AN OVERVIEW OF THE AGA GAS QUALITY MANAGEMENT MANUAL

Terrence A. Grimley

Southwest Research Institute®

INTRODUCTION

This paper provides an overview of the recently released Gas Quality Management Manual [1] that was developed by the American Gas Association Transmission Measurement Committee over a period of roughly seven years. The manual pulls together a wide range of information and provides context that allows both the expert and the novice to understand the "why, how and what" needed to develop a plan for managing gas quality.

BACKGROUND

In the early 2000's changing sources for natural gas supply that initially were anticipated to involve a substantial increase in the use of liquefied natural gas (LNG) and other concerns, including hydrocarbon liquid dropout, caused a renewed interest in gas quality. In 2005, the Natural Gas Council Plus (NGC+) working groups published white papers on gas interchangeability [2] and liquid drop out [3] which established interim guidelines for gas interchangeability and identified many of the topics that were subsequently expanded upon in the gas quality management manual. The gas quality management manual grew from its original form as an engineering technical note on gas quality into a comprehensive guide to the management of gas quality. Projections in the growing supply of natural gas and changes in the sources shown in Figure 1 [4] suggest the importance of managing gas quality.

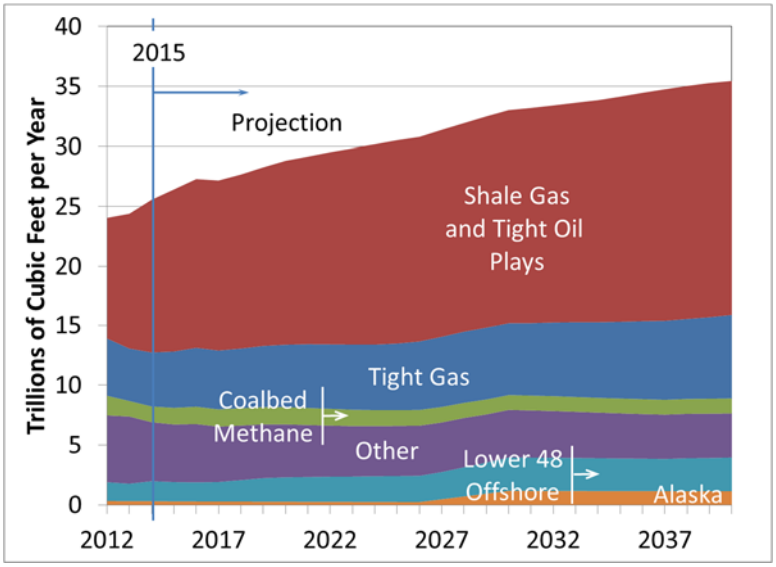

Figure 1. Historical and Projected Gas Sources (Trillion Cubic Feet)

The sections that follow provide brief descriptions of each of the six major sections of the document (and the appendices) and extract a few key pieces of information from various sections. The Gas Quality Management Manual contains nearly 200 pages of information; however, it is not intended to replace existing standards and references, but rather provide context and perspective for those reference documents.

1. OVERVIEW

Section 1 provides an introduction to the document and defines the overall scope.

The manual is intended to provide sufficient background and reference information to allow the variables that define a gas quality management plan to be assessed, monitored, and managed. The essential information that should be gained from the document includes understanding:

- the fundamental constituents and properties of natural gas, the resulting properties, and their potential effects on delivery and end use,
- the basis of historical pipeline receipt and market area delivery data, and

- the pipeline and delivery system design including limitations at potentially sensitive points within the pipeline system.

In addition, the reader should understand what is necessary for conducting the ongoing data collection and retention necessary to define gas quality for a system, and to manage gas quality changes within that system.

2. UNDERSTANDING NATURAL GAS CONSTITUENTS AND PROPERTIES

This section provides an introduction to natural gas including the constituent hydrocarbon and non-hydrocarbon gases that make up natural gas and parameters and that need to be understood when creating a gas quality management plan.

Although it's common to refer to "pipeline quality," the term has a very broad meaning since there is a considerable range of mixtures that are commonly accepted in pipelines. Table 1 illustrates the range of values for various gas quality indicators that are currently present in existing contracts and tariffs. In addition to indicators of the gas constituents and heating value, also included are specifications for water content limits, sulfur limits, and limits for other particulates and contaminants.

