Sample Conditioning and Contaminant Removal for Water Vapor Content Determination in Natural Gas
Class # 5265

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Introduction

The Natural Gas Industry experiences numerous operational problems associated with high water vapor content in the natural gas stream. As a result several problems are experienced such as, equipment freezes, dilution of physical properties reducing heating value, volume measurement interference, and pipeline corrosion. Contracts and Tariffs usually limit the amount of water vapor content allowed at the custody transfer point. For these and other reasons, **accurate** Water Vapor Dewpoint measurements are critical measurements for all companies involved in natural gas production, gathering, transmission and delivery.

The industry continues to experience problems in obtaining accurate water vapor dewpoint measurements, primarily due to interference problems associated with contaminants and poor sampling techniques. Various types of analytical equipment are being used to determine Water Vapor Dewpoint Measurements. All are susceptible to contaminate interference or poor sampling techniques being utilized. Proper design and utilization of the correct type of sample conditioning devices or improved sampling techniques will provide much more reliable results, regardless of the equipment being utilized.

This paper is intended to address these problems and provide some practical solutions by utilizing improved sampling procedures, including properly placed and specific filtration methods.

Definitions:

Water Dew-point – of a gaseous fuel - *The temperature (at a specified pressure) at which liquid water will start to condense from the water vapor present.*
Natural Gas Moisture Content - *The amount of water held within a specified volume of natural gas. Usually expressed in pounds per million cubic feet.*
Contaminant Interference - *Any undesired compound arriving at the measurement element, which would be injurious to the moisture analyzer's measurement element.*
Non-Representative Sample Interference – *Unabated liquids arriving at the measurement element or a change in physical state of the sample prior to the measurement element.*

Analytical Methods

There are several methods for determining the Water Dew-point Temperature or the Moisture Content of a Gaseous Fuel. Some of the more common types are:

1. Chilled Mirror
2. Electronic Moisture Analyzers
3. Length of Stain Tubes
4. Laser Based Absorption Spectroscopy

All methods are prone to errors in determining an accurate reading caused by poor sampling techniques or poor sample system design. Both may cause or fail to take into account the potential for interference. Uncontrolled pressure or temperature changes in the sample system, or ignoring ingested contaminants in the gas sample are examples of poor sampling techniques, which contribute to problems encountered when taking dewpoint measurements.

Different contaminants result in a variety of problems unique to each type of measurement method. Recognizing the potential for these contaminants is the first step in protecting the measurement element from the interference caused. Most problems associated with interference can be either controlled or eliminated to increase the accuracy and confidence of the analytical measurement.

Interference problems covered in this paper include:

1. Poor Sampling Techniques
2. Hydrocarbon Liquids
3. Glycol

Sampling Techniques

The most common problem, in any analytical measurement of a flowing gas stream, is maintaining the integrity of the sample when collecting and transporting it to the measurement element. If the sample integrity is not maintained, all of the results are in question.

Physical properties of gases, vapors and liquids make stability of the physical state difficult to maintain under changing pressure and temperature conditions. This alone makes retrieving a representative sample from a flowing gas stream very difficult, if the proper technique is not employed. Controlling pressure changes and stabilizing the temperature throughout the sample system will ensure that the sample will not have condensation or vaporization occurring in the sample line or other system components.

Analytical methods covered in this paper require moisture content to be in a vapor state for analysis. This means that the sample transport system must adequately remove liquids and maintain the sample in the vapor state until it reaches the measurement element.

When designing a sample system the first consideration is at the sample take-off point. Two very important considerations are, ensuring the sample probe extends well away from the pipe wall, (it is recommended that this be in the center one third of pipe) and that any pressure reduction, does not reduce the sample temperature to a point, which condenses the water vapor.

1. Liquids tend to travel along pipe walls and can be easily ingested if a probe is not utilized.
2. If pressure reduction takes place, the temperature will drop at the point of reduction. Large pressure reductions and high flow rates can significantly reduce the temperature.

Probe type regulators allow operators to use the stream gas temperature to offset a drop in temperature, caused by pressure reduction, while utilizing the benefits of a sample probe. The pressure reduction is taken at the end of the probe allowing main-stream gas temperature to stabilize the sample temperature. Different manufacturers use various designs to take advantage of thermal properties of the probe construction.

Conventional Probe Regulator

Another consideration is to remove any liquids as soon as possible to prevent re-vaporization of the liquid in the sample transport tubing. The transport system must also protect against the condensation of water vapor to a liquid, prior to arriving at the measurement element. If condensation is allowed to occur, the sample will not be representative of the flowing gas stream.

At least one probe available to the industry utilizes membrane technology to reject liquids at the end of a probe or a probe regulator, prior to pressure or temperature changes in the sample system.

