Manual of Petroleum Measurement Standards Chapter 11.2.4

Temperature Correction for the Volume of NGL and LPG Tables 23E, 24E, 53E, 54E, 59E, and 60E

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Contents

Figures

Charts

Tables

Nomenclature

A, B, C	parameters in Section 5.1.2 quadratic equation
C_{TL}	temperature correction factor
h_2	scaling factor
k_1, k_2, k_3, k_4	parameters in saturation density equation
T_B	base temperature (60 °F, 15 °C, or 20 °C)
T_{BK}	base temperature (288.15 K, or 293.15 K)
T_c	fluid critical temperature (K)
$T_{c, ref}$	reference fluid critical temperature (K)
T_F	observed measurement temperature (°F or °C)
$T_{r,x}$	reduced observed temperature
T_x	observed temperature (K)
V_{60}/V_{Tx}	ratio of volume at 60 °F to volume at temperature T_x. Is the basic definition of C_{TL}
X	interpolating factor
Z_c	critical compressibility factor
α, β, ϕ	parameters in Section 5.1.2 quadratic equation
δ	interpolation variable
τ	parameter in saturation density equation
τ_x	parameter in saturation density equation at observed temperature
γ_x	relative density at observed temperature
$\gamma_{x, high}$	relative density at the observed temperature corresponding to the upper boundary for the 60 °F relative density
$\gamma_{x, low}$	relative density at the observed temperature corresponding to the lower boundary for the 60 °F relative density
$\gamma_{x, mid}$	relative density at the observed temperature corresponding to the intermediate 60° F relative density used in Section 5.1.2 iteration procedure
$\gamma_{x, trial}$	trial relative density at the observed temperature used in Section 5.1.2 iteration procedure
γ_{TB}	relative density at the base temperature, T_B
γ_{60}	relative density at a base temperature of 60 °F
γ_{Tx}	relative density at the observed temperature, T_x
$\gamma_{60, high}$	upper bound for the observed fluid's 60 °F relative density
$\gamma_{60, low}$	lower bound for the observed fluid's 60 °F relative density
$\gamma_{60, mid}$	intermediate 60 °F relative density value used in Section 5.1.2 iteration procedure
$\gamma_{60, trial}$	trial 60 °F relative density value used in Section 5.1.2 iteration procedure
ρ_c	critical molar density (kmol/m^3)
ρ_{60}	density at a base temperature of 60 °F (kg/m^3)
ρ_{15}	density at a base temperature of 15 °C (kg/m^3)
ρ_{20}	density at a base temperature of 20 °C (kg/m^3)
ρ^{sat}	saturation molar density (kmol/m^3)
ρ_{60}^{sat}	saturation molar density at 60 °F (kmol/m^3)
ρ_T^{sat}	saturation molar density at observed temperature (kmol/m^3)
ρ_{w60}	density of water at 60 °F (kg/m^3)

Temperature Correction for the Volume of NGL and LPG Tables 23E, 24E, 53E, 54E, 59E, and 60E

Implementation Guidelines

This revised standard is effective upon the date of publication and supersedes the ASTM-IP 1952 Petroleum Measurement Tables, GPA 2142, GPA TP-16, Tables 33 and 34 of API *MPMS* Chapter 11.1-1980 Volumes XI/XII (Adjuncts to ASTM D1250-80 and IP 200/80), and API/ASTM/GPA TP-27. However, due to the nature of the changes in this revised standard and the fact that it is or may be incorporated by reference in various regulations, it is recognized that guidance concerning an implementation period may be needed in order to avoid disruptions within the industry and ensure proper application. An application, for this purpose, is defined as the point where the calculation is applied.

The actual standard represented by this report consists of the explicit implementation procedures. Sample tables and other examples created from a computerized version of these implementation procedures are presented within. However, these are for examples only and do not represent the standard.

Once the revised standard is implemented in a particular application, the previous standard will no longer be used in that application.

However, the use of API and GPA standards remains voluntary, and the decision on when to use a standard is an issue that is subject to the negotiations between the parties involved in the transaction.

1 Introduction

For custody transfer purposes, natural gas liquid (NGL) and liquefied petroleum gas (LPG) volumes are generally stated at a fixed base temperature and saturation pressure. As most volume transfers occur at temperatures and pressures other than standard conditions, these volumes are adjusted to standard conditions through the use of correction factors. The document is specifically titled as being suitable for NGL and LPG liquids. Light hydrocarbon mixtures containing significant quantities of methane, carbon dioxide and nitrogen which have density ranges which overlap those contained in these tables can be encountered. However, the two-fluid correlation which is the basis of these tables was not calibrated for such mixtures. Separate factors for temperature (C_{TL}) and pressure (C_{PL}) are used to make these corrections. This document presents a new method to calculate temperature correction factors. Pressure correction factors are not within the scope of this document, but can be calculated using American Petroleum Institute *Manual of Petroleum Measurement Standards* (*MPMS*) Chapter 11.1-2004 [1] (which superseded Chapter 11.2.1-1984 [2] and 11.2.1M-1984 [3]), Chapter 11.2.2-1986/GPA 8286-86 [4] or Chapter 11.2.2M-1986/GPA 8286-86 [5], depending on product type.

