TECHNIQUES FOR NATURAL GAS SAMPLING
A DISCUSSION OF FIELD METHODS FOR OBTAINING SPOT SAMPLES

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Purpose

Natural gas sampling is performed for a variety of reasons. Sampling is performed to determine total gas composition, hydrocarbon dew point, specific gravity, and most importantly, the value of the gas. Three techniques are normally used to obtain gas samples; continuous composite sampling, continuous online sampling, or spot sampling. This paper will discuss the various spot sampling techniques, proper sampling implementation, and equipment utilized to obtain spot samples.

Introduction

Natural gas production, storage, and distribution are increasing at a staggering rate which makes accurate testing increasingly important. Determining accurate gas composition is important from not only an economic stand point but also from a treatment standpoint. Natural gas is utilized as a feed stock, or raw material, for a variety of petrochemical products. BTU and gas composition is of vital consideration during the production of specialized products that contain natural gas and even slight variations of any number of components will change production processes to obtain a consistent final product.

A gas sampling publication from the Gas Processors Association (GPA 2166-05) states, "The object of any sampling procedure is to obtain a representative sample of the hydrocarbon from the system under investigation. Any subsequent analysis of the sample, regardless of the test, is inaccurate unless a representative sample is obtained." The International Standards Organization (ISO) standard ISO-10715 describes a representative sample as "A sample having the same composition as the material sampled, when the latter is considered as a homogenous whole." The American Petroleum Institute (API) Manual of Petroleum Measurement Standards (MPMS), Chapter 14.1, states "a representative sample is compositionally identical, or as near to identical as possible, to the sample source stream." This statement is also quoted in the American Society for Testing and Materials (ASTM) International standard ASTM 5287-97. These published standards are the most commonly referenced materials in the industry concerning the subject of natural gas sampling. The American Gas Association's (AGA) Gas Measurement Manual, Part No. 11, Section 11.3 is another often referenced reference.

Accurate samples and proper sampling techniques of are of the utmost importance in determining gas composition and specific gravity. Specific gravity is utilized in determining the flow formula which determines quantity. Therefore, any error in sampling equipment or technique will not only effect the determination of composition, but also of flow and have detrimental effects in determining the fundamental factors utilized in determining price. In short, proper sampling equipment and techniques will ensure that producers, distributors, and end users are all on the same page and therefore allows for the proper exchange of natural gas from an economic stand point.

Costs associated with equipment, maintenance, and training directly related to gas sampling is not only necessary, but can prove to be instrumental in accurate pricing. Therefore, accurate equipment and highly trained employees will pay dividends in accuracy that will translate directly into dollars.

Gas Sampling

Sampling of natural gas has been performed in one way or another from the advent of the discovery of natural gas 2000 years ago in gas vents in China. Sampling techniques varied for various reasons throughout history and would be deemed inadequate when compared with today's demands for not only accuracy, but repeatability. Several sampling standards have been developed to ensure continuity across the industry; the two most widely known and popular standards being ISO-10715 and GPA-2166-05. The API has also revised its standard, MPMS chapter 14.1 which was published in 2006.

Personnel who will be sampling or collecting samples should be continually trained on proper techniques and handling of any equipment associated with sampling as standards and best practices change.

Poor technique, poorly maintained equipment, dirty equipment, and divergence from standard testing

procedures are all variables that will negatively impact the accuracy of the samples taken.

Components of a Gas Sampling System

Tubing – Gas will be transferred from the process line to the sample chamber via tubing or piping. For the purpose of this paper, the terms tubing and piping will be interchangeable. It is important that tubing utilized to transfer the gas from the process to the collection chamber be as short in length and small in diameter as possible. The will reduce the amount of time between the sample point and the collection chamber thereby maintaining the sample's integrity.

Valves – Isolating different parts of the sample system is important for obvious reasons during different times in the sample procedure, installation, and maintenance of equipment. An important factor to consider when positioning valves is the phenomenon of condensation. When gas experiences a restriction (partially closed valve) a pressure drop ensues causing condensation which causes inaccurate samples. This phenomenon is known as The Hydrocarbon Dew Point and is explained in greater detail later in this paper. Valves should also be checked for leaks during installation and normal operation. Leaks at the sample cylinder are very important because the leaks will cause the lighter components of the gas to escape leaving the heavier components (C3, C4, etc.) overrepresented in the sample and therefore providing a non-representative sample. Larger orifices in valves will reduce fractionalization of the sample. Experience has also determined that soft seats are preferable in valves utilized in sampling systems.