Probe Regulator with Inlet Membrane

Ambient temperature effects on the process tubing can be avoided by using insulated tubing or heat traced insulated tubing when necessary. Keep in mind, that raising the temperature without first removing any free liquids may vaporize any liquids present and give a false reading. The diameter and length of the sample tubing should be minimized to reduce ambient temperature affects as well as minimize sample transport time.

A Well Designed Sample System

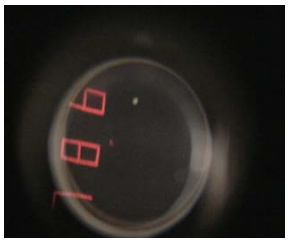
1) Utilize a probe.
2) Remove liquids prior to temperature or pressure changes.
3) Utilize the appropriate filtration media to remove contamination.
4) Minimize the size and length of sample transport tubing.
5) Reduce or eliminate the effects of changes in pressure and temperature.

Hydrocarbon Liquids

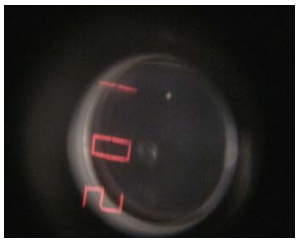
Hydrocarbon liquids often exist in some gas streams. Like liquid water, these liquids should not be allowed in the sample system. It is also likely that condensation may occur in the sample system dependent on the makeup of the sample gas. Rich gases have a higher dewpoint temperature than that of lean gases making them more prone to condensation.

When hydrocarbon liquids are allowed to come in contact with the measurement element, the effects can cause a direct interference to the reading or an interference, which causes the operator to misinterpret the reading observed.

1) Hydrocarbon Liquid Interference on a Chilled Mirror
   a) Depending on the experience of the operator, the Effects of Hydrocarbon Liquids on a Chilled Mirror could lead to the misinterpretation of a Water Dewpoint Temperature reading.
   b) Sometimes in very rich gas streams the amount of hydrocarbon liquid is sufficient enough to make determination of the Water Vapor Dewpoint difficult by flooding the mirror and obscure or wash off the water dew point.



Clear Mirror on Dewpoint Tester



Hydrocarbon Droplet on Mirror

Water Vapor Dewpoint with Hydrocarbon Droplet

Large amount of Hydrocarbon Liquids on Mirror

2) Hydrocarbon Liquid Interference on an Electronic Moisture Analyzer
   a) Capacitance-type-cells use an aluminum coating with Al_2O_3 as part of a capacitor. The capacitor changes its capacity in relation to the amount of water present. The capacitance properties of the cell are affected if hydrocarbon liquids come in contact with the cell.
   b) Electrolytic-type cells are composed of two noble metal electrode wires coated with P_2O_5. A bias voltage is applied to the electrodes, and water vapor chemically reacts, generating a current between the electrodes proportional to the water vapor present. The current is affected by Hydrocarbon Liquids and the properties of the P_2O_5 reaction to water are also affected.

3) Hydrocarbon Liquid Interference on Length of Stain Tubes
   a) This method is typically not susceptible to liquid hydrocarbons due to the sampling techniques recommended by manufacturers.

4) Hydrocarbon Interference on Laser Based Detection systems is reportedly not a problem in limited quantities. Problems may occur if significant amounts are allowed to accumulate on the mirror, which would distort the reflection of the laser light source back to the detector.

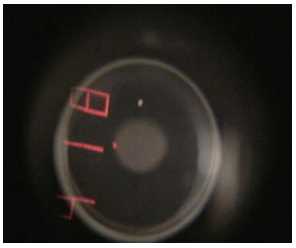
<u>Solutions to Hydrocarbon Liquid Interference</u>

1. Follow good sampling techniques as outlined in industry standards such as GPA and API.
2. Reject entrained Hydrocarbon Carbon Liquids at the sample point or as soon as practical is a must. This is best accomplished by using a membrane type separator.
3. Temperature stabilized pressure reduction will lower the Hydrocarbon Dewpoint temperature decreasing the chance of Hydrocarbon Condensation in the sample transport system.
4. Use insulated or heat trace sample lines to prevent Ambient conditions from condensing Hydrocarbon vapors to liquid.

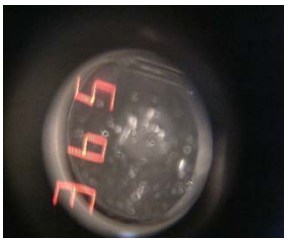
Glycol

Although used effectively in processing systems to reduce the water vapor content of natural gas, glycol is typically the most common and the most injurious contaminant to any analytical device. Once entrained in the gas stream, glycol stays suspended, usually in an aerosol or vapor form, and is carried along with the sample gas into a sampling system. Not only can glycol contaminate the measurement element it can also absorb and desorb water vapor in the sample system depending on the temperature and pressure. This property of glycol may cause the water vapor content to increase or decrease depending on conditions.

