QuantityWare Working Paper

LPG Measurement Standard Selection

How does the selection of my LPG measurement standard influence my business processes?

Version History

Version	Date	Description
00	2009-03-27	Initial Version
01	2020-07-17	Editorial revision
02	2021-09-24	Modern QW document style applied, editorially revised and confirmend
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Contents

1. Introduction

The selection of a measurement standard for any product within the petroleum and chemicals industries requires careful attention. The ultimate guiding principle, as noted in almost all measurement standards, is that buyer and seller need to agree on a standard for the products they trade, taking into consideration the potential boundary conditions that legal requirements and regulatory bodies may impose.

Thus, a selection of a measurement standard could be a relatively easy task, if, for each well defined product, a single globally accepted measurement standard was available, based upon a universal product weighing procedure, where our business processes would always be based on product weight. Believe it or not, this is the case in an "ideal world".

With the advent of modern ERP systems, the selection of the agreed standard also requires the implementation of software calculation procedures which are utilized within highly automated business processes.

In real life, the story is less ideal. Typically, measurement standards coexist with different versions for some time in parallel and various national standards also have to be considered for a given product. Changing software implementations of legacy systems can be cumbersome, and negotiating new agreements with your business partners can be hindered by the simple fact that defining and reaching new agreements can cost time and money. Due to the large quantities handled and high costs for weighing even small portions of product, business processes still heavily depend on volumetric accounting, i.e. the determination of product volumes during process execution, which are then used as the basis for freight rates, prices and duties.

In this case study we analyze the current situation within the LPG (Liquefied Petroleum Gas) market and provide guidance for decision makers as to how to analyze their current LPG business processes with respect to the volume correction factor (CTL) measurement standard situation. These standards describe the effect of temperature on product volume. Effects of pressure, which also need to be considered, are not part of this study.

Let's create an example.

Assume that you buy 100,000 gallons of commercial propane. You need to know at which temperature you receive that quantity, since the product volume changes with changing temperature. Typically, buyer and seller agree on a so called standard temperature at which you nominally trade the product. For many countries e.g., the United States, this base temperature is defined as 60 °F, other countries use 15 °C or 20°C as base temperature.

Now back to our Propane. 100,000 gallons of product are delivered to your storage facility on a hot afternoon, and are unloaded into an empty tank with an observed temperature of 87 °F. Early next morning, another measurement is taken and you find that "only" 97,000 gallons of liquid are in your tank.

You did not consume any of the propane overnight.

The tank has no leaks.

According to the security cameras, no-one has stolen 3,000 gallons of propane overnight.

What could have happened?

Your technicians report to you that the propane liquid's temperature is now 70 °F – and herein lies the answer.

Your liquid propane has expanded with rising temperature, and has shrunk in volume now that the temperature has fallen.

The exact numerical determination as to "how much" the product volume changes with changing temperature is described in a measurement standard that tells you how to calculate the correction factor due to the effect of temperature CTL. This factor used to be called the "Volume Correction Factor" (VCF) in older versions of measurement standards.

2. LPG Measurement Standard – GPA 8217 / TP-27

As described in the introduction of this case study, there is one "state-of-the-art" standard available for the calculation of the effect of temperature on LPG volumes:[1]

- API Manual of Petroleum Measurement Standards

  Chapter 11—Physical Properties Data

  Section 2, Part 4—Temperature Correction for the Volume of NGL and LPG

  Tables 23E, 24E, 53E, 54E, 59E, and 60E

- GPA Standard 8217 / formerly GPA Technical Publication TP-27
- SECOND EDITION, JUNE 2019

which for simplicities' sake, we will refer to as "GPA 8217" in this document. (GPA stands for the "Gas Processors Association").

Like all new standards in this field, it provides an implementation procedure describing how to develop software programs that calculate temperature correction factors.

In any case, this standard should be considered when reviewing existing software programs for LPG temperature correction factor calculations. It supersedes older standards that may still be in use. However, it is important to note again that ultimately buyer and seller need to agree on a standard which will be used for their business transactions.

