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 many reasons. Primarily sampling is performed to determine total gas composition, gas quality, and gas value. The three techniques normally used to obtain gas samples are 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 continually increasing and this makes accurate testing extremely important. Determining accurate gas composition is important not only from an economic standpoint but also from a treatment standpoint. Natural gas is utilized as a feed stock, or raw material, for a variety of petrochemical products. The BTU and composition is of vital consideration during the production of specialized products that contain natural gas so much so that even slight variations to the any of the components can require a change in production processes to maintain 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.

Accurate samples and proper sampling techniques are of the utmost importance in determining gas composition, quality, and specific gravity. As an example, specific gravity is utilized in determining the flow formula which determines quantity. Therefore, any error in sampling equipment or technique can not only affect the determination of composition, but also the flow calculation. Errors in flow calculation will result in quantity errors which will undoubtedly affect the pricing. In short, proper sampling equipment and techniques will ensure that the producers, refiners, distributors, and end users all of which are stakeholders in the proper exchange of natural gas are fairly represented. One can also easily conclude that the 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. In summary, utilizing the proper equipment, procedures, and highly trained employees will pay dividends in accuracy that will translate directly into dollars.

Gas Sampling

In 1821, the first well with the specific intent of bringing natural gas to the service was drilled by William Hart in Fredonia, New York. Since that time we have been continuously working to improve the processes and quality. To keep up with this ever growing industry and to meet the demands for increased accuracy and repeatability, there have also been many changes to the sampling techniques used throughout history. Several sampling standards were developed to ensure continuity across the industry. The most commonly referenced is API 14.1 Manual of Petroleum Measurement Standards (MPMS). The sixth edition was published in 2006 with the seventh edition expected to be released in 2015. The GPA (Gas Processors Association) Standard 2166 is also a widely referenced standard.

Personnel who will be sampling or collecting samples should be continually trained on proper techniques and handling of any equipment associated with sampling as these standards and best practices change. Poor technique, poorly maintained equipment, and deviation from these

standards can negatively impact the accuracy of any samples taken.

Components of a Gas Sampling System

Tubing – Gas will be transferred to the sample cylinder via tubing that is connected directly to the process pipe. The tubing should be as short in length as possible and should have a minimum diameter of ¼" (6mm). The short tubing run reduces the transfer time from the sample point to the sample cylinder, and the tubing size helps to ensure that any chilling from expansion occurs downstream from the sample cylinder. Selecting and utilizing the proper tubing will help to maintain the sample integrity.

Valves – It will be necessary throughout the process of collecting a sample to isolate parts of the sample system and this is typically done with the installation of a valve. It is important to consider the type, size, and placement of the valves used. Gas expansion through small orifice valves or partially open valves can cause the Joule-Thomson effect which in turn will cause condensation to form. When condensation forms in the sample system during the sample collection process, components of the sample can be lost and the sample collected will no longer be representative of the flowing gas stream. Valves should also be checked for leaks after installation. Any leakage through the valves however small can allow the lighter components to escape and the sample collected will no longer be representative. Larger orifice valves will also reduce sample fractionalization.

Filters – If used, inline filters are intended to remove contaminants and particulates without altering the sample quality. Sample quality can be affected when components that are part of the vapor phase of the flowing gas stream are removed by filtration. In general, filters do not affect the analytical results more than +/- 0.25%. When installed, they should be changed on a regular schedule and frequently checked for formation of condensation.

Heating – To prevent the formation of condensation during the sample collection process, it may be necessary to heat the components and equipment used. Condensation will form if the sample being collected is exposed to temperatures below the hydrocarbon dew point of the flowing gas stream. When it is known that the gas being sampled may be at or near the hydrocarbon dew point, the sample transfer lines as well as the sample cylinder must be maintained above the hydrocarbon dew point. Keeping the tubing between the pipe and the sample cylinder as short as possible will help to facilitate this effort. Very short connections between the sample point and the sample cylinder can be insulated and will not require supplemental heating.

Probes – Selection and installation of the sample probe is a crucial part of the sample collection process as it is the one piece of the sample system that is installed directly into the process stream. While the probe can be fixed or retractable, the industry standard for representative sampling is for the tip of the probe to be in the center one third of the pipe. This is the area of the process stream where positive flow will exist and the most representative sample can be found. Extracting a sample too close to the pipe walls can result in the liquids migrating along the pipe wall being drawn into the sample. While placing the probe tip in the center one third of the pipe is standard there are applications where the length of the probe should be limited. Probe length should be evaluated in large pipe and/or high flow applications to determine whether or not probe failure due to resonant vibration is a risk. Resonant vibration occurs when the vortex shedding frequency (wake frequency) is equal to or greater than the probes natural resonance frequency.

Sample Cylinders – The two types of cylinders primarily used for natural gas sampling are the spun end cylinder and the constant pressure cylinder.

