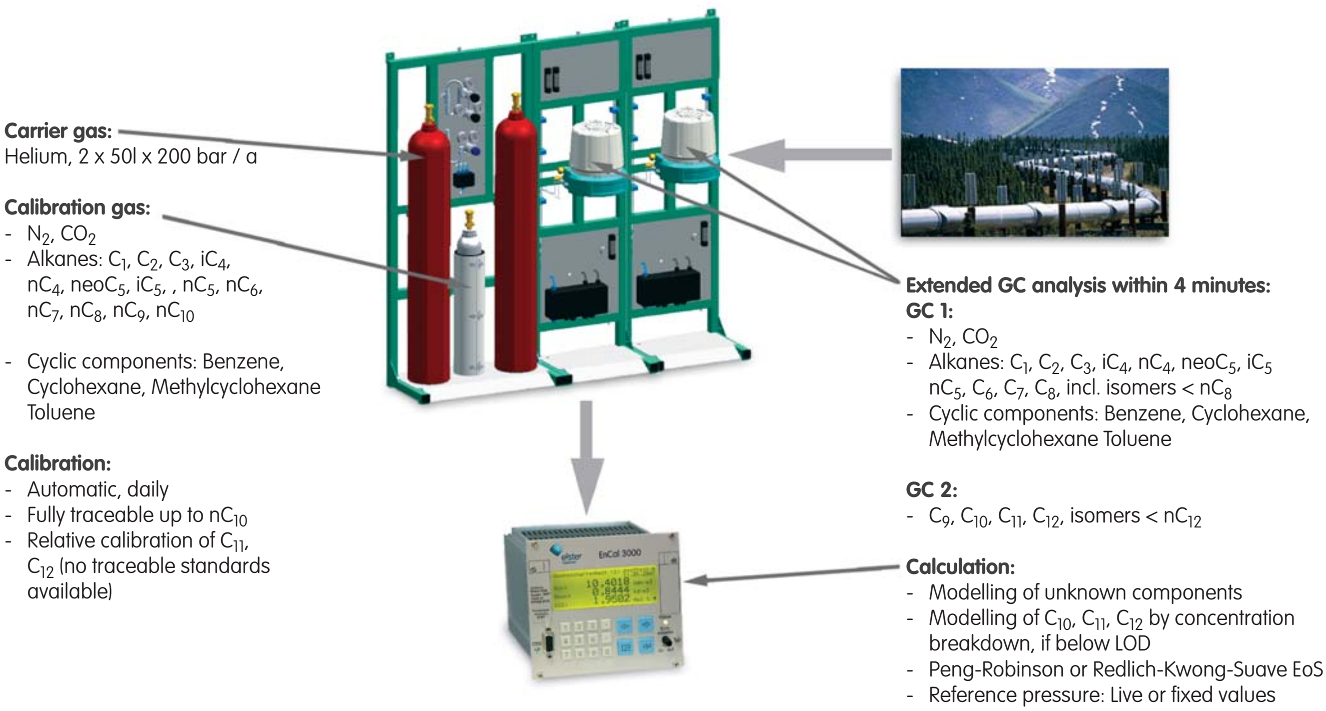
- Automatic and daily calibration. The frequency of calibration will reduce the time frame of potential mis-measurement dramatically compared to for example monthly calibration. Warnings can be generated based on too big variations in calculated response factors.

- The automatic calculation of the relative response factors for C_{11} and C_{12} based on C_{10} response factor will reduce the chance of errors towards manual calibration.

- Rather then ignoring C_{10}, C_{11} and C_{12} concentrations below the detection limit it is better to use a model calculation for them based on the C_9 concentration. However if C_{10}, C_{11} and C_{12} will be present in concentrations above the detection limit then the measured value will be used. This means that any calamities that result in high concentrations of C_{10}, C_{11} or C_{12} components but which are not necessarily reflected by a higher C_9 concentration will be taken into account and will be reflected correctly in the HC dew point.

- Low total cost of ownership:
  - Helium consumption per year will be approx. 2 * 50 L @ 200 bar
  - No site visits for manual calibration required

Hydrocarbon Dewpoint Analysis EnCal 3000 (C_{12+})



Analyser specifications

	HC dew point calculation C_9	HC dew point calculation C_{12}
Analytical hardware	1 EnCal 3000 with 2 parallel isothermal GC modules with narrow-bore capillary column technology in combination with MEMS based analytical components Controller Unit EnCal 3000	GC1: EnCal 3000 with 2 parallel isothermal GC modules GC2: EnCal 3000 with 1 isothermal GC module All modules use narrow-bore capillary column technology in combination with MEMS based analytical components Controller Unit EnCal 3000
Analysis output	Full composition of any natural gas up to C_9 Heating value, density, Wobbe index HC dew point temperature	Full composition of any natural gas up to C_{12+} Heating value, density, Wobbe index HC dew point temperature
Component range	N2, CO2, C1, C2, C3, iC4, nC4, neoC5, iC5, nC5, C6, C7, C8, C9, including isomers < nC9. For HC dew point calculation following cyclic components are identified and directly calibrated: Benzene, Cyclohexane, Methylcyclohexane and Toluene	GC 1: N_2, CO_2, C_1, C_2, C_3, iC_4, nC_4, $neoC_5$, iC_5, nC_5, C_6, C_7, C_8, including isomers < nC_8. For HC dew point calculation following cyclic components are identified and directly calibrated: Benzene, Cyclohexane, Methylcyclohexane and Toluene GC 2: C_8, C_9, C_{10}, C_{11}, C_{12}, incl. isomers <nC_{12}
Performance		
Repeatability	0.01 % Heating value	0.01 % Heating value
Uncertainty	0.1 % (Heating value excl. calibration gas uncertainty)	0.1 % (Heating value excl. calibration gas uncertainty)
Analysis time	5 min. for C_9 analysis	4 min. for C_{12} analysis (both GC's parallel)
Detection limit	1 ppm for n-C_9	0.5 ppm for nC_9 –nC_{11} 1 ppm for nC_{12}