[1] If the LPG/NGL consists of more than 20 % unsaturated hydrocarbons, ISO 6578 should be used to determine the volume corrections.

3. Comparison of GPA 8217 with Superseded Standards

Among the older standards used for LPG temperature correction factor calculations, the following are superseded by GPA 8217 (list is not complete):

- 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" – Table 33
- 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" Table 34
- ASTM-IP 1952 Petroleum Measurement Tables

These standards provide temperature correction factors in a table format. Table 33 and Table 34 are basically a condensed form of ASTM-IP 1952 table values. Legacy systems may still utilize these values for custody transfer calculations.

3.1. Comparison with ASTM-IP 1952 Petroleum Measurement Tables

The good news.

GPA 8217 / TP-27 contains a detailed analysis of the differences between CTL values provided by the ASTM-IP 1952 Petroleum Measurement Tables and GPA TP-27 calculated values.

Typically, the differences are within +/- 0.2% for temperatures between -10 °F and 90 °F, for LPG products ranging from commercial propane to commercial butane.

Towards high and low temperatures, with reference to the base temperature (60 °F) the deviations typically tend to increase

If you are utilizing one of these old standards for your LPG business, you should obtain your own licensed version of the specific standard from the Gas Processors Association (GPA) and organize an assessment of the differences. Remember, if you decide that you need to change to GPA 8217 / TP-27, you may possibly have to start a negotiation process with your business partners.

3.2. Comparison with ASTM D1250-80 Implementations

(The not so good news)

In contrast to the ASTM-IP 1952, one of the first modern standards for temperature correction factor calculations which provided a detailed implementation procedure for the calculation, was ASTM D1250-80. While it clearly stated that LPG was not within the standard's scope, it is quite possible that due to the lack of any other alternative (besides the historical table versions noted above), buyers and sellers *agreed to extend the lower density limits of ASTM D1250-80, to enable automatic quantity value calculations for LPG within computer systems.*

Such standard's manipulation can have good reasons and reflect physical business necessities e.g. catering for very heavy crude oil or extreme climate conditions (very low or very high temperatures), but should be very carefully analyzed before implementation takes place.

QuantityWare also provides implementations of ASTM D1250-80 and ASTM D1250-04 (and later) as part of our BCP product, which allows the responsible parties to extend specified validity ranges if buyer and seller agree that this is the only feasible way in which to provide a calculation basis for defined products.

However, for LPG we strongly recommend the usage of the GPA 8217 / TP-27 standard for LPG.

To support this recommendation, we have analyzed and compared the calculation results if a "range extended" (manipulated) ASTM D1250-80 implementation was used for product calculation against the GPA 8217 / TP-27 results, for three products:

1. Commercial propane
2. A 50/50 mixture or propane and butane
3. Commercial butane

For the comparison calculations, these three products are distinguished by their relative density at 60 °F and absolute density at 15 °C. Since the product specifications for commercial propane and butane differ on a global scale (with respect of the detailed composition), we have taken the density values of 100% propane, 100% butane and the 50/50 mixture accordingly for our calculations:

	Commercial Propane	**50/50% Mixture**	**Commercial Butane**	**Source/Calculation**
Density @ 15 °C	**507.6 kg/m³**	**546.1 kg/m³**	**584.5 kg/m³**	DIN 51757
CTL 60 °F to 15°C	0.99840	0.99872	0.99895	GPA 8217 / TP-27
Density @ 60 °F	506.8 kg/m³	545.4 kg/m³	583.9 kg/m³	Density @ 15 °C * (CTL 60 °F to 15°C)
rel. Density @ 60 °F	**0.507**	**0.546**	**0.584**	Divide density @ 60 °F by 999.016 kg/m³ (60 °F Density of water (ASTM D1250-04)
critical temperature:	96 °C		152 °C	Various sources / MSDS sheets

Without being able to use exact product definitions, we can assume that commercial propane and commercial butane are located very close to the 100% propane and 100% butane density values (Typically, the densities lie within 507 kg/m3 +/- 5 kg/m³ for commercial propane and 584 kg/m³ +/- 5 kg/m³ for commercial butane).

