The Need For Accurate Hydrocarbon Dew Point Determination

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Within the past few years, the natural gas industry has identified a need that is vital both for current operations and for management of future gas supplies — the accurate prediction of the hydrocarbon dew point of a natural gas stream.

The hydrocarbon dew point, or HCDP, is the temperature and pressure at which heavy components of the stream condense and begin to form liquids. It is not uncommon in some parts of the country for ambient temperatures to cool a natural gas stream down to its hydrocarbon dew point and cause condensation within the pipeline. If these liquids are not recovered, the heating value they represent will be lost from the stream and the liquids themselves may pose operational problems to equipment within the natural gas delivery system. In the future, accurate dew point data will be crucial to accommodating the introduction of LNG and marginal gas supplies into the natural gas transmission network. As a result, the HCDP is being considered as a current and future specification for custody transfer.

This article presents a summary of recent research to improve the methods by which the industry can predict hydrocarbon dew points using analytical gas compositions. As research continues, the results will be used by the American Petroleum Institute to create an industry standard on HCDP determination.

Origin Of The Research

Several different methods are available for predicting hydrocarbon dew points from an analytical gas composition. These include different software packages, different equations of state and equation parameters, and different methods of characterizing the heavy ends that cannot be resolved by typical field gas chromatography. However, industry experience indicated that these different methods could produce significantly different results, particularly as the percentages of hexane (C6) and heavier components increased.

As a result, Gas Technology Institute and the U.S. Department of Energy funded a research program at Southwest Research Institute (SwRI) beginning in 2002. The purpose of the research was to identify the most accurate analytical methods for predicting HCDPs. Because very little useful HCDP data existed for gases of interest to the natural gas transmission and production segments, experiments were performed to collect HCDP data on gases with a broad range of heavy hydrocarbon content at multiple pressures.

The test apparatus was built around a Bureau of Mines chilled mirror dew point tester, which is accepted by the industry for use in assessing gas quality and dew points. A digital video camera was mounted to the eyepiece of the dew scope to record condensation on the mirror and temperature readouts in the field of view during HCDP measurements. The test gas blends were prepared gravimetrically by gas standard manufacturers to minimize the uncertainties in the gas compositions.

During the first experiments in 2002 and 2003, it was confirmed that common equations of state had significantly under-predicted the dew points of the richer gas blends. As a result, the system was redesigned to operate at temperatures up to 250ºF. The modified test loop was successfully used in early 2005 to complete the experiments.

Comparisons Of Measured And Predicted HCDPs

When the measured dew points were compared to values predicted by equations of state, the agreement of the predictions with actual gas behavior was found to depend both on the gas composition and on the pressure at which the dew point was determined.

Figure 1 compares temperatures and pressures of hydrocarbon dew points measured in 2005 tests for the leanest test gas (1,050 Btu/scf) to curves computed using the certified test gas composition and two common equations of state, Peng-Robinson and Soave-Redlich-Kwong (SRK). The error bars on the data points represent uncertainties in the dew point measurements, while the dashed lines on the predicted dew point curves reflect uncertainties in the certified test gas compositions from the gravimetric blending process.

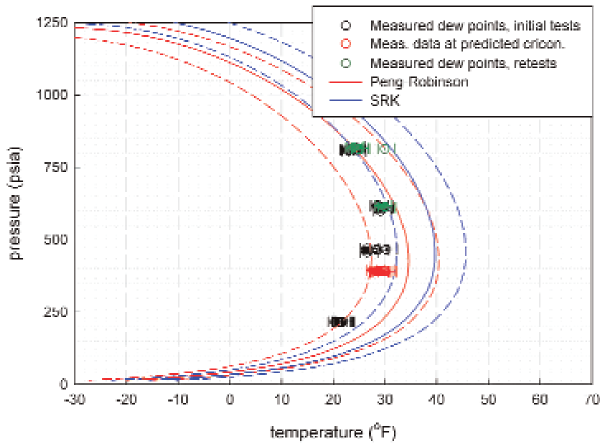

Figure 1: Experimental and predicted dew point data for the 1,050 Btu/scf test gas.

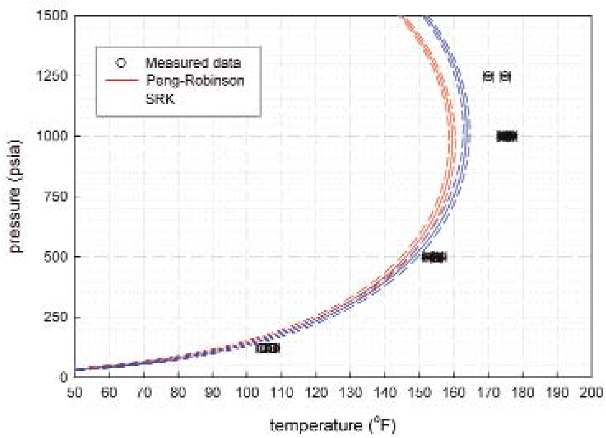

Figure 2: Experimental and predicted dew point data for the 1,522 Btu/scf test gas.

Here, the confidence intervals of the measured data overlap the confidence interval of the curve predicted using the Peng-Robinson equation, and the predicted curve is in good agreement with the actual dew points. The SRK equation predicted dew points 10-15ºF higher than were observed in the tests. In comparisons to data from a 1,145 Btu/scf test gas (not shown here), the SRK equation of state tended to predict the measured values more accurately, while the Peng-Robinson equation under-predicted the dew point by 10-20ºF at pressures of 700 psia and above.

