Measurement of Thermally Cracked Gas

API TECHNICAL REPORT 2575
FIRST EDITION, SEPTEMBER 2014

AMERICAN PETROLEUM INSTITUTE

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Contents

Introduction

This document initiates improving thermally cracked gas (TCG) property calculation methods for measurement applications. It is a research report on TCG research work in progress. The methods presented here are for example illustration purposes only. They are not for use at this stage in the development work. Modifications will occur to the methods presented here and to other industry methods commonly used for TCG measurement once the research work is completed. The goal is to reduce TCG custody transfer uncertainty. TCG is not a naturally occurring natural gas mixture. It is produced as a by-product in the refining process of petroleum fluids.

The principal flow measurement method used to measure TCG is orifice measurement as applied in API *MPMS* Ch. 14.3/AGA Report No. 3/GPA 8185. These documents reference the use of API *MPMS* Ch. 14.2/AGA Report No. 8/GPA 8185 for compressibility factor calculations. The assumption in the current application of API *MPMS* Ch. 14.3/AGA Report No. 3/GPA 8185 is that the fluid sampling, measurement, and calculations conditions are in the single gas phase region and that the fluid components are consistent with API *MPMS* Ch. 14.2/AGA Report No. 8/ GPA 8185. TCG mixtures contain significant quantities of olefins and hydrogen. These fluid mixtures are not natural gases and fall outside of natural gas measurement and operation practices.

No reference or inference is made in API *MPMS* Ch. 14.2/AGA Report No. 8/GPA 8185 to applying natural gas components as chemical analogs for olefinic compounds, or that high concentrations of hydrogen can be permitted in such mixtures. Nor do current industry measurement documents make statements regarding the uncertainty of such practices.

Current orifice measurement standards do not address the metering, operations, or physical properties of TCGs. Industry practice has been to substitute natural gas component analogs as a means to estimate TCG property values for custody transfer. This practice increases measurement uncertainties.

In order to address the issues associated with TCGs, API initiated a four-phase project on TCG measurement. Phase I evaluated current TCG measurement practices. The results suggested that component substitution methods produced mass density uncertainties of 0.3 % to 5 % for TCG mixtures. The uncertainty depends on operating conditions. Phase I identified experimental data gaps and the need for experimental reference data over custody transfer and common pipeline operating conditions. In order to initiate filling experimental data gaps for TCG mixture mixtures, a single gas mixture was prepared and measured during Phase II. The Gas Technology Institute (GTI) provided the experimental setup and measured data to support Phase II work. The experimental work measured gas phase measurements of density, sound speed, and capacitance for a synthetic TCG mixture over a narrow operating range. Measured data were compared to predicted values from API *MPMS* Ch. 14.2/AGA Report No. 8/GPA 8185, NIST14-DDMIX, GERG 2004/GERG 2008, and the Soave-Redlich-Kwong equations of state. Subsequent analysis was also made using ISO 20765-2 for extended range applications. This report completes the Phase III work. The final phase, Phase IV, will obtain data over a broad range of TCG operating conditions. Measured reference data for many key TCG mixtures are not available. The mixture data from the Phase IV lab work may be used to evaluate TCG mixture data and determine the applicability of various measurement equations to TCG mixtures.

Measurement of Thermally Cracked Gas

1 Scope

This technical report presents a method to compute the density, compressibility factor, and supercompressibility factor for thermally cracked gas (TCG) for custody transfer using orifice meters. It provides equations, parameters, computation flow diagrams, and example spreadsheet calculations.

This technical report applies to TCG mixtures after treatment. See Table 2 for more information on the types of gases covered. It applies for temperature from 90 °F to 120 °F (305 K to 322 K) at pressures up to 300 psig (2 MPa). It is limited to a specific operating region. The method is for the single gas phase only.

2 Normative References

The following referenced documents are indispensable for the application of this document or provide additional information pertinent to mass measurement of natural gas liquids. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API *Manual of Petroleum Measurement Standards (MPMS)*, Chapter 14.2, *Compressibility Factors of Natural Gas and Other Related Hydrocarbon Gases* (AGA Report No. 8 [1]) (GPA 8185 [2])

3 Terms, Definitions, Abbreviations, and Symbols

3.1 Terms and Definitions

The quantities used in the equations in this document are defined when they are used.

3.2 Abbreviations and Symbols

For the purposes of this document, the following abbreviations and symbols apply.

B	second virial coefficient
B_{mix}	mixture second virial coefficient
b_{n}	constant in Table 4
C	third virial coefficient
C_{mix}	mixture third virial coefficient
c_{n}	constant in Table 4
d	mass density (mass per unit volume)
$\rho(T_{\rho}, P_{\rho})$	molar density at reference condition T_{ρ}, P_{ρ}
F_{pv}	supercompressibility factor
M_{r}	molar mass (molecular weight)
M_{r} (air)	molar mass of air
$M_{\text{r}_{\text{i}}}$	molar mass of ith component
N	number of components in gas mixture
n	number of moles of gas

1 American Gas Association, 400 N. Capitol Street, NW, Suite 450, Washington, DC 20001, www.aga.org.
2 Gas Processors Association, 6526 E. 60th Street, Tulsa, Oklahoma 74145, www.gasprocessors.com.