Field verification of on-line HC dew point measurements

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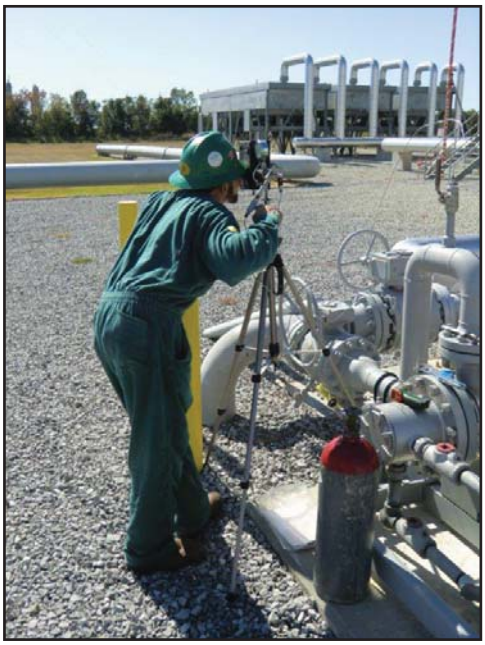
Introduction:

The Michell Condumax II applies a fundamental measurement principle for direct measurement of hydrocarbon dew point. Measurement performance is assured through comprehensive factory test and calibration, to verify that each analyser offers accurate determination of the temperature at which hydrocarbon condensate forms. Further extensive examination confirms highly sensitive detection response to the fractional condensation characteristics of natural gas from within the onset of a measureable hydrocarbon dew point within the lowest region of condensate in gas density.


Typical Condumax II Installation

Over the last three decades of Michell's experience for this critical gas quality parameter, a number of methodologies have evolved to verify and maintain the performance of our analysers in the field. Such methods are explored below, including the ability to harmonise the measurement sensitivity of the Condumax II to a specific customer-designated reference.

Factory calibration and field verification methods:


Bureau of Mines Operation

Hydrocarbon dew point is defined in ISO 14532: 2001 – Natural Gas Vocabulary as 'the temperature above which no condensation of hydrocarbons occurs at a specified pressure'. The Michell Condumax II applies an adaptation of the fundamental cooled-mirror principle for the direct measurement of hydrocarbon (HC) dew point. The unique 'Dark Spot' detection principle offers a degree of sensitivity and repeatability that cannot be achieved through indirect estimations of this parameter derived from equation-of-state calculation from composition analysis or through direct measurements using a manually operated chilled-mirror dew point apparatus. Since its first introduction in 1985, the Condumax I/II have become established as the industries' leading analyser for policing this key contractual specification parameter of gas quality with gas producers and transmission pipeline operators both across the European network and elsewhere in the world.

Although the Condumax II applies fundamental principles to a high degree of sensitivity the measurement of HC dew point differs from other parameters in that no metrology standards exist against which traceable calibration can be maintained. This calls into question how the calibration of an automatic HC dew-point analyser can be maintained in field service, which is achieved in a number of ways in the case of the Condumax II, to fulfil applicable business practices for gas quality standards and suit specific customer's preferred practices.

The traditional field verification method applied to on-line automatic HC dew point analysers is by periodic comparison with manual visual measurements made using Bureau of Mines dew point apparatus or derivatives thereof, such as the Chandler Dew Point Tester. Such spot-check manual measurements have the advantage of

being a direct determination of HC dew point but with a reputation for being subjective due to high operator dependence. The accuracy of such measurements is dependent on the skill of the operator to adhere strictly to the correct procedure (ASTM D1142 Standard Test Method for Water Vapor Content of Gaseous Fuels by Measurement of Dew-Point Temperature adapted from water to HC dew point measurement) and correctly interpret the condensation formations observed on the cooled mirror, indentifying the HC condensate while discriminating other formations such as glycol, water, ice, methanol and hydrates. This is a growing problem over recent years as personal experienced in making such measurements is becoming rare.