The results of our calculations are displayed in the following two diagrams. We plot the deviation of the calculated CTL values of GPA 8217 / TP-27 and ASTM D1250-80 (extended) and express the deviation as a percent value. A positive percent value means that the ASTM D1250-80 value is higher than the GPA 8217 / TP-27 value and a negative percent value means that the ASTM D1250-80 value is lower than the GPA 8217 / TP-27 value.

In general, the three curves in each figure show the following:

a) Above the base temperature (60 °F / 15 °C) the ASTM D1250-80 values are always higher than the GPA 8217 / TP-27 values

b) Below the base temperature (60 °F / 15 °C) the ASTM D1250-80 values are always lower than the GPA 8217 / TP-27 values

c) At constant temperature, the greatest deviation is achieved by “low density” products, with commercial propane showing the maximum deviation.

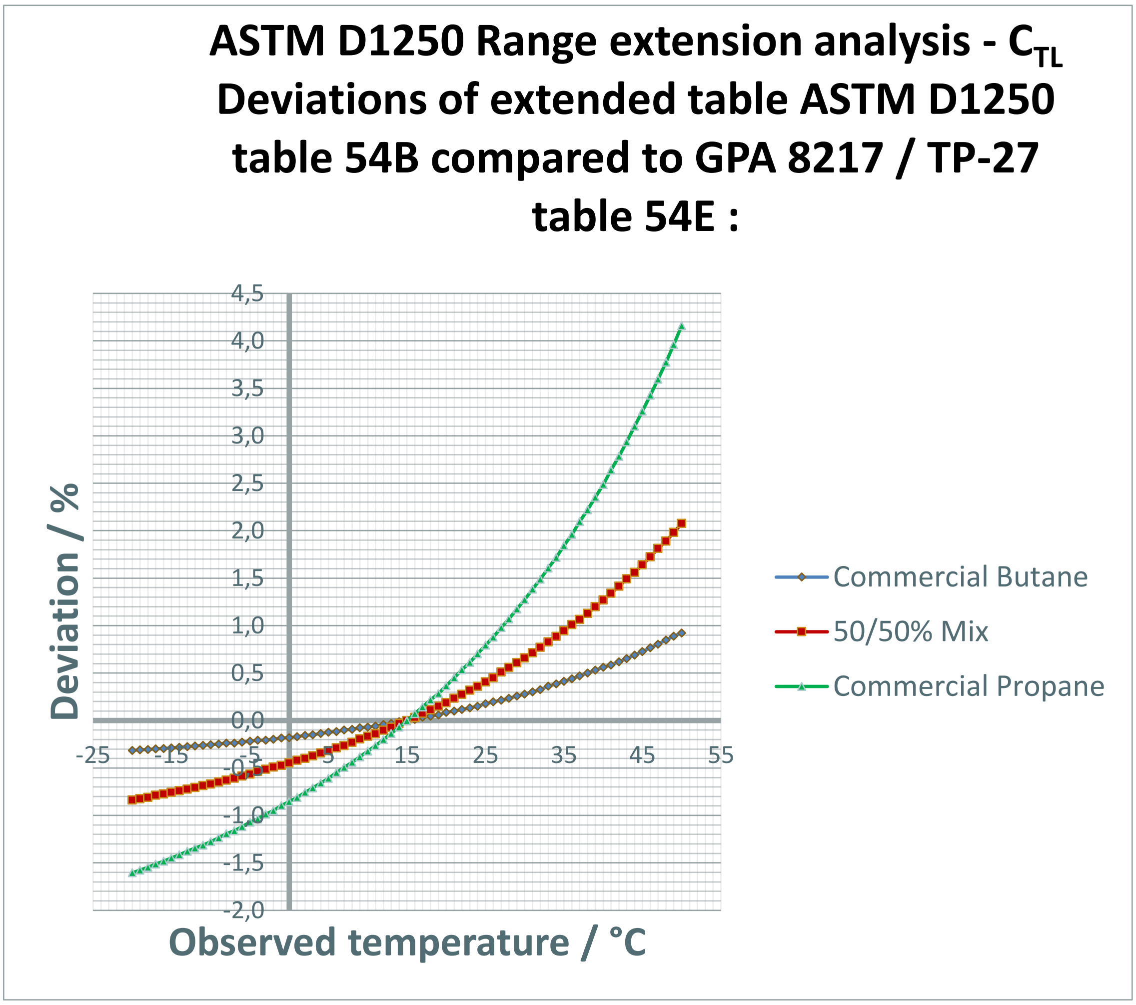

Figure 1: Deviation of CTL values from GPA 8217 / TP-27 results for three products, the base temperature is 15 °C.

Most Material Safety Data Sheets (MSDS) require storage & transportation temperatures for LPG products below 50 °C. As can be easily seen from these two figures, even for moderately high temperatures (approx. 20 °C to 35 °C / 70 °F to 90 °F) as well for very cool temperatures which can quite easily be encountered in the world's climate regions, the deviations exceed the 0.2% range considerably, especially for propane mixtures and commercial propane.