Spun end cylinders are the most commonly used and are used almost exclusively in dry gas applications. These are also known as constant volume cylinders. The cylinder body is of seamless construction and will typically be 316SS. A valve will be applied to each end and per DOT: CFR 49 at least one of the cylinder valves must contain a pressure relief for safety during transportation. Most spun cylinders are DOT 3E rated and will contain a burst port with an 1800 PSI burst disc in compliance with the DOT rating. When filling, care should be taken to leave room for gas expansion. The industry standard is filling to 80% capacity.

Constant pressure cylinders, also known as floating piston cylinders are most often used in wet gas or liquid sampling applications. While they can be used for dry gas and are known to provide a more representative sample, they are not as common in that application as the spun cylinder. The design of the constant pressure cylinder is such that the cylinder piston separates the cylinder body into two parts. The cylinder will have a pre-charge side and a product side. The pre-charge side will be pressurized or 'pre-charged' with the pipeline gas or more typically an inert gas such as nitrogen, helium, or instrument air to a pressure that is slightly above the line pressure of the gas being sampled. Pre-charging will push the piston to the 0 % fill mark at the product end of the cylinder. When sample collection begins the sample gas will push against the piston and the pre-charge gas will be exhausted though an adjustable relief on the pre-charge side. Unlike a spun cylinder this allows the sample gas or liquid being collected to maintain its line pressure throughout the sampling process.

When selecting a cylinder and its components such as valves and burst discs, consideration should also be given to the materials used. As defined in API 14.1, the sample container should not alter the gas composition in any way nor affect the proper collection of the gas sample.

General Considerations

Material Selection – Consideration should be given to all materials that will come in contact with the sample being collected. As previously stated no component of the sampling system should adversely affect the sample being collected in any way. In most cases 316SS with fluoroelastomer soft goods will be utilized as the most compatible materials in the majority of natural gas applications. Additional steps may need to be taken however if the sample gas is extremely dirty or of a corrosive nature. Any O-ring lubricants or cleaning fluids should always be non-petroleum based in composition.

Location of Sample Point – The sample point should be in area of the pipe where continual flow exists. It should be at least five pipe diameters away from any major disturbance to the flow such as elbows, tees, orifice plates, etc. The sample should not be taken from any dead, recirculating, or slow flow sections of pipe.

Hydrocarbon Dew Point – Failure to consider the hydrocarbon dew point is the most common cause of sample distortion in all methods of gas sampling. The avoidance of hydrocarbon dew point issues is a heavily discussed topic and is considered to be the most important factor in any sampling process. It is defined as the temperature at any given pressure at which condensation begins to form. Prior to any sample being collected the hydrocarbon dew point of the process gas should be known. If needed, the necessary steps can then be taken to prevent condensation from forming in the sample system. API 14.1 states that the sample system and all of its components shall be maintained at least 30° F (17° C) above the hydrocarbon dew point of the flowing gas stream.

Spot Sampling - Spot sampling as the name implies is one sample taken at one location and one specified time period. It differs from composite sampling in that it is typically a manual process and one sample is collected for analysis. Composite sampling consists of many small samples taken automatically over a defined period of time which is typically thirty to forty-five days. Once the primary gas sampling method, most spot sampling today is done as a supplement to or in conjunction with continuous composite sampling. There are often times during a continuous sampling cycle that a sample is needed for immediate analysis. As a result spot sampling is still widely utilized in that capacity. The standard recommended procedures and methods can be found in the latest revisions of GPA 2166 and API 14.1.

Spot Sampling Methods – There are eight spot sampling methods accepted by both API and GPA. Each method requires that the sampling equipment be clean and free of contaminants, but not all methods are appropriate for all sample conditions.

The methods are:

- Evacuated container method
- Reduced pressure method
- Helium pop method
- Floating Piston (CP) cylinder method
- Water displacement method
- Glycol displacement method
- Purging – fill and empty method
- Purging – controlled rate method

Each of the above methods will fall into one of three sampling techniques. Those are reduced pressure, constant pressure, and purge and fill or fill and empty. This paper will discuss one method from each technique. Details and procedures for all methods can be found in the API and GPA standards.

Helium Pop Method – The helium pop method uses the reduced pressure technique that requires evacuating the cylinder to absolute pressure, 1mm Hg or less. This method is used when the gas being sampled is at or above the known hydrocarbon dew point. The cylinder is connected to a helium source, and the auxiliary valve is loosened and slowly purged with helium. The valve is then retightened and the cylinder is filled with helium to a pressure of approximately 5 PSI. This method is used in applications where helium is not a component of interest and is also being used as the carrier gas during analysis. An advantage to this method is that it eliminates any concerns related to air purging as the helium charge keeps the cylinder air free prior to sampling. This method can be difficult to perform however and the sample will be helium diluted.

