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

Section 4—Converting Mass of Natural Gas Liquids and Vapors to Equivalent Liquid Volumes

GPA 8173-90

FIRST EDITION, APRIL 1991

REAFFIRMED, JANUARY 2012

AMERICAN PETROLEUM INSTITUTE

GAS PROCESSORS ASSOCIATION

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FOREWORD

This standard was developed jointly by the Gas Processors Association (GPA), Section H, Product Measurement and Handling, and the American Petroleum Institute (API), Committee on Natural Gas Fluids Measurement. Chapter 14.4 of the manual is technically identical to GPA Standard 8173. Only the format has been changed to match that of API's *Manual of Petroleum Measurement Standards.*

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Suggested revisions are invited and should be submitted to the director of the Measurement Coordination Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

CONTENTS

Chapter 14—Natural Gas Fluids Measurement

SECTION 4—CONVERTING MASS OF NATURAL GAS LIQUIDS AND VAPORS TO EQUIVALENT LIQUID VOLUMES

14.4.1 Scope

This standard prescribes a method for converting the measured mass of natural gas liquids or natural gas vapors at operating conditions to equivalent liquid volumes of the components at 60°F and equilibrium pressure for English units, or 15°C and equilibrium pressure for SI units.

14.4.2 Referenced Publications

The following standards, codes, and specifications are cited in this standard:

API
Technical Data Book
Manual of Petroleum Measurement Standards
Chapter 14.6, "Continuous Density Measurement";
Chapter 14.7, "Mass Measurement of Natural Gas Liquids" (GPA Std 8182)

GPA[1]
Std 2145 *Table of Physical Constants of Paraffin Hydrocarbons and Other Components of Natural Gas.*
Std 2186 *Tentative Method for the Extended Analysis of Hydrocarbon Liquid Mixtures Containing Nitrogen and Carbon Dioxide by Temperature Programmed Gas Chromatography.*

GPSA[2]
Engineering Data Book ("Physical Properties" Chapter)

14.4.3 Outline of Method

14.4.3.1 Mass is calculated by multiplying consistent units of a measured volume by its absolute density, with both volume and absolute density determined at the same flowing conditions. The resulting total mass is converted to individual component volumes using a component analysis and proper values of the absolute density in mass per unit volume of each component at 60°F (or 15°C) and its equilibrium pressure.

14.4.3.2 Volume and absolute density determination, sampling, and analysis shall be performed as described or referenced in Chapter 14.7 (Gas Processors Association (GPA) Standard 8182).

14.4.3.3 The absolute density of pure hydrocarbons in pounds mass per gallon (Kg/M^3) as stated in GPA Standard 2145 shall be used in the calculations. Unless contract terms specify otherwise, absolute density values shall be from the latest revision of GPA Standard 2145. In the examples in this publication, the absolute density values stated in GPA Standard 2145-86 were used.

Note 1: The examples in this publication illustrate typical components. In actual practice, all the detected components that are representative of the measured product stream should be included in the conversion to equivalent liquid volumes.

Note 2: If constants for hydrocarbon components that are not presented in GPA Standard 2145 are required, the constants contained in the "Physical Properties" chapter of the GPSA *Engineering Data Book* shall be used. If the required constants are not contained in the GPSA *Engineering Data Book* either, the API *Technical Data Book* constants shall be used.

14.4.4 Precautions

Equipment, installation, and operations shall be in accordance with Chapter 14.7 (GPA Standard 8182); however, the following information is reiterated:

a. Accurate dynamic measurement can be accomplished only with a single phase, homogeneous, Newtonian fluid.

b. To calculate mass accurately, density determination must be made at essentially the same pressure and temperature as the volume measurement. Allowable temperature and pressure deviations are set in Chapter 14.6. Density may either be measured directly or calculated in accordance with Chapter 14.7 (GPA Standard 8182).

c. Dynamic measurement in the vapor phase must occur at a pressure below the equilibrium pressure (dew point pressure) of the mixture at operating conditions.

d. Dynamic measurement in the liquid phase must occur at a pressure above the equilibrium pressure (bubble point pressure) of the mixture at all actual operating temperatures and compositions. This standard may also be applied to the measurement of supercritical fluids.

e. Measuring and sampling equipment shall be located where it will not be affected by pulsation; mechanical vibration; and compressor-, pump-, or control-valve-generated noise that would adversely affect measurement accuracy.

[1]Gas Processors Association, 6526 E. 60th Street, Tulsa, OK 74145.
[2]Gas Processors Suppliers Association, 6526 East 60th Street, Tulsa, OK 74145.

14.4.5 Calculations for Liquid and Vapor Conversion (English Units)

Step 1—Convert mol percent analysis to weight fraction:

Given: Compositional analysis (mol percent)
Molecular weight constants from GPA Standard 2145.

a. Multiply the mol percent of each component by the molecular weight of that component, (1) × (2).

b. Divide the resulting product for each component (3) by the sum of the products of all components to obtain the weight fraction of each component (4).