Table 1. Tariff Gas Quality Specifications

Gas Quality Specification	Range of Values Found in Tariffs
Minimum Heat Content[1] Maximum Heat Content[1]	900 – 1,000 BTU/scf 1,075 – 1,200 BTU/scf
Minimum Wobbe Number Maximum Wobbe Number	1,279 – 1,340 1,380 – 1,400
Minimum Temperature Maximum Temperature	20 to 65°F 80 to 140°F
Maximum Hydrocarbon Dew Point Cricondentherm HDP (CHDP) C4+ Liquefiable Fraction (GPM)C5+ C5+ Liquefiable Fraction (GPM) C6+	0 – 25°F at either fixed or operating pressures 15 – 20°F 0.75 – 1.50% 0.2 – 0.3 gallons/Mscf 0.12 – 0.25% 0.05 gallons/Mscf
Maximum Water Vapor Content	4 – 7 lbm/MMscf
Maximum Total Sulfur Compounds, as Sulfur	0.5 – 20 grains/100 scf
Maximum Hydrogen Sulfide (H2S)	0.25 – 1 grain/100 scf
Maximum Mercaptans (RSH)	0.20 – 2.0 grains/100 scf
Maximum Solid Particles Size	3 – 15 microns
Maximum Hydrogen	400 – 1,000 ppm
Maximum Diluent Gases Total Carbon Dioxide (CO2) Nitrogen (N2) Oxygen (O2)	3 – 6% 1 – 3% 1 – 4% 0.001 – 1%

[1] Dry, Higher heating value (HHV) at 14.73 psia, 60°F

The properties and parameters shown Table 1 are among those that are described in Section 2 of the document. Explanations of the different types of heating values, use of hydrocarbon dew point curves, and computation of basic gas properties are covered along with an introduction to combustion interchangeability parameters such as the Wobbe number.

For example, a hydrocarbon dew point curve (also known as a phase diagram) similar to that shown in Figure 2 is explained in the context of various pipeline operations (e.g., gas sampling, pressure regulation), as well as relative to gas quality specifications.

3. UNDERSTANDING PIPELINE SYSTEM IMPACTS

The major topic areas covered in Section 3 are provided in the list that follows:

- System Considerations
- Contract and Tariff Considerations
- Supply Source Considerations
- Gas Processing Operations and Economics
- Pipeline Facilities
- Storage Facilities and Operations
- Imported LNG and Peakshaving Operations (LNG & Propane-Air)
- LDC and Direct Connect Issues with Delivery, Infrastructure and Utilization

- Measurement and Gas Quality Analysis
- Effect of Gas Quality Changes on Compressor Facilities and Operations
- Regulation and Flow Control

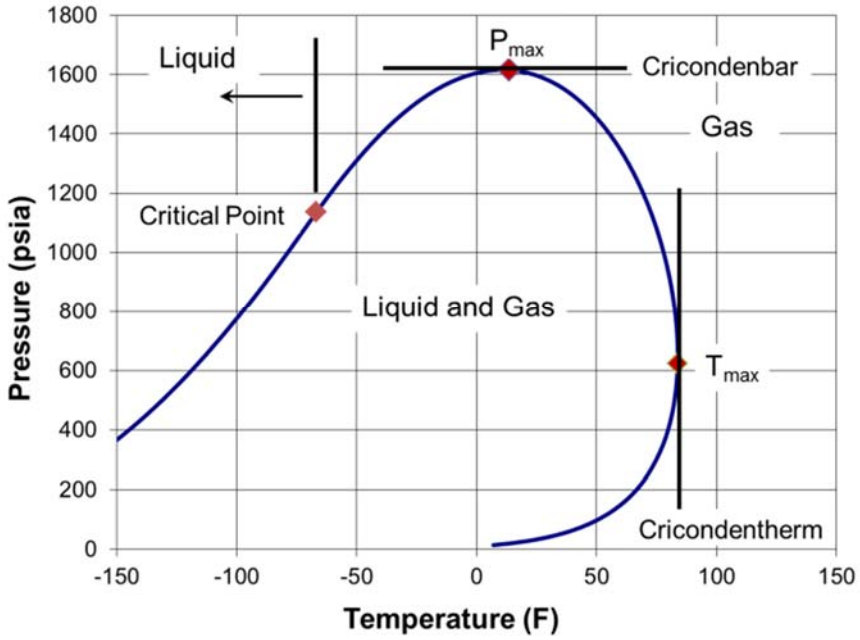

Figure 2. Example Hydrocarbon Dew Point Curve

Examples of the general characteristics, including the compositional variation and heating value of different gas sources, are provided. Issues related to condensate formation, and specific methods for avoiding condensation are discussed. Also included is an overview of common gas processing methods and their relative efficiency as well as the economics involved in the decision of whether or not the gas should be processed.