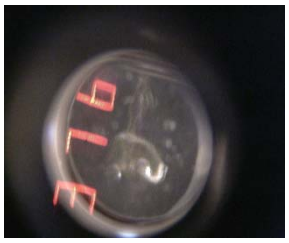
1) Glycol interference on a chilled mirror.
   a) Glycol has an oily residue and can coat the mirror. This will obscure the reading making it difficult to determine the dewpoint temperature.
   b) If glycol liquids are present they can wash away the water vapor dewpoint image.



Clean Mirror with Water Vapor Dewpoint



Mirror with Water Vapor Dewpoint and Glycol



Glycol & Liquid Hydrocarbons On Mirror

Mirror outside of Instrument coated With Glycol

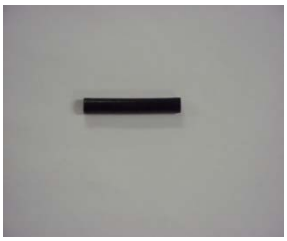
2) Glycol Interference on Electronic Moisture Analyzers
   a) The oily nature of glycol allows it to adhere to surfaces, including analytical cells. This changes the chemical properties of the cell and affects the accuracy of the analyzer.
   b) Small amounts of glycol vapor will slowly degrade the cell affecting responsiveness and readings. This requires continual calibration of the analyzer. Eventually the cell will need replaced or re-generated.
   c) Glycol in a liquid form will immediately destroy the cell's ability to provide accurate readings, requiring replacement or regeneration of the cell.

Clean P_2O_5 Cell

P_2O_5 contaminated With Glycol

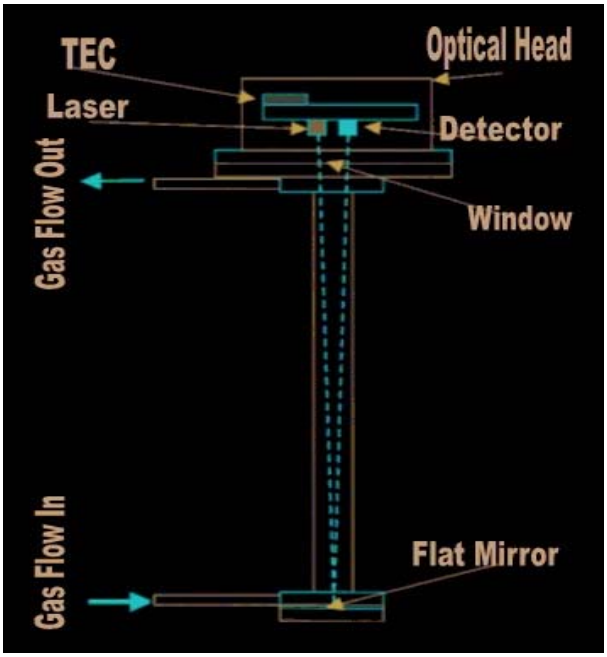
3) Glycol Interference on a Length of Stain Tube
   a) Glycol interferes with the coloration of Length of Stain Tubes, resulting in a potential misinterpretation of the reading.
   b) The Manufacturer of the tube being used should be consulted for the proper use and specific interpretations of their tubes.

Glycol Filter Housing



Glycol Filter Element

4) Glycol Interference on Laser Based Detection Systems
   a) This is reportedly not a problem in limited quantities.
   b) Problems may occur if significant amounts are allowed to accumulate on or coat the surface of the mirror, which would distort or limit the reflection ability of the laser light source back to the detector.



Laser Based Detection System

Laser based absorption spectroscopy technology utilizes a laser light source operating in the infrared wavelength region to emit various wavelengths through a gas sample stream and reflect off of a mirror back to a detector. Because the absorption capabilities of each gas component is known, the wave lengths can be characterized so that Methane and other gases won't absorb very much light and the quantity of H2O determines the amount of light returning to the detector. This correlates to how much light is returned to the detector a reading can be produced. If the reflected light intensity is significantly diminished by accumulation of film on the mirror or liquids in the bottom of the chamber and on top of the mirror then, interference is likely to occur.

<u>Solutions to Glycol Interference</u>

1. Select a sample point that is least likely to have liquids present even in an aerosol or mist. Stay away from points immediately downstream of a dehydrator. Select long straight runs of pipe and stay away from proceeding tees, elbows, valves or other obstructions.
2. Use a membrane type separator to reject any glycol liquids early in the sample system.
3. Use a glycol vapor filter.

Conclusions

Sampling methods play an important role in acquiring accurate results in moisture analysis of natural gas. Good techniques are often not incorporated in the sampling process, which leads to questionable results. Operators should review recommended practices and make them a part of their routine whenever sampling for water vapor dewpoint or moisture content.

Contaminants are often found in natural gas streams and must be dealt with prior to having adverse affects on the sample or the analytical measuring element. These contaminants are best dealt with through appropriate filtration incorporated early in the sample system.