

# TECHNIQUES OF NATURAL GAS COMPOSITE SAMPLING

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Kevin Gainey  
Regional Sales Manager  
PGI International  
Houston, TX USA

## Introduction

In today's competitive market, a producer of natural gas must strive to maximize their market value and achieve the highest return of invested income. In order to accomplish this goal they must ensure they are receiving full value for the natural gas products they produce. In addition to the producer, it is extremely important for the other stakeholders, whether they be government, gathering system operator, processor, or transporter to do their due diligence to ensure they are also receiving or properly accounting for the true and full value of the natural gas products that pass through their systems. Royalty rates, transportation levies and processing fees are based on the value of the natural gas being commercially bought and sold, processed or transported.

Wells may be owned by different companies and may flow into a common gathering system. There may be lean wells as well as rich wells, sweet wells, or sour wells. The gathering system may then transport the combined flows to a common gas plant for processing. The challenge for the production accountant is to ensure that every stakeholder will be compensated correctly based on the volume and quality of the gas that they produced.

Gas allocation is made up of two components; the volume of natural gas and the compositional make up of the gas or heating value of the gas.

The key to accurate allocation can only be accomplished through the accurate measurement of these values and accurate measurement depends on the ability to accurately determine the compositional analysis of the gas.

Raw natural gas is composed of many different components. These components typically include nitrogen, carbon dioxide, hydrogen sulfide, as well as a variety of different hydrocarbons. Some of these components such as nitrogen and carbon dioxide have no commercial heating value while the hydrocarbon components not only have heating value but will have different heating values depending on their molecular structure. Therefore, the total heating value determination of a natural gas stream is dependant on and accurate compositional analysis of the stream.

The ability to accurately analyze the compositional make up of the natural gas stream is essential to accurate measurement and allocation. This can only be accomplished if the sample being analyzed is representative of the flowing gas stream.

This paper will discuss issues that should be considered to obtain a good representative gas sample.

## Industry Standards vs. Regulations

There are several well known **industry standards** that detail the potential causes of sample distortion and recommend proper sampling equipment and sampling techniques to avoid these pitfalls. The findings and recommendations of these standards are based on years of hands on experience and exhaustive field testing. The two most referenced standards for gas sampling standards are:

*American Petroleum Institute (API)  
Manual of Petroleum Measurement Standards  
Chapter 14 – Natural Gas Fluids Measurement  
Section 1- Collecting and Handling of Natural  
Gas Samples for Custody Transfer*

This standard is commonly known as API 14.1

*Gas Processors Association (GPA)  
Obtaining Natural Gas Samples for Analysis by Gas Chromatography*

This standard is commonly known as GPA 2166

Both the API and the GPA are industry standards that have been developed by industry stakeholders and recommend how sampling should be done to obtain the best representative sample from the flowing stream. Many of the points and recommendations in this paper are discussed in greater detail in these standards. Before any company sets up a sampling program they should consult these sources in order to completely understand the problems and solutions that exist when trying to obtain a true representative sample of the flowing gas stream.

### Common Issues in Obtaining a Representative Sample

#### 1. Phase Change Issues – Single Phase Flow Streams

API and GPA both define single phase flow as “natural gas flowing at a temperature above the hydrocarbon dew point and free of compressor oil, water, or other liquid or solid contaminants in the flow stream”.

Accurate gas sampling can only be accomplished if the flowing stream is in a gas only phase. Therefore it is critical that the sample be taken at a point in the system where single phase flow is present. This may sound like a simple requirement, but there are a number of factors that conspire to make a single phase flow difficult to maintain, especially in cold temperature climates. The potential for cold ambient conditions coupled with the fact that many separator designs expose the gas leg to the ambient environment contribute to the potential of two phase flow.

In a gas separator, phase equilibrium exists at the line pressure and temperature. The gas leg exists at the hydrocarbon dew point directly downstream of the separator outlet. Should the temperature drop below the hydrocarbon dew point, droplets of liquid hydrocarbons will condense from the flowing stream. These droplets may be entrained in the flow stream or, more commonly, they attach themselves to the pipe wall and are carried along the pipe wall in the direction of the gas flow. Two phase flow now exists and sample distortion will occur if taken at this location

## 2. Phase Change Issues – Retrograde Condensation in the Sample System.

Some believe that once a sample has entered the sample system, it is no longer necessary to be concerned about phase behavior. The belief exists that the sample can be returned to original state by heating the sample in the lab which is false. Retrograde condensation (decrease or increase in pressure) in the sampling system will result in sample distortion if it occurs prior to the sample being captured in the sample cylinder.

Let us consider a gas sample that is being drawn through a probe located on the top of a flowing pipe. If the temperature of the probe or the sample lines leading from the probe to the sampler pump inlet is below the hydrocarbon dew point (at lines pressure), retrograde condensation will occur. The heavier components will be the first to drop out. Droplets of hydrocarbon liquid, following the laws of gravity, will either run down the probe and be returned to the flow stream or they will accumulate in low spots or cavities in the sample system. Eventually, any accumulation of liquids in low spots will spill back into the flowing stream and be lost or it will be “sucked up” and injected into the sample cylinder. Either way, the sample has been distorted and is now non-representative of the flowing stream.