Floating Piston Cylinder Method – This method applies the constant pressure technique and is also used when the sample gas is at or above the known hydrocarbon dew point. Prior to sample collection the cylinder is pre-charged with an inert gas and the gas used should be known to not be present in the sample. This will allow the pre-charge gas to be easily detected during analysis should a leak have occurred. The pre-charge pressure should be equal to or slightly above the line pressure of the gas being sampled. As sample collection begins, the pre-charge gas is slowly vented to atmosphere while not allowing the sample gas to drop below line pressure. Sample is collected until the cylinder's visual indicator shows it to be approximately 80% full. This method eliminates the need for air purging and improves sample accuracy by keeping the collected sample at its original pipeline pressure. Challenges in using this method are that constant pressure cylinders can be difficult to clean and sample contamination can occur if non-synthetic O-ring and seal lubricants are used. The floating piston cylinder method cannot be used in some low pressure applications as a certain amount of pressure is required to move the pistons within the cylinder. The source gas pressure typically required will be ≥ 15 PSI.

Purging – Fill and Empty Method – The fill and empty method is the most commonly used spot sampling method. This method utilizes the technique of fill and empty to eliminate all possibilities of air contamination in the sample system. The sample cylinder is connected to the source gas and connection lines and valves are purged but not to the point of chilling. The cylinder is then filled and alternately purged as a continuous action for a pre-determined number of cycles. The number of cycles used is determined by the line pressure but may be further defined by individual company policies and procedures. The sample connection line should be kept as short as possible and an extension tube or 'pigtail' is required (see Figure 1). The smallest orifice in the sample system must be at the end of the pigtail and this is most often done by applying a drilled plug to the end of the tubing. This small orifice drilled plug will move any potential condensation associated to chilling (Joule-Thomson Effect) to the end of the extension tube. The temperature of all the sampling equipment used in this process must be maintained above the known hydrocarbon dew point of the gas being sampled. It may be necessary to heat the cylinder and tubing prior to sampling or to provide supplemental heating during sample collection. Avoiding issues related to condensation is the biggest challenge related to this sample collection method.

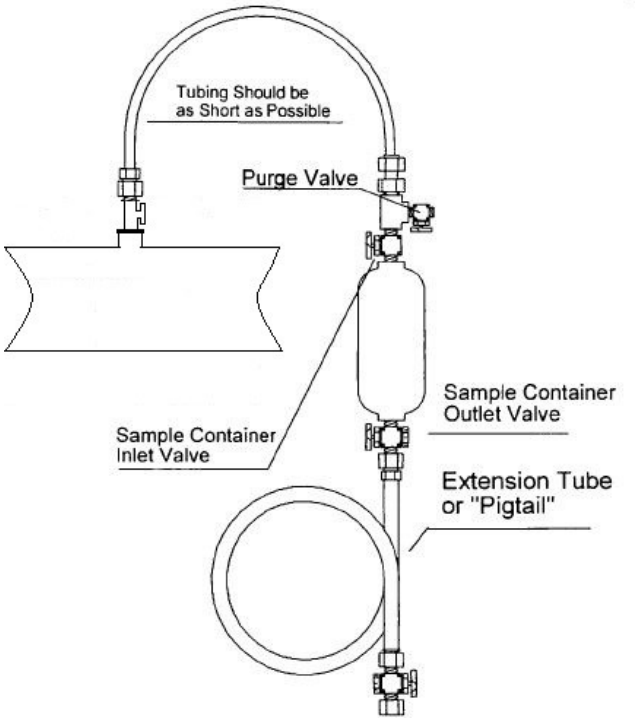

Figure 1 Example: Purging – Fill and Empty

Transportation – As noted earlier in this paper sample cylinders regardless of type should never be filled to capacity. Room for gas expansion during transportation should be allowed. Transportation of filled sample cylinders is strictly regulated by DOT, CFR 49 and any transportation of a sample cylinder must adhere to these guidelines. All sample collection that requires the sample to be transported for analysis should be done in DOT rated and approved sample cylinders.

Conclusion – The goal of any gas sampling technique or method is to obtain as representative a sample as possible. Proper technique, equipment, and training are key elements in achieving this goal. The GPA and API industry standards provide the most up to date sampling methods and practices and should be used as a basis for all training and procedures. In following the guidelines set forth by these standards accurate sampling under almost any condition can be achieved.

References:

GPA (Gas Processors Association) Publication 2166 - "*Obtaining Natural Gas Samples for Analysis by Gas Chromatography"*

API (American Petroleum Institute) 14.1- *"Manual of Petroleum Measurement Standards Chapter 14 – Natural Gas Fluids Measurement"*

ISO (International Standards Organization) ISO 10715 – *Natural Gas – Sampling Guidelines*

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