Filters – Proper selection of filter flow capacity and particle size is of significant consideration due to filters with insufficient drip pot capacity for gases that have entrained water, liquid, or condensate. Filters that have insufficient flow capacity and drip pot capacity will directly impact accuracy.

Heating Elements – To prevent condensation of the sample, heating elements maintain a constant temperature above the hydrocarbon dew point preventing any part of the sample from condensing. Knowledge of ambient temperatures and dew point levels will determine the necessity of including heating elements in specific sampling applications.

Probes – As the part of the sampling system that is directly installed into the process, certain considerations should be taken in regards to the probe assembly. Installation of the probe is recommended on the top of the pipe with the probe extending into the middle 1/3 of the pipe from which the sample is being gathered. For large diameter pipes, the probe should extend at least 200 mm or 8 inches into the pipe if the middle 1/3 of the pipe is greater than 8 inches. Probes should also be placed in an area of the process pipe in which turbulence is at a minimum. Turbulence causes contaminants at the bottom of the pipe to be stirred up and could potentially cause the contaminants to be included in the sample thereby providing a sample that is not representative of the gas being sampled. Turbulence is caused by bends, valves, headers and any other items that restrict, change, or impact the "normal" flow of gas. Various probe tips are available but testing has verified that different tip configurations due not impact or increase sample accuracy. The most important considerations in regards to the sample probe/sample probe assembly is that the end of the probe be placed in the middle 1/3 of the pipe and that the integrated valve in the probe assembly function properly.

Sample Cylinders – Used primarily in the collection of purely gas samples or samples with light liquid hydrocarbons.

Spun end cylinders are the most common form of sample cylinders. Care should be taken with the valves used for isolation in the sample cylinder. Valves should contain safety devices or rupture disks in case the cylinder is exposed to a heat source. Instances have been noted that cylinders without proper safety devices installed on the valves containing gas samples have exploded when exposed to extreme amounts of heat.

Constant Pressure Cylinders (CP) are an alternative to a single cavity or spun end cylinder. CP cylinders are also known as floating piston cylinders. The cylinder takes the form of a closed end cylinder with an internal piston. The cylinder is prepared for use by pressurizing one end or side of the cylinder forcing the piston to the cylinder end. When the spot sample is pulled, the sampled product is collected and stored at whatever pressure that was initially utilized to "charge" the cylinder. Utilizing CP cylinders allows a sample to be collected at a pressure which is above the vapor pressure of the light ends present in the natural gas. Having the floating piston in the cylinder eliminates the need for excessive purging. Constant pressure cylinders help guarantee that the sample taken is composed only of the gas in the system and does not include any ambient air or other contaminants.

Materials used for construction of cylinders should be considered in reference to various components of the gas being sampled. For instance, H2S or hydrogen sulfide can be absorbed into the atomic structure of 316 stainless steel and thereby contaminate any subsequent tests utilizing the same sample cylinders. If H2S is present, a proper coating should be considered for the interior of the sample cylinder.

Burst pressure disks or relief valves should also be of the utmost consideration when utilizing single cavity or spun end cylinders. Without a method to reduce an over pressure scenario serious injury or death can result.

Clean sample cylinders are of the utmost importance. Any residual particles present in the sample cylinder will cause inaccurate samples.

Material Selection – Any materials utilized in the equipment used for obtaining samples should be compatible with the gas being sampled. Normally, 316 stainless steel and Viton elastomeric components are compatible in the vast majority of sampling situations. However, the end user is ultimately responsible for determining chemical compatibility in regards to their specific gas composition.

Location of Sample Point

The location of the sample point should be in a section of the pipeline that includes a positive velocity, minimum turbulence, and the sample tap being located on the top of the pipe.