Retrograde condensation can also be caused by a reduction in pressure in the sample system. Reduction in pressure causes an associated reduction in temperature. This phenomenon is known as the Joule – Thomson Effect. This effect can happen when sample probes are used that have a small flow orifice or when taking samples through a small orifice manifold valves or when purging sample cylinders without the use of an extension tube (pigtail) attached to the cylinder outlet valve.

In order to avoid retrograde condensation the sampling technician should consider the following points when designing the sample system:

- Insulation or heating must be used to eliminate any cold spots between the sample point and the sample cylinder.
- Sample lines should be as short as possible and designed to avoid any low spots where liquids could collect.
- Minimize the use of small orifice valves on the probe and sample lines.
- Avoid using orifice meter impulse lines and manifold valves for the purpose of taking samples.
- Include a properly designed tube extension (pigtail) for purging of the sample cylinder.

### Contamination of the Sample Due to Cleanliness and Handling Issues

Two of the more common causes for sample distortion are:

1. Lack of cleanliness of the sample cylinder and sampling equipment.
2. Air contamination of the sample through improper handling of the sample cylinder and/or cylinder valve leakage.

Prior to a sample cylinder being used, it should be completely clean and free of any contaminants that may distort the compositional analysis of the flowing stream. Both API and GPA make reference to proper methods of cleaning sample lines and cylinders.

When performing maintenance or re-building a sample pump cleaning solvents must not leave a residue and "O" ring lubricants must be of a non-petroleum based material to avoid sample distortion.

Air contamination of the sample is typically the result of either not purging the sample line properly after changing the cylinder or as a result of improper handling of the sample cylinder.

Examples of improper handling are as follows:

- Opening the valve on the sample cylinder to check that the cylinder is still under vacuum.
- Opening the valve on the cylinder to check that the cylinder has a blanket gas fill.
- Opening the valve on the cylinder to confirm that there is not another sample in the cylinder.

Sample cylinder valves leakage is also a cause of air contamination of the sample. Consideration and evaluation of the quality and type of valve used on the inlet and outlet of the sample cylinder should be taken. In most cases these valves are not designed to contain a vacuum and require the stem packing to be maintained to prevent the sample from leaking.

Valve manufactures can be of assistance in recommending the best choice of valve for sampling systems and cylinders. They can also provide recommended maintenance procedures to ensure longer leak free performance of the valve. The chart below represents the amount of revenue a company could be off with errors in sample accuracy due to contaminated or dirty sample equipment, leaking valves, or low sampling temperatures (below the hydrocarbon dew point).

No. of Wells	Cost/ MMBTU	Calculated BTU/scf	Flow Rate (MCF/day)	Value of Gas Produced Per Day	% BTU Error	Cost of Error		
						Per Day	Per Month	Per Year
1	\$7	1,000	200	\$ 1,400	1%	\$ 14	\$ 420	\$ 5,040
					3%	\$ 42	\$ 1,260	\$ 15,330
					5%	\$ 70	\$ 2,100	\$ 25,200
2	\$7	1,000	200	\$ 1,400	1%	\$ 2,800	\$ 84,000	\$ 1,008,000
					3%	\$ 8,400	\$ 252,000	\$ 3,066,000
					5%	\$ 14,000	\$ 420,000	\$ 5,040,000

### Frequency of Sampling – How Often Do I Need to Sample?

In most cases, the basic standard for sampling is the "grab sample" or "spot sample". This type of sampling has been used for many years and when done in accordance with GPA and API standards it will provide an representative sample of the flowing stream. By definition, however, a spot sample is exactly that. A spot

sample represents what exists in the flowing stream at that instant in time. Should the composition of the flowing stream change after a spot sample is taken, the change may never be discovered or will not be discovered until the next sample is analyzed.

A spot sample will not provide accurate compositional data for a company who operates a gathering system or processing facility where wells of different producers and different gas quality all flow into a common stream. The more often you sample, the better the data. Where spot sampling does not provide the required quality information the operator should consider automated composite gas sampling systems or gas chromatographs.

Automated composite gas sampling systems are designed to take small bite size samples from the flowing stream at regular intervals and store them in a sample container or cylinder. When the cylinder is filled, usually monthly, it is taken to the lab for analysis. Field testing and research have proven that these systems can provide results comparable to that of an on line gas chromatograph when the system is designed and used in accordance with API standards. These systems provide an economical solution when increased sampling frequency is required.

### **Composite Samplers**

Composite samplers can consistently provide accurate, high quality samples every collection period. They also provide an affordable sampling method when compared to on-line gas chromatographs. Composite samples will provide more accurate sample than traditional spot sampling.

