

## The Fallacy of Calculating Hydrocarbon Dewpoints From GC-Based Measurements

### KEY CONCEPTS

- Hydrocarbon dewpoints have to be measured, not calculated
- GC-based calculation of hydrocarbon dewpoint have significant errors
- C9+ and C12+ GCs are only marginally better than C6+ GCs for calculation of hydrocarbon dewpoints
- New CEIRS™ technology has enabled the accurate and unambiguous **measurement** of hydrocarbon dewpoints
- ZEGA7 CEIRS™ Technology is immune to contaminants and corrosives in natural gas.
- ZEGA7 CEIRS™ Technology does not need calibration as it is a

### EXECUTIVE SUMMARY

Despite a wealth of research and data that show the very large errors associated with calculating hydrocarbon dewpoints (HCDP) from GC-based measurements, this practice continues in the natural gas industry. This technical note discusses the various sources of errors which cumulatively render such calculations completely unacceptable as a means of determining HC dewpoints in natural gas. These errors can potentially add up to >90°F (50°C) of error in calculations. Accurate HC dewpoints have to be measured rather than calculated.

### INTRODUCTION

The hydrocarbon dewpoint of natural gas is an important quality that needs to be measured and controlled from processing, to transport and distribution. Formation of hydrocarbon liquids in pipelines, compressors and gas turbines creates significant measurement uncertainties as well as operational and safety issues. Controlling the hydrocarbon dewpoints can also significantly reduce pigging operations resulting in cost savings.

Chilled-mirrors are the only way one can measure a dewpoint, whether it is a hydrocarbon dewpoint or water dewpoint. Various attempts have been made at automating the chilled-mirror process, but most of those have fallen short of providing an unambiguous and accurate measurement.

ZEGA7 Instruments' CEIRS™ technology addresses these shortcomings with a unique and patented approach. This approach is the only approach that combines the chilled-mirror principle with infra-red spectroscopy to provide an absolutely reliable and accurate measurement.

### WHY NOT USE A GC-BASED CALCULATION

GC-based calculations of HC dewpoint have several sources of error. Each one of these errors is significant by itself. Taken together, they render GC-based calculations, completely useless as an analytical measurement.

These errors are:

- a- Distribution error of heavy components (C<sub>6</sub>+ and C<sub>9</sub>+)
  - b- Pressure reduction error
  - c- GC Uncertainty error
  - d- Equation-of-State error
  - e- Sample collection error (for laboratory GCs)

We discuss each one of these sources of error in detail.

#### ***a- Distribution of heavy components error***

Most GCs deployed in the natural gas industry cannot measure all the components in natural gas. The most widely deployed natural gas GCs only measure components to C<sub>6</sub>. In other words, they measure N<sub>2</sub>, CO<sub>2</sub>, and C<sub>1</sub>-C<sub>5</sub>. They lump all other heavier hydrocarbons as C<sub>6</sub>+. While this practice is reasonable for calculating heating values, it is

completely unacceptable when calculating HC dewpoints. The HC dewpoint of any natural gas depends heavily on the concentration of the heavier components.

An early attempt was made to account for the fact that  $C_6+$  components really include  $C_6-C_{12}$  (or higher) components. The popular “ $C_6$  splits” were employed. In some case a 60/30/10 split was used; meaning that 60% of the  $C_6+$  components were hexane, 30% heptanes, and 10% octane. In some other cases a 47/35/17 split was assumed and used in calculations.

This practice is erroneous for two reasons; i) there are typically heavier components beyond  $C_8$  in a natural gas stream; ii) These splits may represent only one specific natural gas mix. It cannot possibly apply universally to every other natural gas mixture. Therefore calculation of HC dewpoints using these splits produces very large errors. This fact is even acknowledged by some GC manufacturers<sup>i</sup>. The referenced paper from a GC manufacturer shows that using a  $C_6+$  GC will have 80°F (~45°C) error.

Introduction of  $C_9+$  GCs was an attempt to address the distribution error. However, they only partially address the problem, as all the components heavier than  $C_9$  are lumped into the same bucket. Although this reduces some of the error, it still represents an error as high as 35°F (~20°C)<sup>ii</sup>.

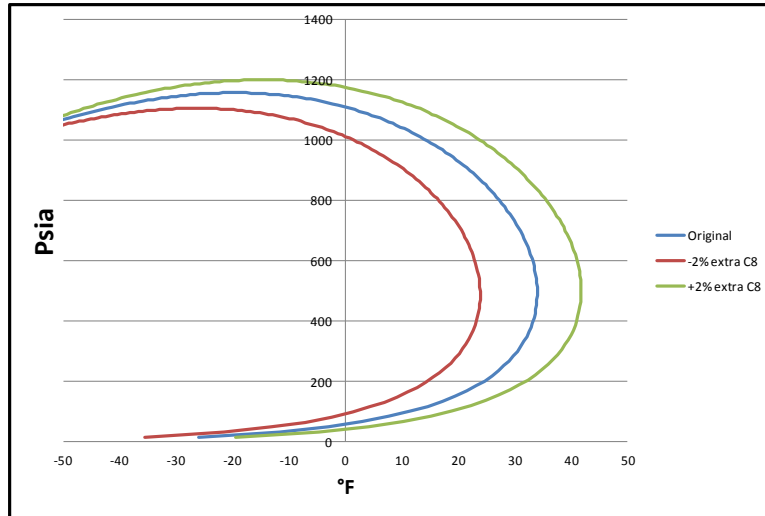
#### **b- Pressure reduction error**

GCs operate at close to atmospheric pressure (~15 psig). However, most gas operations including pipeline transport, storage, and compression are performed at elevated pressures, up 2000 psig (~ 150 barg). Therefore one needs to reduce the pressure of the gas from the operating pressure down to 10 psig. This pressure reduction can change the composition of the gas significantly, unless it is performed in multi-stages with significant external heating. If not done correctly, heavier components (as well as moisture) will condense out, introducing significant error in composition of the heavies, in turn introducing significant error in the calculation of the HC dewpoint using the GC<sup>iii</sup>.