Hydrocarbon Dew Point

Arguably, the most important factor when performing any type of gas sampling is the hydrocarbon dew point. In the simplest terms, hydrocarbon dew point is the point at which the gas components begin to change phase from gaseous to liquid. When phase change occurs, certain components of the gas stream "drop out" and form liquids thereby making an accurate gas sample impossible to obtain. The hydrocarbon dew point is a function of gas composition and pressure. A hydrocarbon dew point curve is a reference chart that determines the specific pressure and temperature at which condensation occurs. No two hydrocarbon dew point curves are alike due to differing gas compositions.

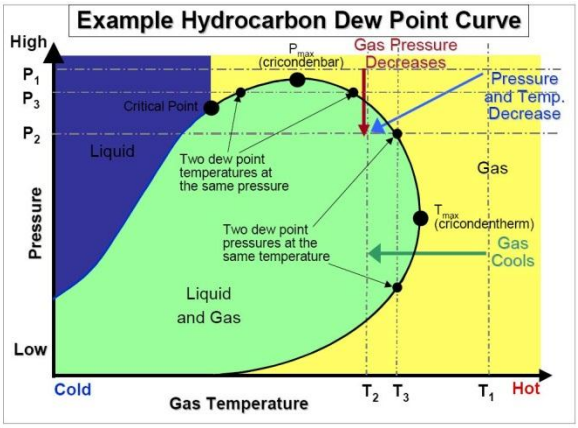

Figure 1
Example Hydrocarbon Dew Point Curve

Spot Sampling

Spot sampling, by definition, is different from composite sampling or constant sampling. Composite sampling is performed when a sample is taken over a specific amount of time or a specific amount of flow. Therefore, composite sampling is normally described as either "Flow Based" or "Time Based." Continuous sampling is exactly like it sounds, continuous. Spot sampling is taking a sample at a given point in time. This difference is very important when considering the definition of a representative sample. Therefore, a spot sample may or may not necessarily be "representative" of the gas flow when considered as a whole.

Spot sampling was the primary method for obtaining samples prior to the early 1970's. Spot sampling is still widely utilized today when one considers that "Time" and "Flow" based composite sampling is simply a series of very small "Spot" samples over a period of time or flow.

Early spot sampling was performed by simply connecting a sample cylinder to the pipe line until the pressure in the sample cylinder reached that of the pipeline. The cylinder was then removed and sent to a laboratory for analysis. Laboratories would test the sample using either a chromatograph or calorimeter. During this time the BTU value or "quality" of the gas was becoming increasingly important for producers, distributors, and end users. The sampling method at the time was suspected of introducing various contaminants and thereby providing erroneous data in regards to the actual gas composition and BTU value. The Fill and Purge method was adopted and after a period of time, it was determined that this method was causing condensation and therefore the GPA method was adopted. This method utilizes a manifold or a "pig tail" for filling the single cavity cylinder. This method reduced the negative effects connected to the "fill only" procedure. The manifold allows the gas to be trapped in the cylinder instead of "dead ended" into the cylinder. In addition, sampling situations with free liquids present in the pipeline required an additional approach and the GPA liquid separator was developed and added to the technique.

Types of Spot Sampling

Standards for spot sampling procedures are contained in GPA Standard 2166. Eight methods of sampling are accepted. Sample cylinders should be clean prior to employing any of these methods. The methods are:

1. Evacuated Container Method.
2. Reduced Pressure Method.
3. Helium Pop Method.
4. Floating Piston Cylinder Method.
5. Water Displacement Method.
6. Glycol Displacement Method.
7. Purging – Fill and Empty Method.
8. Purging – Controlled Rate Method.

The evacuated container method, reduced pressure method, and helium pop method all require evacuating the

sample container to 1 mm Hg (1/2" H20) or less, absolute pressure. The floating piston cylinder method, glycol displacement method, and water displacement method are constant pressure methods and choices to be considered when the pressure inside the sample cylinder must remain equal to the line pressure during the sample procedure. Several methods are accepted for obtaining spot samples, but the two most widely used are the purging – fill and empty method in GPA-2166-05, Section 9.1 and the floating piston method in section 9.7.

