QuantityWare

QuantityWare Working Paper

NGL & LPG Measurement Standard Comparison

An analysis of different NGL and LPG standards and their comparison against GPA 8217 / TP-27

Version History

Version	Date	Description
00	2009-02-02	Initial Version
01	2017-08-03	Editorially revised and confirmed
02	2021-09-23	Modern QW document style applied
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Contents

1. Introduction

For custody transfer purposes, NGL (Natural Gas Liquid) and LPG (Liquefied Petroleum Gas) measurements are stated at a fixed base temperature and saturation pressure; however, most volume transfers occur at temperatures and pressures other than the defined base conditions. In these cases, such volumes must be adjusted to base conditions using correction factors. A full correction can be performed by using a correction factor for temperature (CTL) and a correction factor for pressure (CPL).

Different standards are in use for the calculation of these factors.

Pressure correction factors are not within the scope of this paper but can be calculated using the American Petroleum Institute Manual of Petroleum Measurement Standards (API MPMS) Chapter 11.2.2(M).

This paper demonstrates the ranges and limits of different measurement standards for the calculation of CTL factors as well as the density at base conditions and compares the results against the most modern available standard.

2. Types of Calculations

2.1. Calculation of Base Density

The calculation of a base density, at the base temperature, founded on a measured density, at an observed temperature. These procedures generally also make use of CTL calculation (see 1.2.).

In the daily business, the base density is usually determined in a laboratory using a product sample, instead of it being calculating using a standard's tables or procedures.

2.2. Calculation of a CTL Factor

The calculation of a factor to correct the volume measured at any observed temperature to the volume at basis temperature.

These tables and procedures are widely used in custody transfer calculations.

3. Currently Used Standards

Even today (2023), multiple historical standards are still in use for temperature and pressure corrections of LPG/NGL volumes.

This paper provides an analysis of the most common, but superseded standards (as now globally confirmed by ISO 91:2017) and provide a comparison of their calculated results against the standard recommended by the API and GPA - API MPMS Chapter 11.2.4 – GPA 8217 / TP-27. For the sake of brevity, the term GPA 8217 / TP-27 will be used to denote this standard.

3.1. GPA Standard 8217 - Technical Publication TP-27

API MPMS Chapter 11.2.4 - GPA Standard 8217 is the current standard for volumetric temperature corrections of NGL and LPG[1]. It was released in September 2007 and supersedes all other standards. GPA 8217 / TP-27 contains procedures for 60 °F, 15 °C and 20 °C base temperature.

As with ASTM D1250-04, the calculation procedures based on 15 and 20 °C are based upon the 60 °F procedures. GPA 8217 contains two pairs of procedures (still called “tables”) for the three supported base temperatures:

- Tables 23E, 24E 60 °F and relative density
- Tables 53E, 54E 15 °C and density in kg/m³
- Tables 59E, 60E 20 °C and density in kg/m³

3.2. Petroleum Measurement Tables - ASTM D1250-80

This standard has never been certified for use with NGL and LPG, however it contains equations (which can be easily extended to lower NGL/LPG densities) instead of printed tables and supports base temperatures of 60 °F and 15 °C. Later extensions (tables 59 and 60) provide support for base temperatures of 20 °C. Tables 59 and 60 are modified versions of the of the 15 °C tables.

[1] If the LPG/NGL consists of more than 20 % unsaturated hydrocarbons, ISO 6578 is the recommended standard for volume corrections.

The following tables (with range extensions) are still widely in use for calculations of NGL and LPG:

- Table 23B, 24B 60 °F, relative density
- Table 53B, 54B 15 °C, density in kg/m³
- Table 59B, 60B 20 °C, density in kg/m³

Since this standard is based on equations and software implementations exist, it is possible to extend the ranges by simply modifying the density and temperature range checks. QuantityWare allows such range extensions to be made via solution-specific "SAP customizing" (a process known and understandable by projects, business, and audit bodies), instead of forcing changes in source coding.

However, as QuantityWare's BCP is a complete calculations solution, GPA 8217 - TP-27 is provided in the same package as the multiple ASTM D1250 implementations and should be used for NGL and LPG calculations where possible.

Note that standard ASTM D1250-80 has not been developed nor designed to support calculations outside of the supported ranges as necessary for NGL and LPG. Accuracy cannot be guaranteed if ranges are extended. In this document, we will analyze and document the differences between ASTM D1250-80 with extended ranges and the GPA 8217 / TP-27.