	(1)		(2)		(3)		(4)
Component	Mol percent	×	Molecular Weight	=	Mol Percent × Molecular Weight	Sum of Mol Percent × Molecular Weight ÷	Weight Fraction
CO_2	0.11	×	44.010	=	4.84	4372.27	0.001107
C_1	2.14		16.043		34.33	4372.27	0.007852
C_2	38.97		30.070		1171.83	4372.27	0.268014
C_3	36.48		44.097		1608.66	4372.27	0.367923
IC_4	2.94		58.123		170.88	4372.27	0.039083
NC_4	8.77		58.123		509.74	4372.27	0.116585
IC_5	1.71		72.150		123.38	4372.27	0.028219
NC_5	1.82		72.150		131.31	4372.27	0.030032
C_{6+}	7.06		87.436[a]		617.30	4372.27	0.141185
	100.00				4372.27		1.000000

Step 2—Calculate the mass of each component:

Given: Total pounds mass = 825,300
Component weight fractions from Step 1.

a. Multiply the weight fraction by the total mass to obtain the pounds mass of each component.

b. Add the pounds mass of all components to ensure that the sum equals the total pounds mass.

Component	Weight Fraction ×	Total Mass (pounds)	=	Component Mass (pounds)
CO_2	0.001107	825,300		914
C_1	0.007852	825,300		6,480
C_2	0.268014	825,300		221,192
C_3	0.367923	825,300		303,647
IC_4	0.039083	825,300		32,255
NC_4	0.116585	825,300		96,218
IC_5	0.028219	825,300		23,289
NC_5	0.030032	825,300		24,785
C_{6+}	0.141185	825,300		116,520
	1.000000			825,300

Step 3—Calculate the volume of each component at equilibrium pressure and 60°F:

Given: Absolute density of each component from GPA Standard 2145.
Component mass from Step 2.

a. Divide the component mass of each component by its absolute density to obtain the equivalent liquid volume.

Component	Component Mass (pounds)	÷	Density (pounds per gallon)	=	Gallons at 60°F, EVP
CO_2	914	÷	6.8199	=	134
C_1	6,480		2.5000		2,592
C_2	221,192		2.9696		74,485
C_3	303,647		4.2268		71,839
IC_4	32,255		4.6927		6,873
NC_4	96,218		4.8690		19,761
IC_5	23,289		5.2082		4,472
NC_5	24,785		5.2617		4,710
C_{6+}	116,520		5.951[a]		19,580
					204,446

[a]From extended analysis as described in GPA Standard 2186. The hexanes—plus component may be reported as hexanes and heptanes—plus.

14.4.6 Calculations for Liquid and Vapor Conversion (SI Units)

Step 1—Convert mol percent analysis to weight fraction:

Given: Compositional analysis (mol percent)
Molecular weight constants from GPA Standard 2145.

a. Multiply the mol percent of each component by the molecular weight of that component, (1) x (2).

b. Divide the resulting product for each component (3) by the sum of the products of all components to obtain the weight fraction of each component (4).

	(1)		(2)		(3)		(4)
Component	Mol percent	×	Molecular Weight	=	Mol Percent × Molecular Weight	Sum of Mol Percent × Molecular Weight ÷	Weight Fraction
CO_2	0.11	×	44.010	=	4.84	4372.27	0.001107
C_1	2.14		16.043		34.33	4372.27	0.007852
C_2	38.97		30.070		1171.83	4372.27	0.268014
C_3	36.48		44.097		1608.66	4372.27	0.367923
IC_4	2.94		58.123		170.88	4372.27	0.039083
NC_4	8.77		58.123		509.74	4372.27	0.116585
IC_5	1.71		72.150		123.38	4372.27	0.028219
NC_5	1.82		72.150		131.31	4372.27	0.030032
C_{6+}	7.06		87.436[a]		617.30	4372.27	0.141185
	100.00				4372.27		1.000000

Step 2—Calculate the mass of each component:

Given: Total kilograms mass = 374,350
Component weight fractions from Step 1.

a. Multiply the weight fraction by the total mass to obtain the kilograms mass of each component.

b. Add the kilograms mass of all components to ensure that the sum equals the total kilograms mass.

Component	Weight Fraction		Total Mass (kilograms)		Component Mass (kilograms)
CO_2	0.001107	×	374,350	=	414
C_1	0.007852		374,350		2,939
C_2	0.268014		374,350		100,331
C_3	0.367923		374,350		137,732
IC_4	0.039083		374,350		14,631
NC_4	0.116585		374,350		43,644
IC_5	0.028219		374,350		10,564
NC_5	0.030032		374,350		11,242
C_6+	0.141185		374,350		52,853
	1.000000				374,350

Step 3—Calculate the volume of each component at equilibrium pressure and 15°C.

Given: Absolute density of each component from GPA Standard 2145.
Component mass from Step 2.

a. Divide the component mass of each component by its absolute density to obtain the equivalent liquid volume.

Component	Component Mass (kilograms)		Density (kilogram/cubic meter)		Cubic Meters at 15°C, EVP
CO_2	414	÷	821.94	=	0.50
C_1	2,939		300.00		9.80
C_2	100,331		357.76		280.44
C_3	137,732		507.30		271.50
IC_4	14,631		562.98		25.99
NC_4	43,644		584.06		74.73
IC_5	10,564		624.35		16.92
NC_5	11,242		631.00		17.82
C_6+	52,853		713.10[a]		74.12
	374,350				771.82

[a]From extended analysis as described in GPA Standard 2186. The hexanes—plus component may be reported as hexanes and heptanes—plus.

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