Example Procedure for Fill and Empty Method

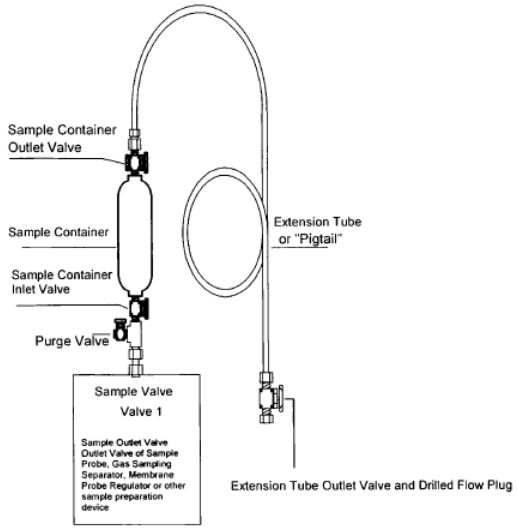

Figure 2
Purging, Fill and Empty and Purging Controlled Rate Methods Example Sample Setup

Spot sampling procedures should be obtained from the publications already referenced or from a company's standard operating procedure (SOP). This paper is not intended to provide an exhaustive reference for spot sampling. However, for informational purposes only, a description of a typical spot sample procedure follows.

1. Open valve at sample point and blow out any accumulated material. Close valve at sample point.
2. Install sample cylinder in the vertical position. Cylinders installed horizontally will cause heavier components of the gas stream to settle in the lower part of the cylinder and cause inaccurate sample gathering.
3. With all valves closed, open the sample valve at the sampling point to the fully open position.
4. Open purge valve at sampling point and blow out any accumulated material. Close purge valve.
5. Slowly open the cylinder inlet valve to pressure up the cylinder. Open the cylinder outlet valve. Open the "pig tail" line valve. Purge the line slowly with the gas to displace air.
6. Close the "pig tail" line valve and allow pressure to build up rapidly to the sample supply pressure.
7. Close the cylinder inlet valve. Open the "pig tail" line valve and the vent the container through the "pig tail" to almost atmospheric pressure. Close the "pig tail" extension valve.
8. Open the cylinder inlet valve and allow the pressure to build up rapidly to sample supply pressure.
9. Repeat step 7 and 8 to comply with Figure 3. Table represents the minimum number of cycles required to effectively purge the container of the original gas in the cylinder.

Fill and Empty Purge Cycles

Maximum Gas Pressure in container, psig	Number of Fill and Purge Cycle
15-29	13
30-59	8
60-89	6
90-149	5
150-500	4
>500	3

# of Purge Cycles = log (x)y

Where:
X = atmospheric pressure + fill pressure (psia)
Y= maximum allowable mole fraction of components

Figure 3
Fill and Empty Purge Cycle Chart

This method will normally yield a "good" spot sample. However, one must take into consideration that a spot sample is not necessarily representative of the overall quality and composition of the gas over a given flow or time. ***A spot sample is only representative of the gas quality and composition at the time the sample was taken and should not be used to determine gas quality and composition over a given time or volume of gas greater than that of the time and volume experienced during the spot sample procedure.***

Transportation and Analysis

After the sample has been obtained it will be transported to a laboratory for analysis. All samples being transported must meet and comply with The United States Department of Transportation (DOT) certification. CFR – 49 covers the rules and regulations required for transporting samples under pressure. Other considerations include:

1. Proper tagging of cylinder for time, date, and location
2. Pressure and temperature of source gas
3. Technician that obtained sample
4. Method used for obtaining sample
5. Leak checks
6. Proper protection of cylinder for transport
7. Ambient temperature concerns during transportation

Considerations for analysis include calibration standards utilized at different laboratories. Ensure that the calibration standard includes elements similar to the gas being analyzed. If the calibration standard does not include all elements of the sample being tested the BTU measurement can be compromised.

Conclusion

Accurate samples of gas are vital to determining components and quality of gas. Spot sampling is not always representative of gas quality and components over a given time or volume of gas. Procedures and techniques should either be derived or followed from the references mentioned in this paper. Testing methods, techniques, and equipment can all affect the quality of the sample taken. Great care should be taken when obtaining samples in order to ensure that the most accurate sample is obtained. Accurate samples translate directly to the bottom line of all companies.

References

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GPA 2166 2005

API 14.1