Issues related to the impact of gas quality on storage operations are summarized and details of potential problems related to the presence of liquid hydrocarbons, contaminants, and other adverse quality conditions are provided.

Many of the same quality issues that affect storage operations also impact the operation of local distribution companies (LDCs) and other industrial users that directly connect to the pipeline. In addition, for the effect of high/low heating values (or Wobbe numbers) on end-use equipment needs to be considered for maintaining safe and efficient equipment operation.

Pipeline compression facilities, measurement stations, and regulation and control facilities are all impacted by gas quality issues. Specific considerations and potential adverse effects on different types of equipment are summarized. For example, the combustion efficiency and emission levels for engines and turbines are affected not only by heating value, but also on the distribution of gas constituents.

4. MONITORING GAS QUALITY

Central to the idea of managing gas quality is the realization that gas quality can vary significantly with the source of gas and with the processing and transportation of the gas. In order to provide accurate gas measurement and to maintain the quality of gas in the pipeline, the gas quality must be measured.

Section 4 includes a discussion of data collection approaches and the potential effect of a given approach may have on the ability to manage gas quality.

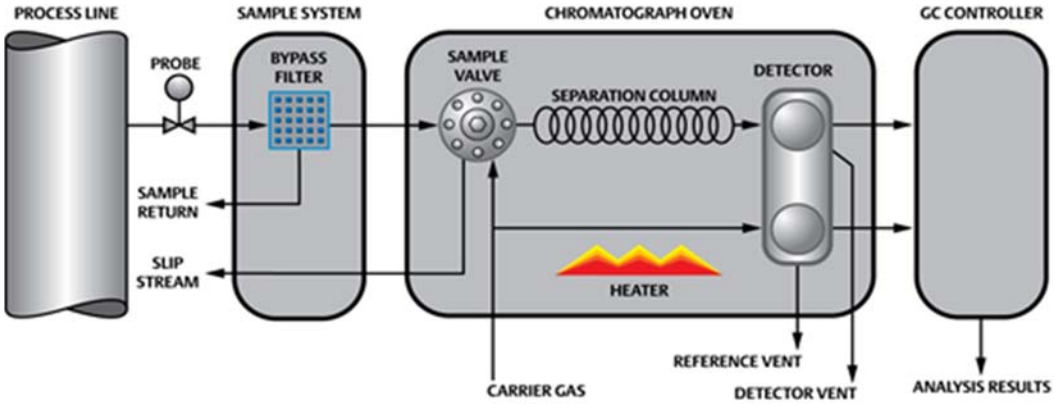

Figure 3. Block Diagram Example of a Gas Chromatograph

There is also a broad description of analytical tools and methods that can be used for measuring various gas quality parameters. This includes a summary of gas sampling systems and direct and indirect methods of determining heating value. Also included are basic descriptions and explanations of gas chromatographs, dew point measurement systems, CO_2 and H_2O monitoring systems as well as sulfur analyzers. Some analytical tools and devices are introduced at the concept level, while others, like the gas chromatograph shown in

Figure 3[1] have a significant level of detail.

5. DETERMINING AND MAINTAINING HISTORICAL GAS QUALITY DATA

Historical records of gas composition and other properties as well as operational information on pressure and temperature conditions are important to managing the gas quality of a pipeline system. Section 5 provides the background information needed to understand which parameters may be desirable to gather for assessing different purposes (e.g., interchangeability, hydrate formation, liquid dropout, corrosion, etc.), and the frequency at which the information should be recorded.

The document describes how an understanding of the historical range of gas quality can be used to establish the effect of changes in the gas supply and gas quality on various end-use equipment. It is recognized that without knowledge of the potential ranges of adjustment gases previously used, interchangeability of "new" gas cannot be assessed.

A discussion of practical and regulatory issues related to creating archival information on gas quality is also included in this section.