### **Sample Probe Options & Locations**

#### **Location**

The location of the sample probe is very important because a sample should be taken from the longest section of pipe available. Unfortunately, this is usually a meter tube where swirls can occur and cause the flowing stream to create aerosols from the liquid collecting on the walls of the pipeline. Therefore, a sample probe tip should be positioned in the center third of the pipeline where there is a positive velocity and less likelihood of turbulence. For larger line sizes, probe lengths in excess of 10 inches are not required. Sample probes with end tips located too close to the walls of the pipe can pick up liquids and not provide a representative natural gas sample. This probe should also be located eight pipe diameters downstream of any obstruction.

#### **Single Flow Sample Probes**

The single flow sample probe is the simplest of sample probes, generally constructed from a piece of tubing and welded into  $\frac{1}{2}$ " or  $\frac{3}{4}$ " brushing or  $\frac{1}{2}$ " or  $\frac{3}{4}$ " valve. Application of a single flow sample probe should include a hot loop installation between the sampler and a downstream pressure drop to create a positive sample flow.

#### **Dual Flow Sample Probes**

The dual flow probe includes built-in passages that allow positive sample flow through the sampler. Dual flow probes come with optional built-in valves that enable the technician to remove the sampler without blowing down the meter tube. This enables a fresh sample each time a sample is taken.

## Samplers

Composite sampling systems are composed of a sample probe, product loop, sample pump, sample vessel, and required logic circuits to control the system throughout an extended period of time. The composite sampler should have the capability to provide either time-based or flow-based sample control.

### **Time Based**

Time-based sample control is designed to inject a selected amount of sample over a predetermined time to fill a sample cylinder to line pressure. Calculation tables are available to determine the time versus the amount of sample taken to be injected into a specified volume sample cylinder. The volume injected and time interval will fill the sampler cylinder in the desired time, typically a 31-day time period.

### **Flow Based**

The flow based sampler is electronically set to take a sample proportional to flow; the higher the flow rate the larger the sample. Flow Based is generally preferred over time-based sampling because it provides a more proportionate therefore accurate sample.

## Installation

The location of the sampler is critical as it should be as close to the sample point as possible. Two mounting methods are currently available.

### **Direct Mounted Sampler**

The direct mount method is generally preferred for several reasons. The sampler is mounted directly on the sampler probe, providing the shortest distance to the sample point, and ultimately, provides the freshest sample. Most samplers include a port for a hot loop, which keeps the gas flowing through the sampler chamber. Samples should then represent the gas that is flowing through the line at that point in time.

### **Remote Mounted Sampler**

Remote mounted samplers should be mounted as close to the sample point as possible to minimize the length required for sample tubing. Dual flow probes are preferred on remote mounted samplers, as with the direct mount samplers, to enable the sample to flow through the sample chamber. If a dual flow probe is not used there should be a "hot loop" with tubing run from the sample chamber to a lower pressure point down stream. This system enables a fresh sample to be injected into the sample cylinder.

## Heated Sample System

Revision of Chapter 14.1 of the API manual of Petroleum Measurement Standards' latest revision was published in February of 2006. The standard is suitable as an instructional tool and as a guide to composite sampling system techniques written primarily for field personnel it calls for all natural gas sample system components to be kept at least 30°F above hydrocarbon dew point temperature of the gas being sampled. If the sample stream comes in contact with sampling equipment that is at a temperature below the hydrocarbon dew point temperature, this could cause distortion. If the temperature of the sampling equipment drops below the hydrocarbon dew point, errors of more than 10% may occur.

## Conclusion

Obtaining a good representative sample of the flowing gas stream is essential for stakeholders to ensure that they get full value for the natural gas products that they produce, process and transport.

The responsibility for this task must be shared by a number of company personnel in order for any sampling program to work effectively.

The personnel that installs and/or maintains the sample system must ensure that retrograde condensation does not occur by taking the necessary preventative steps to maintain the system above the hydrocarbon dew point and eliminate any low points in the tubing where liquids could collect.

The technician who takes the sample and handles the sample cylinder is responsible for avoiding sample contamination. A properly maintained and cleaned sample cylinder should be used for each new sample. The technician must also understand the proper methods and procedures for taking samples in order to avoid air contamination of the sample and to prevent flashing of hydrocarbon liquids.

Understanding and following the published industry standards and regulations insures your company will get what it deserves from the production, processing or transport of this valuable resource.

## References

*American Petroleum Institute (API)*  
*Manual of Petroleum Measurement Standards*  
*Chapter 14 – Natural Gas Fluids Measurement*  
*Section 1 – Collecting and Handling of Natural Gas Samples for Custody Transfer.*  
*Sixth Edition, February 2006*

*Gas Processors Association (GPA)*  
*Obtaining Natural Gas Samples for Analysis by Gas Chromatography*  
*GPA Standard – 2166-05*

*Energy and Utilities Board (EUB) of Alberta*  
*Directive 17 – Measurement Requirements for Upstream Oil and Gas Operations*  
*Draft Chapter – Gas Sampling and Analysis*