Field Verification Using Certified Gas

It is an increasing practice of some natural gas companies to perform in-situ performance checks on their on-line HC dew point analysers using cylinder gas of certified composition provided by technical/ speciality gas suppliers. The form of gases applied varies from a high purity single component hydrocarbon such as 100% n-propane, to a binary mix of a hydrocarbon in a carrier gas such as 10% n-butane in nitrogen. Alternatively, a synthesised natural gas mixture can be applied, comprising up to 8 or more components from methane to octane or even including a small single-figure ppm concentration of nonane and decane. The HC dew point temperature versus pressure relationship is predicted using an equation of state.

Such a methodology can be applied to good effect but special consideration must be given to a number of important technical aspects:

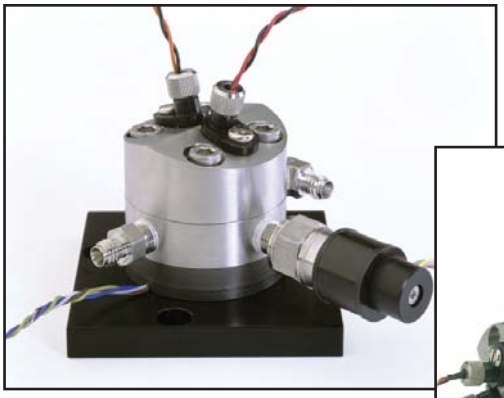
- Preparation of the cylinder through rolling and heated jacketing to assure composition integrity in conformance to certification,
- attention to the purity of individual components within the mixture and the uncertainty of gravimetric certification, and, most significantly –
- the correct application of equation-of-state to derive predicted HC dew point values and the uncertainty margin thereof.

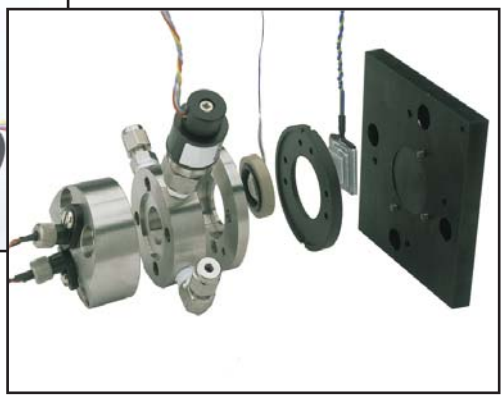
All these methods of field verification can be applied to the Michell Instruments' Condumax II to fulfil individual customer preference.

In some cases a customer may employ the specialist skills of the analyser calibration laboratories at the Michell factory to provide a replacement HC dew point Sensor Cell on an annual or biennial basis. The period varies as recommended by the Michell depending on the severity of the application. For example, sour gas applications may benefit from a more stringent performance and preventative maintenance schedule.

The sensor cell incorporates all the critical measurement components of the analyser, including:

- optical surface (mirror),
- cooled surface temperature sensor,
- detection photo-electronics and
- Peltier heat-pump.





The replacement Sensor Cell will benefit from Michell's factory calibration, the same as applied to newly-built Condumax II analysers, using three test gases carrying gravimetric certification (traceable to metrology mass standards):

1. A binary mixture of n-butane in a background of nitrogen. This gas has a precisely defined HC dew point temperature versus pressure relationship, so enables confirmation of the accuracy of condensate formation temperature over a wide range of temperatures from -30 to 20°C.

2. and 3. Complex synthesised natural gas blends of compositions comprising methane to octane and methane to decane. In addition to the gravimetric certification, the C1-C10 mixtures are calibrated by the UKAS[1]-accredited laboratory in accordance with ISO 6143:2001 - Gas Analysis - Determination of Composition of Calibration Gas Mixtures - Comparison Methods. These gases prove the sensitivity and repeatability of the analysers' 'Dark Spot' detection principle to respond to the minute fraction (order of single figure mg/m^3) of low surface tension film that forms in the onset to a measureable HC dew point.

The replaced Sensor Cell taken from the field can be returned to Michell for refurbishment and re-calibration, on a change-out rotation basis, so replenishing the customer's site spares inventory while achieving an effective preventative maintenance routine for the installed analyser.