6. DEVELOPING A GAS QUALITY MANAGEMENT PLAN

Section 6 provides suggestions on items that should be considered when developing a plan. The major topics included are listed below:

- Establishing Gas Quality Goals
- Application of Specifications
- Understand the History, System Constraints and End Use Limitations
- Establishing an Ongoing Monitoring and Corrective Action Program
- Summary and Recommendations
- Gas Quality Management Plan Checklist

It is recognized that a "one size fits all" solution is typically too restrictive for establishing gas quality specifications; therefore, the plan should consider regional differences in the system, sources, and end-use needs when establishing limits, and other specifications.

The plan should include an approach for monitoring gas quality, archiving gas quality information, and establishing a response plan when limits are violated. The approach for inclusion of new sources and significant expansion of existing supplies should be planned for.

The checklist given in Section 6 provides a useful tool for ensuring that the gas quality management plan considers all the critical issues that have been described in the previous sections of the document.

APPENDICES

A total of 14 appendices are included in the document. These appendices provide supplemental information on a variety of topics ranging from basic hydrocarbon chemistry to a detailed discussion of the development of interchangeability parameters. A brief description of each of the appendices follows.

A. Definitions and Industry Publications, Standards, and References
This section provides select definitions specifically as used in the context of the Gas Quality Management Manual, and references to the important industry standards related to the measurement, evaluation, and computation of gas quality as well as information on gas interchangeability and other critical gas quality references.

B. Fundamentals of Hydrocarbon Chemistry — Structure and Properties of Hydrocarbon Molecules
This section provides introductory information regarding the chemistry of hydrocarbons that are commonly present in natural gas mixtures.

C. NGC+ Typical Gas Composition Data by Region and State
The tables provided in this section summarize two snapshots of the ranges of gas composition on a state-by-state basis that existed around 1995 and around 2002 and a comparison of the changes that occurred over this time period.

D. Chemical and Physical Properties of Natural Gas Constituents
The gross heating value tables in this section are extracted from AGA Report No. 5 and are included in the manual for convenience.

E. Moisture Correction and Saturation Tables
This section provides a discussion of the effect of water in natural gas and summarizes a method to compute the correct energy content in the presence of water.

F. The Gas Laws
A summary of ideal gas laws is presented for reference purposes.

G. Predicting Hydrocarbon Liquid Dropout
This section provides a tutorial of hydrocarbon dew point measurement, prediction, and a discussion of the importance of understanding hydrocarbon dew point relative to proper gas sampling and quality determination.

H. Stoichiometric Combustion and Calculation of Volumetric Heating Value
This section provides an overview of the basic combustion equations related to natural gas components and the method for computing the heating value of a natural gas.

I. Interchangeability Parameters and Combustion First Principals
This section provides a tutorial on natural gas combustion with emphasis on the parameters typically used to assess the interchangeability of various natural gas mixtures.

J. Development of Weaver and AGA Bulletin 36 Interchangeability Indices and Limits
A discussion of the basis for the development of the subject interchangeability indices is provided.

K. Mercaptan and Sulfur Compound Measurement and Conversion Table
This section includes a table that lists the amount of sulfur contained in various compounds.

L. Sample Calculations
This section contains example calculations for ideal and real heating value, conversion of heating value to other base conditions, calculation of Wobbe number, and other calculations that are typically used in assessing gas quality.

M. Biogas or Biomethane
A tutorial on the unique characteristics and sources of biogas and biomethane is provided in this section.

N. LNG Storage, Liquefaction & Propane-Air Peakshaving Gas Quality Considerations
This section provides an overview of quality considerations both in the use and generation of LNG.

SUMMARY

The Gas Quality Management Manual brings together information from a number of relevant resources and provides a comprehensive treatment of the subject of developing a plan for managing gas quality. The document does not replace

existing reference documents, but instead provides contextual information that will allow the reader to better apply existing industry references.

REFERENCES

1. AGA Transmission Measurement Committee, *Gas Quality Management Manual*, American Gas Association, August, 2013, Washington, DC.

2. Natural Gas Council Plus Interchangeability Work Group, *White Paper on Natural Gas Inter-changeability and Non-Combustion End Use*, February, 2005.

3. Natural Gas Council Plus Liquid Hydrocarbon Drop Out Task Group, *White Paper on Liquid Hydrocarbon Drop Out in Natural Gas Infrastructure*, February, 2005.

4. U.S. Energy Information Administration, *Annual Energy Outlook 2015*.