Previously, most NGL and LPG temperature correction factors have been obtained from a variety of sources:

- ASTM-IP "Petroleum Measurement Tables" [6], published in 1952. This publication is limited to a 60 °F relative density range of 0.500 and higher.
- GPA Standard 2142, "Standard Factors for Volume Correction and Specific Gravity Conversion of Liquefied Petroleum Gases" [7], published in 1957, also contains the same correction factors as the 1982 ASTM-IP document.
- GPA TP-16 "Composite Pressure and Temperature Volume Correction Factor Tables for Liquefied Petroleum Gas (LPG) and Natural Gasoline" [8], published in 1988. It is limited to the following products: HD-5 Propane with relative densities of 0.501, 0.505, and 0.510; iso-butane at a relative density of 0.565; normal butane at a relative density of 0.585; and natural gasoline (12-14 psia RVP) at a relative density of 0.664.
- API *MPMS* Chapter 11.1-1980/ASTM D1250-80 Volume XII, Table 33 "Specific Gravity Reduction to 60 °F For Liquefied Petroleum Gases and Natural Gasoline" [9].

— API *MPMS* Chapter 11.1-1980/ASTM D1250-80 Volume XII, Table 34 “Reduction of Volume to 60 °F Against Specific Gravity 60/60 °F For Liquefied Petroleum Gases” [9].

— API/ASTM/GPA 8117 “Temperature Correction for the Volume of Light Hydrocarbons” [10].

— API/ASTM/GPA TP-27 “Temperature Correction for the Volume of NGL and LPG” [11].

With the publication of this document, the above API, ASTM and GPA documents should no longer be used for NGL and LPG temperature correction factors. Text for GPA 8217 as approved is included without technical change in this present document. Some edits have been made to align flow charts with examples shown so that they may be consistent.

2 Scope

The actual standard represented by this report consists of the explicit implementation procedures. Sample tables, flow charts, and specific examples created from a computerized version of these implementation procedures are presented within. The examples are to provide guides and check points to those who wish to implement a computerized procedure to represent the Standard, however these are not a part of the actual Standard.

This standard covers a 60 °F relative density range of 0.3500 to 0.6880 which nominally equates to a density at 15 °C of 351.7 kg/m^3 to 687.8 kg/m^3 and a density at 20 °C of 331.7 kg/m^3 to 683.6 kg/m^3. The temperature range of this standard is –50.8 °F to 199.4 °F (–46 °C to 93 °C). At all conditions, the pressure is assumed to be at saturation conditions (also known as bubble point or saturation vapor pressure).

NOTE These are nominal ranges which are further refined within the standard by correlation limits to be the ranges bounded by the points in Table 1:

Table 1—*MPMS* 11.2.4 Correlation Limits

Relative Density (60 °F/60 °F)	Lower Temperature Limit (°F)	Upper Temperature Limit (°F)	Lower Temperature Limit (°C)	Upper Temperature Limit (°C)	Lower Temperature Limit (K)	Upper Temperature Limit (K)
0.35000	–50.8	87.4	–46.0	30.8	227.15	303.93
0.35599	–50.8	8[illegible].9	–46.0	32.2	227.15	305.32
0.42928	–50.8	140.9	–46.0	60.5	227.15	333.65
0.47038	–50.8	174.8	–46.0	79.3	227.15	352.48
0.49935	–50.8	199.4	–46.0	93.0	227.15	366.15
0.68800	–50.8	199.4	–46.0	93.0	227.15	366.15

As shown in Figure [illegible] which follows:

Input range—the box defined in the scope of the standard as a (60 °F/60 °F) relative density of 0.35 to 0.688 and –46 °C to 93 °C.

Correlation range—the polygon defined by line segments connecting the relative densities and critical temperatures of the reference fluids in Table 1 of the standard for the upper boundary, –46 °C for the lower temperature boundary, the relative density of EE (68/32) for the lower relative density boundary and the relative density of n-heptane for the upper relative density boundary. See Figure 1 in this document for an illustration.

The calculation method was developed from GPA RR-148 “Volume Correction Factors for Natural Gas Liquids—Phase II” [12] and API/ASTM/GPA Technical Publication, TP-25, September, 1998 [10]. The implementation