Wet Gas Sampling

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Foreword

Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue NW, Suite 1100, Washington, DC 20001, standards@api.org.

Abstract

The API Wet Gas Sampling Committee, under the API Committee on Production Measurement & Allocation (CPMA), conducted a study to identify potential sources of errors in the sampling of natural gas flow streams containing small amounts of free hydrocarbon liquid (wet gas). The objectives of the study were to quantify measurement uncertainty associated with using dry gas sampling methods to sample wet gas streams, and to provide recommendations for future wet gas sampling test programs.

A binary mixture of methane and n-heptane was used as a testing media. The testing was conducted in a closed-loop test facility at an elevated pressure of 700 psig and ambient temperatures in a 3-in. pipe. The dry gas sampling method per API *Manual of Petroleum Measurement Standards* (*MPMS*) Chapter 14.1 (*Collecting and Handling of Natural Gas Samples for Custody Transfer*), Section 12.7 purging—fill and empty (PFE) was used to collect the wet gas samples.

NOTE API *MPMS* Ch. 14.1 scope is limited to gas sampling at or above the natural gas hydrocarbon dew point. Furthermore, API *MPMS* Ch. 14.1 states the sampling of multiphase flow streams (free liquid and gas) should be explicitly avoided.

The wet gas samples were analyzed using gas chromatograph (GC) methods and compared to measured reference gas flow rate and liquid flow rate streams. This report summarizes the wet gas testing methodology, test setup, test results, conclusions, lessons learned, and recommendations.

Contents

Figures

Tables

Disclaimer

The dry gas sampling method per API *MPMS* Ch. 14.1, Section 12.7 PFE was used to gather the wet gas samples in this study. API *MPMS* Ch. 14.1 scope is limited to gas sampling at or above the natural gas hydrocarbon dew point. Furthermore, API *MPMS* Ch. 14.1 states, “The sampling of multiphase flow streams (free liquid and gas) should be explicitly avoided.”

Wet Gas Sampling

1 Introduction

Current API/GPA[1] standards only address dry gas sampling, such as encountered with pipeline quality gas. Dry gas can be defined as gas at or above the saturation temperature at the operating pressure in the pipe with no free hydrocarbon liquids present. Dry gas sampling techniques can produce large bias errors when free liquids are brought into the sampling vessel. Captured wet gas samples may not represent the true ratio of the gas and the liquid components in the flow stream.

In two-phase flow, the gas and the liquid components are not homogenous; they flow at different velocities and in different quadrants of the pipe. The phase distribution in the pipe is a function of the fluid's two-phase flow regime that depends on complicated wet gas parameters, including the gas–liquid density ratio, superficial gas and liquid velocities, pipe diameter, interfacial tension, and other two-phase flow parameters. Upstream and downstream fittings and pipe elevation changes can create liquid "hold-up" areas where liquid velocities slow and occupy a larger percentage of the pipe. The objective of the study is to characterize the uncertainties of using dry gas sampling techniques to collect samples from a wet gas stream.

2 Wet Gas Physical and Technical Challenges

Extracting the correct liquid-to-gas ratio is crucial to obtaining a sample that represents a two-phase source. In a two-phase natural gas stream, the liquid phase contains high concentrations of the heaviest hydrocarbon components, the heaviest components have the highest heating value per unit volume, and a small volume of liquid expands to a large volume of gas. Uncertainty in the quantity of liquid included in a two-phase sample magnifies uncertainty in the composite fluid composition, which is the basis for determining heating value. Too much liquid in the sample and the heating value will be too high; too little liquid in the sample and the heating value will be too low.

The ratio of the gas mass flow rate to the liquid mass flow rate directly impacts the fluid's overall composition, which in turn affects the BTU content traveling down the pipe. Extracting a wet gas sample from a single, discreet location in the pipe may not represent the true ratio between the gas and the liquid bulk mass flow rates. Liquids may not flow uniformly from the sampling probe's tip through the connecting tubing leading to the sampling vessel. Depending on the sampling fluid velocity in the connecting tubing, liquids can cling to the connecting tubing walls or collect in the connecting fittings. Depending on heat losses between the connecting tubing and the ambient air, the saturated gas flowing through the connecting tubing can further condense depositing additional liquids in the connecting tubing walls and fittings. Depending on the pressure drop from the sampling probe's tip to the sampling vessel, liquids clinging to the connecting tubing walls may flash or further condense and change the sample vessel's composition.

Existing analytical methods of a captured wet gas sample require the entire sample be raised to an elevated temperature that vaporizes all the sample's components. Since the components in the captured sample are not known a priori, one must guess the required elevated temperature to vaporize all the components. Additionally, sampling bottle seals are often not rated to the temperature required for complete vaporization.

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[1] GPA Midstream Association (GPA), 6060 American Plaza, Suite 700, Tulsa, OK 74135, www.gpamidstream.org.