On the other hand, for richer gas blends, both the Peng-Robinson and SRK equations under-predicted the experimental dew points by as much as 25ºF. Data collected on the 1,522 Btu/scf gas blend, shown in Figure 2, were 10-20ºF above the predictions of both equations of state at all pressures, from 125 psia up to 1,250 psia. Overall, the comparisons provided evidence of a trend among predicted hydrocarbon dew points: as the line pressure and heating value of a natural gas stream increase, existing equations of state are more likely to under-predict the HCDP of the stream.

Further Evaluation Of HCDP Prediction Techniques

Clearly, improvements are needed in the tools available to the natural gas industry for predicting hydrocarbon dew points. The data collected during the experiments at SwRI and data found during earlier literature searches are now being used in further research to identify the most accurate prediction methods available. Related work has already begun at SwRI to assess the accuracy of various methods for predicting hydrocarbon dew points and to provide this information for use in future industry standards.

Some key information has already been gathered from the study. While common equations of state can under predict hydrocarbon dew points even with complete knowledge of the gas composition, other details of the dew point calculation may lead to additional sources of error. For instance, several different software packages are available to the industry to perform dew point calculations, and each of these may yield different predictions using the same gas compositions, equations of state and pressure conditions.

To investigate the impact of using different software packages, dew points were computed using several common programs. Given the same gas compositions, line pressures and equations of state, all the software packages examined by SwRI predicted dew point temperatures that agreed to within ±5ºF of one another — a relatively small variation when compared to the 25ºF margins of error seen earlier. Similarly, differences in dew points predicted by the Peng-Robinson and SRK equations of state, all else being the same, were within ±5ºF.

One detail of dew point prediction known to have a large impact on accuracy is the method used to characterize the distribution of heavy hydrocarbons in the gas stream when the exact composition beyond C6 cannot be resolved by field gas chromatography. Characterization methods commonly used to "fill in the blanks" of an unknown composition have also been tested in studies at SwRI. These include:

- Lumped C6+ method: The amounts of all hydrocarbons with carbon numbers < 6 are added together and input to the software as normal hexane. Many field GCs provide a complete analysis of a gas stream through pentane, but provide a lumped value of hexane and heavier components that is equivalent to this characterization.
- Lumped C9+ method: Hydrocarbons such as normal hexane, benzene, normal heptane, toluene, etc. are specified individually in the gas composition used for dew point calculations. The amounts of all hydrocarbons with carbon numbers < 9 are added together and assigned to normal nonane.
- GPA 60/30/10 method: This method treats the "lumped C6+" amount as 60% n-C6, 30% n-C7, and 10% n-C8. This method was developed for accurate calculations of natural gas density, but is often used for predicting dew points as well.

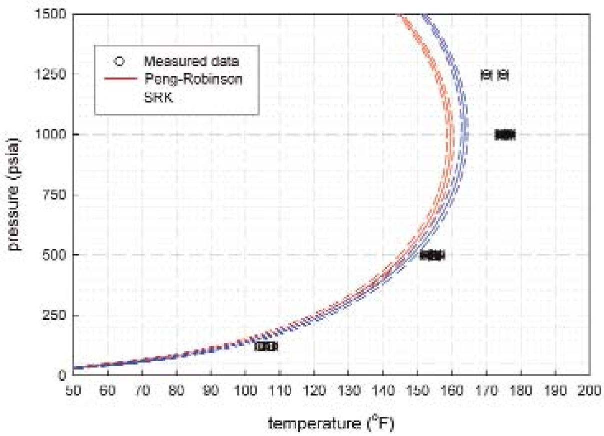

Figure 3: Comparisons of dew points computed for the 1,145 Btu/scf test gas using several common heavy-end characterizations and the SRK equation of state.

Figure 3 shows one example of the calculated dew point curves produced by these different characterizations of the same gas stream. Using a C6+ characterization instead of a full characterization containing all known components of the gas was found to change the computed dew point by as much as 70ºF, and invariably led to under-prediction of the dew point. The characterization method that most closely predicts experimental dew points varied from one test gas to another.

Based on the comparisons to date, however, the C9+ characterization most often appears to predict measured dew points to within ±25°F. This is consistent with the opinion of many researchers that the composition of a gas stream must be known through at least C9 to accurately predict HCDPs. Some researchers advocate analyzing the gas stream through C12 to compute the dew point accurately, though this requires analysis with a laboratory GC instead of a field GC.

Conclusion

Work is continuing to advance the industry's knowledge of natural gas HCDPs so that dew points can be accurately predicted to accommodate anticipated changes in the natural gas supply. Current methods of predicting dew points, particularly software packages using the Peng-Robinson and Soave-Redlich-Kwong equations of state, are increasingly likely to under-predict the hydrocarbon dew points of a gas stream as the line pressure and the heating value of the gas stream increase. However, for leaner gases, accuracy of predicted dew points can be improved when a proper characterization of the heavy ends is used.

Although the exact composition of a gas stream may not be available, research has found that obtaining and using accurate data on the gas composition through C9 will allow prediction of true hydrocarbon dew points to within ±25°F in many cases. Evidence to date suggests that the best characterization method may depend on the actual composition of the gas for which the dew point is being predicted.

Additional work in 2005 is being funded by Pipeline Research Council International to complete the evaluation of analytical dew point prediction methods. This work will investigate possible causes for the differences between experimental and calculated dew points. When the evaluations are complete, the results will be used to create industry guidelines for predicting analytical or operational hydrocarbon dew point temperatures.

The findings of the research program to date have been published, and are available to benefit the industry in such areas as LNG accommodation and accurate spot sampling techniques. Interested readers can obtain a complete listing of all research reports and technical papers from the GTI website (www.gastechnology.org) or the Metering Research Facility website (www.grimrf.org).

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