Harmonisation to designated measurement sensitivity:

Such field verification and performance maintenance methods applied to Condumax I and II have proven satisfactory in meeting the needs of the natural gas production processing and pipeline transmission industries over recent the last 30 years. None can be said to be an ideal reference given the superior detection sensitivity and objective measurement repeatability for the Dark Spot detection principle of the Condumax II.

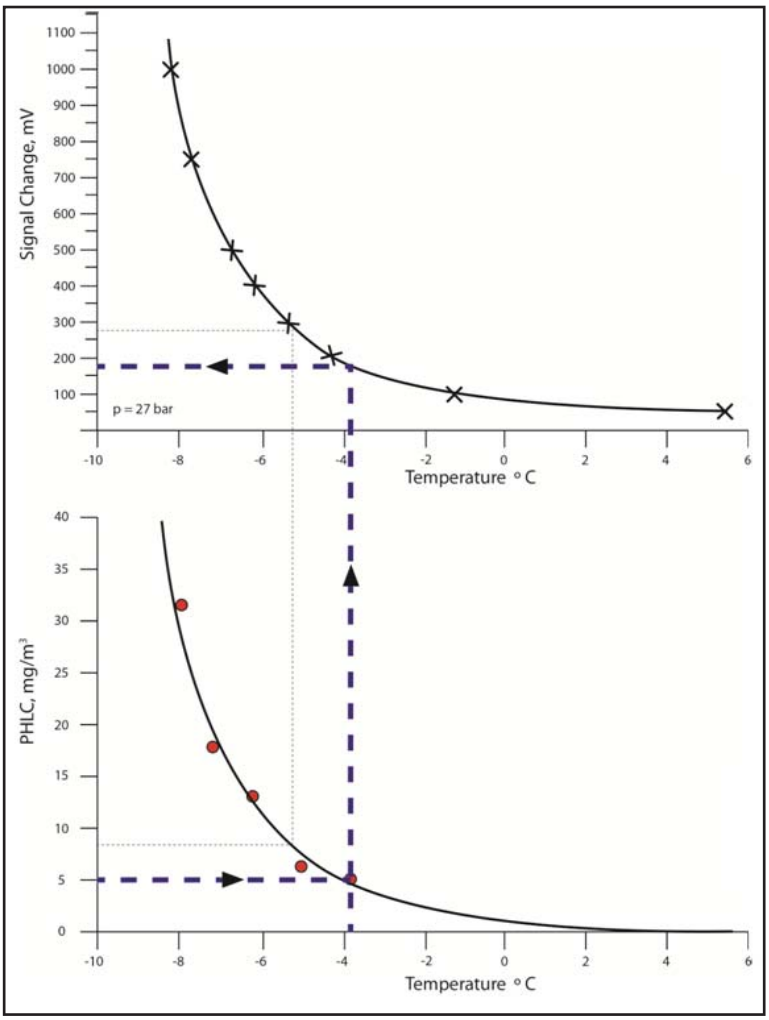
An exception to these methods is found with Gasunie Transport Services (GTS) in The Netherlands. Work carried out by Gasunie Research from 2004 lead to an ISO Technical Report in 2008 defining a calibration method for automatic HC dew point analysers to a specific measurement sensitivity quantified in terms of mass of HC condensate per unit volume of gas (so density of condensate in gas) occurring at the measured HC dew point and prevailing analysis pressure. Gasunie apply a PHLC (Potential Hydrocarbon Liquid Concentration) value of 5mg/Nm^3, in accordance with the specific gas quality contractual specification applicable for their national gas supply network. To implement this calibration practice in the field, Gasunie Research (now KEMA GCS) applied a specialist analysis system they developed for pseudo on-line PHLC measurement using an automatic weighing method in accordance with ISO6570 – Natural Gas – Determination of potential hydrocarbon liquid content – Gravimetric methods. The sensitivity of the Condumax II is harmonised to the desired PHLC threshold by fine adjustment of the trip point value of the signal change response to detecting the HC condensate formation on the cooled 'mirror' optical surface of the analyser. Through such trip point threshold adjustment the measurement sensitivity of the analyser is aligned to the desired PHLC concentration value of 5mg/m^3. This is far more sensitive than a Bureau of Mines measurement of HC dew point that achieves a measurement aligned to 15 to 40 mg/m^3, depending on operator skill and the characteristics of the gas composition in terms of rate of condensate formation. GTS currently apply this method of field calibration to the 20 or more Condumax II that operate across the transmission network within The Netherlands. The calibration method applied is described in ISO TC 193/SC 1 N 299 – Natural Gas – Calibration of chilled mirror type instruments for hydrocarbon dew point (liquid formation).