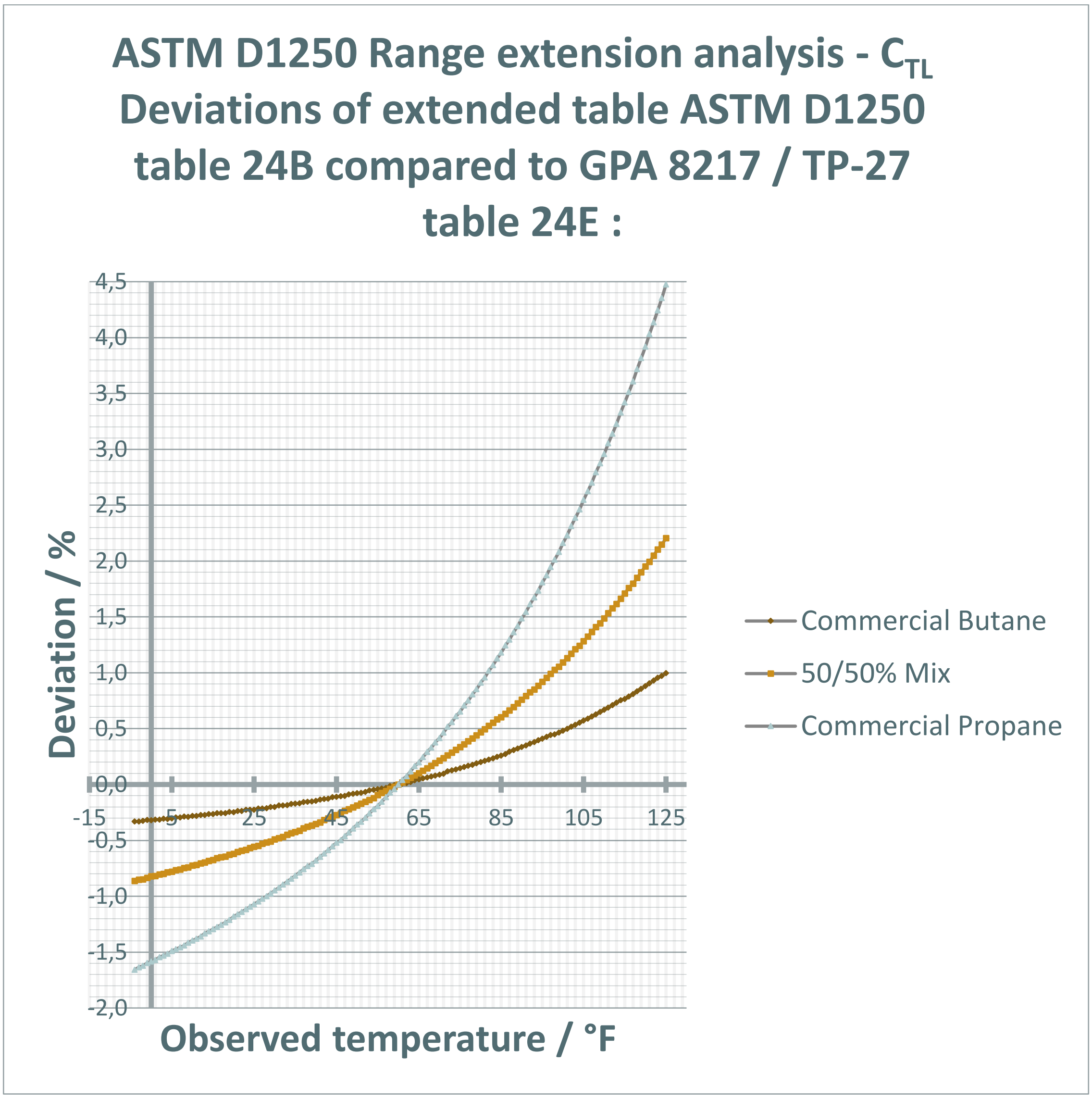

Figure 2: : Deviation of CTL values from GPA 8217 / TP-27 results for three products, the base temperature is 60 °F.

3.3. Business Scenario Implications

As noted above, buyer and seller should always formally agree as to which standard should be applied for LPG custody transfer calculations. If this is not the case, or if despite such an agreement the buyer and seller computer systems calculations are based on different standards, business process disruptions could occur quite naturally, possibly leading to very costly negotiations to resolve the dispute, e.g., if an invoice is questioned by a buyer. Regulatory bodies could also be activated and start assessment of the effect of such arbitrary calculations on the duties and taxes etc. levied on cross-border transfers.

Even if buyer and seller agree on a single standard, this may have negative business implications for one involved party.

Example:

Let us assume that both parties of a transaction have explicitly agreed to utilize an extended ASTM D1250-80 calculation for LPG custody transfer calculations.

You buy 100,000 gallons of commercial propane, which is delivered at an observed temperature of 82 °F and calculate the corresponding gallon figure at 60 °F using the ASTM D1250-80 extended CTL value (or accept the calculated values as agreed with the seller).

You obtain a corrected value @ 60 °F of 97,208 gallons, for which you pay the agreed price.

Using the GPA 8217 / TP-27 CTL value, the corrected value obtained would be 96,143 gallons, which is more than nominally 1,000 gallons less product being transferred to your storage facility.

For low product temperatures, the situation reverses.

If we take for example a typical year 2023 price for a petrochemical customer of 180 U.S. cent per gallon @ 60 °F, you are paying 1,800 U.S. Dollars for a shipment of 100,000 gallons more if you use the “wrong” standard.

Thus, even if you agree with your business partners to use a defined standard, it may turn out to be an agreement which has a negative financial impact on your business.

4. Conclusion

In this working paper, we have demonstrated that measurement standards for temperature corrections need to be selected carefully by buyers and sellers alike.

While state-of-the art standards are available globally, and contracts typically require the usage of the most current standard, implementation of every new standard within complex computer systems may require considerable time and financial effort, especially if resulting in negotiating changes with your business partners and regulatory bodies; however, this effort can be justified if an analysis (as described above) shows a positive return on investment.

The analysis described above can be made with the QuantityWare Petroleum Measurement Cockpit. Within the cockpit, you can print out the CTL data for all standards noted in this paper.

BCS considerably reduces the effort when changing from a previous standard to a new standard version for a given product line, while fundamentally increasing transparency. The QuantityWare PAIG, tailored around the Petroleum Measurement Cockpit, provide a proven methodology for the implementation of such changes by an expert team, while extended cockpit functionality allows GRC principles to be applied in the analysis, execution, and validation phases of such changes.

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