#### **c- GC Uncertainty error**

Like all other instruments, GCs have some inherent uncertainty. This uncertainty is larger for the heavier components. GC manufacturers typically mention an uncertainty of 2% on concentration measurement. Even at 2% uncertainty on  $C_6+$ , the uncertainty introduced in the calculation of the dewpoint is tens of degrees. However, the typical field installed GCs actually have an uncertainty of 5% or more, depending on the condition of the GC columns, the sample composition, the frequency of calibration, etc.<sup>iv</sup>

The chart below illustrates this issue. The blue line is the phase diagram of a typical natural gas with components up to  $C_8$ . The green line is the phase diagram of the same gas if we add the 2% uncertainty of the GC to the  $C_8$  concentration. The red line is the phase diagram if we subtract 2% GC uncertainty from the  $C_8$  concentration. It is clear that the uncertainty of the GC, at its best case 2%, will add 20°F uncertainty to the value of the dewpoint at cricondentherm.

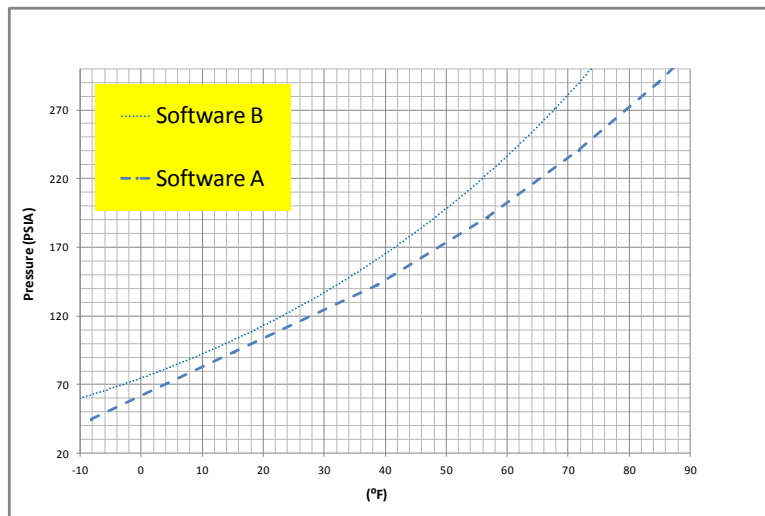


If we use a more typical 5% uncertainty for the GC, the error in the dewpoint calculation is even higher. Furthermore, if we include the uncertainty in all the other components of natural gas, the error will be greater yet.

**d- Equation-of-State(EOS) error**

There are quite a few different Equations-of-State (EOS) for calculation of gas properties<sup>v</sup>. Some of the more popular ones are Peng-Robinson (PR), Soave-Redlich-Kwong (SRK), and the GERG model amongst others. Some of these models work better at higher pressures, some at lower pressures. Some perform better for lean gases, and some for rich gases. It is possible to use two different EOS models and get two distinctly different results for the calculated HC dewpoint<sup>vi</sup>.

The example below corresponds to a very simple gas mixture comprising of only C<sub>1</sub>-C<sub>3</sub> components plus N<sub>2</sub> and CO<sub>2</sub>. The phase diagram of this simple gas mixture was calculated using two different Equations-of-State. We can observe a deviation of 10°F (6°C) even at a relatively low pressure of ~270 psia (~18 bar). Gases with components with C<sub>4</sub> and above will have far greater variance between different equations of state.



### *e- Sample collection error (for laboratory GCs)*

Given all of the above errors, which cumulatively could be well in excess of 90°F (50°F), it is tempting to sample the gas and use a higher-end C<sub>12</sub> process GC. While the C<sub>12</sub> GC will address some of the heavy distribution error, it adds another set of errors, namely sample collection and transport. Sampling natural gas at a high pressure sample point is difficult. Multiple experiments have shown that a representative sample is difficult to obtain, particularly in terms of the heavy components. Moreover, when the sample is transported and re-heated from use in a lab, additional errors can be introduced<sup>vii</sup>.

## Conclusions

**Hydrocarbon dewpoints cannot be calculated from GC-based measurements and have to be measured using an automated chilled-mirror device.**

ZEGAZ Instruments CEIRS™ is the most advanced automated chilled-mirror in the World. It is the only device that uses Infra-Red spectroscopy to measure the HC dewpoint analytically, without any assumptions, equations, or approximations.

## References

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  - <sup>ii</sup> Darin L. George, Ph.D., Andy M. Barajas and Russell C. Burkey, Pipeline & Gas Journal, Sep. 2005
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  - <sup>vi</sup> K. K. Shah, G. Thodos, *Ind. Eng. Chem.*, 1965, 57 (3), pp 30–37
  - <sup>vii</sup> Eric Kelner and Darin L. George, American School of Gas Measurement Technology, Sept. 2008.

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*For more information contact ZEGAZ Instruments:*

ZEGAZ Instruments  
9639 Doctor Perry Road  
Suite-120  
Ijamsville, MD 21754  
Tel : (877) 934-2910  
[info@zegaz.com](mailto:info@zegaz.com)  
[www.ZEGAZ.com](http://www.ZEGAZ.com)

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