Broader across the European transmission network consideration is being given to implementing such a tighter definition for HC dew point measurement sensitivity. Gas quality parameter limits are set in EASEE-gas Common Business Practice (CBP) – 2005-001/01 – Harmonisation of Natural Gas Quality for cross boarder points entering the EU and across the European gas transmission network. Together with limitation set in this CBP for Wobbe Index, gas density and trace impurities a limit is set on the maximum permissible HC dew point temperature. This limit is -2°C at any pressure from 1 to 70 bar(abs), commonly measured at 27 barg analysis pressure as recognised to be at (or very near to) the cricondentherm condition (the maximum temperature at which this condensation can occur on the retrograde phase envelop). This specification limit is currently stipulated without any defined analysis method or required sensitivity of measurement.

Representatives from European gas transmission companies and other interested parts such as major producers are currently discussing under CEN working group CEN/TC 234 WG 11 Gas Quality the list of parameters contained in the EASEE-gas CBP. Discussions have taken place to consider the merits of applying the practices of GTS with

regards to measurement of HC dew point to a sensitivity of 5mg/m^3 across the broader network. To date no such decision has been made, as many parties have observed that the current practices have proven to be satisfactory in assuring the reliable and safe transmission of gas.

Within the realm of pan-European natural gas industry research, GERG[2] Project 1.64 Phase 1 – Installation, calibration and validation guidelines for on-line hydrocarbon dew point analysers carried out tests to develop field calibration methods. This work, of which Phase 2 continues, is conducted by Gas Competency Centre Open Grid Europe on behalf of a consortium of 11 European gas transmission companies. Full reports are limited in circulation to within the funding partners of the project but a summary has been presented by a representative of OGE as a poster at EGATEC[3] 2011 in Copenhagen. This work confirmed the feasibility to adjustment of trip point variable of Condumax II to harmonise the measurement sensitivity for HC dew point with a PHLC value of 5mg/m^3. See below diagram in which the top graph shows the detection Signal Change, mV, produced by the Sensitivity Calibration routine of a Condumax II, and how that relates in the bottom graph to the PHLC analysis carried out for the same natural gas concerned. In this case, a trip point adjustment to 185mV (reduced from factory default setting of 275mV) is seen to align the measurement sensitivity of the Condumax II to a detection threshold of 5 mg/m^3. Further GERG work under Phase 2 of that project (yet to be published at time of writing) extends the investigations to include gases of different characteristics, both of varying rates of condensation formation below the thermodynamic HC dew point, from which indications are that the method applied (adjustment of trip point value) is independent of gas composition variation in achieving a consistent sensitivity of HC dew point measurement harmonised to a specific PHLC level.



Conclusion:

Calibration methods applied to on-line HC dew point analysers have evolved over time. Michell Instruments is able to support our customers in applying their preferred method to their Condumax I/II. The superior detection sensitivity of the Condumax II is proven capable of making measurements to even the most stringent implementations of HC dew point measurement, so ensuring that our customers apply best measurement practices both now and into the future.

Notes:

1. UKAS: United Kingdom Accreditation Service www.UKAS.org.uk

2. GERG: European Gas Research Group www.gerg.eu

3. European Gas Technology Conference organized under the joint auspices of MARCOGAZ and GERG together representing the complete technological arm of the European gas industry. http://www.egatec2013.com/