Manual of Petroleum Measurement Standards Chapter 14—Natural Gas Fluids Measurement

Section 7—Mass Measurement of Natural Gas Liquids and Other Hydrocarbons

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Foreword

Measurement by mass is often preferred for chemical reactions and various processes where the mass ratios of components are of primary interest in effecting control of the operation.

Since the 1970s, the importance of measuring mixed streams such as natural gas liquids (NGLs) using mass measurement techniques has been recognized. The volume at standard conditions of each component of an NGL mixture may be accurately derived from the mass measurement process because, unlike volumetric measurement, the mass measurement process is not sensitive to the effect pressure, temperature, intermolecular adhesion, and solution mixing have on the measured stream.

Solution mixing and intermolecular adhesion occurs when smaller molecules fill in the spaces between the larger molecules in the solution. Temperature and pressure also affect the amount of shrinkage caused by solution mixing and intermolecular adhesion. Due to these behaviors, the sum of the volumes of individual components in their pure state is greater than the volume of the mixture.

Today, mass measurement systems are commonly used to measure NGL mixtures and ethane-propane mixes, as well as products such as specification ethane, ethylene, and propylene. On the other hand, many propane, isobutane, normal butane, and natural gasoline streams are measured using volumetric techniques. A number of industry-developed standards address the design, construction, operation, and maintenance aspects of mass and volumetric measurement systems. Volumetric measurement depends on tables and correlations to correct the volume measured at flowing conditions to a volume at base conditions. The actual stream composition is important to both mass and volumetric techniques.

GPA Midstream publishes specifications for some of the products resulting from natural gas processing and fractionation, including commercial propane, HD-5 propane, commercial butane, and others. Many companies also have specifications describing, among other things, the compositional requirements of a particular product. Mass measurement is the recommended method of measurement for these mixtures.

These specification products rarely, if ever, are comprised of a single component. Instead, specification products are themselves a mixture of several components, and the actual composition may vary somewhat over time as a function of plant operation. Solution mixing, therefore, occurs in specification products, as well as in NGL mixtures. Industry-developed tables and correlations address physical properties of certain specification products, within the limits of the research database. Volumetrically measured streams are then adjusted using these tables and correlations for temperature, pressure, and density effects. Errors may result when performing these volumetric measurement adjustments if the composition of the stream does not match the compositions for which the volume correction tables and correlations were derived.

This standard was developed jointly by GPA Section H, Measurement, Calculations & Handling of Hydrocarbon Fluids Including NGL and Natural Gas, and the API Committee on Gas Fluids Measurement (COGFM). It is referenced by API as Chapter 14, Section 7 (14.7), of the API Manual of Petroleum Measurement Standards (MPMS). The participation of COGFM in developing this standard is gratefully appreciated and acknowledged.

Throughout this publication, the latest appropriate API and GPA standards are referenced.

API *MPMS* Ch. 14.7 *partially* supersedes API *MPMS* Ch. 14.8.

Contents

Standard for Mass Measurement of Natural Gas Liquids and Other Hydrocarbons

1 Scope

This standard describes the criteria for the equipment selection, design, installation, calculation processes, operation, and maintenance of single-phase dynamic liquid mass measurement systems that operate in the density range of 351.7 kg/m^3 to 687.8 kg/m^3 at 15 °C and equilibrium vapor pressure. The mass measurement systems within the scope of this document include inferred mass measurement, where volume at flowing conditions is combined with density at similar conditions to result in measured mass, as well as direct mass measurement.

2 Application

Liquids with densities below 351.7 kg/m^3 or above 687.8 kg/m^3 at 15 °C and equilibrium vapor pressure and cryogenic fluids (colder than approximately –46 °C) are excluded from the scope of this document, but the principles described herein may apply to such streams.

Mixed products, such as natural gas liquids (NGLs), should be analyzed to determine the mixture composition. This data should be considered in determining the measurement methods and equipment to be used. It is especially important to use mass measurement whenever the range of molecular sizes is great, such as in high ethane content (more than 2 % to 5 % ethane) NGL. It is less critical when molecular sizes are similar, such as in the case of mixed butanes.

Sampling equipment and techniques are covered, including standards for analytical methods used to determine the composition of the sampled product. Equations of state and correlations used to calculate the density of the product are discussed. The standard used to convert mass to equivalent liquid volumes of components is also discussed.

Equipment exists that uses diverse principles for measuring volume, sampling the product, and determining the composition and density of the product. This standard does not advocate the preferential use of any particular type of equipment. It is not the intention of this standard to restrict future development or improvement of equipment. The contracting parties to any agreement should mutually agree on the equipment to be used.

3 Mass vs. Volumetric Measurement—Accuracy and Precision Implications

Mass measurement techniques defined in this and other related industry standards eliminate the bias resulting from solution-mixing effects, as well as eliminating the uncertainty of the volumetric correction algorithms and tables. Mixtures containing multiple components of varying molecular sizes and NGL streams with high ethane concentrations should be measured using mass measurement techniques; otherwise, the quantity derived using volumetric techniques for these streams will always be lower than the volume determined from mass measurement. Volumetric measurement may be suitable for pure or essentially pure products as the aforementioned concerns may not be as significant.

Volumetric measurement is often considered to be acceptable for specification LPG products of relatively high purity, such as HD-5 propane, isobutane, normal butane, and natural gasoline products, which are essentially free of very small molecules such as ethane. Solution-mixing errors for these products may range from as much as greater than 0.5 % for high-ethane HD-5 propane to negligible levels for heavy natural gasolines. Volumetric measurement has an additional uncertainty that is related to the fact that the assumed compositions the algorithms or tables are based on may not be exactly the same as the stream being measured.