The impact on business processes by using the ASTM D1250-80 standard with extended ranges has been analyzed in another working paper available in the Knowledge Base at www.quantityware.com: LPG Measurement Standard Selection

3.3. Petroleum Measurement Tables 33 and 34, ASTM D1250-80 Volume XII

These are printed tables which were released as part of ASTM D1250 in 1952.

The values are taken from the 1952 tables 23 and 24. Tables 33 and 34 are a subset of Tables 23 and 24 and support a base temperature of 60 °F and relative densities.

They were created over a half-a-century ago for the convenience of the liquefied petroleum gas and natural gasoline industries and are still in use owing to old agreements, even although superseded. QuantityWare BCP contains this legacy solution as well.

4. Comparison Between Standards

Since GPA 8217 / TP-27 is the most modern, accurate and recommended standard for NGL and LPG calculations, we calculate the full supported range of the superseded standards and compare the results against those of GPA 8217.

Editorial Note:

The decimal point and thousand separators for numbers and quantity values for this document are defined as follows: The decimal point is a dot '.', the thousand separator is a comma ','. Example: 123,456,789.987

4.1. Ranges, Accuracy & Rounding

Tables 33 and 34 are printed tables and must be used as such. Interpolation of table 33 has been defined in the standard and will be used. The values provided by both tables are compared against GPA 8217 results. A comparison outside the ranges of tables 33 and 34 is not possible.

The ASTM D1250-80 tables are provided as equations. These tables can only be used for NGL and LPG calculations when the temperature and density ranges have been extended. We compare the entire range of GPA 8217 against the extended ranges of ASTM D1250-80. The table below shows the ranges and the accuracy/rounding of the standards compared:

Calculation based on 60 °F:

Standard	Temperature °F	increment °F	Relative Density	increment	Rounding / accuracy
Calculate base density at 60 °F and relative density					
GPA 8217 Table 23E	-50.8 to 199.4	0.1	0.3500 to 0.6880	0.0001	0.0001
ASTM Table 33	30 to 90	1	0.490 to 0.650	0.01	0.001
ASTM D1250-80 Table 23B	0 to 200	0.1	0.6535 to 1.0760	0.001 interp.	0.0001
Calculate volume correction factors to 60 °F and relative density					
GPA 8217 Table 24 E	-50.8 to 199.4	0.1	0.3500 to 0.6880	0.0001	0.00001
ASTM Table 34	-20 to 120	1	0.495 to 0.604	0.005	0.001
ASTM D1250-80 Table 24B	0 to 200	0.1	0.6535 to 0.7795	0.0005	0.00001 0.0001

Calculation based on 15 °C:

Standard	Temperature °C	increment °C	Relative Density	increment	Rounding / accuracy
Calculate base density at 15 °C and relative density					
GPA 8217 Table 53E	-46 to 93	0.05	0.2100 to 0.7400	0.0001	0.0001
ASTM D1250-80 Table 53B	-18 to 90	0.05	0.6536 to 0.7793	0.0005	0.0001
Calculate volume correction factors to 15 °C and relative density					
GPA 8217 Table 54 E	-46 to 93	0.05	0.3521 to 0.6885	0.0001	0.00001
ASTM D1250-80 Table 54B	-18 to 95	0.05	0.6536 to 0.7788	0.0005	0.00001 0.0001

Calculation based on 20 °C:

Standard	Temperature °C	increment °C	Relative Density	increment	Rounding / accuracy
Calculate base density at 20 °C and relative density					
GPA 8217 Table 59E	-46 to 93	0.05	0.2100 to 0.7400	0.0001	0.0001
ASTM D1250-80 Table 59B	-18 to 90	0.05	0.6110 to 0.7585	0.0005	0.0001
Calculate volume correction factors to 20 °C and relative density					
GPA 8217 Table 60 E	-46 to 93	0.05	0.3320 to 0.6843	0.0001	0.00001
ASTM D1250-80 Table 60B	-18 to 95	0.05	0.6536 to 0.7788	0.0005	0.00001 0.0001

The absolute density in kg/m³ has been converted from kg/m³ to relative density for easier comparison of the calculation ranges.

4.2. Statistics of Comparison Calculations

We compared all supported density and temperature pairs of the superseded standards used for NGL and LPG calculations, against the results of the corresponding tables of GPA 8217 / TP-27.

The differences are calculated in percent. “Plus” means that the superseded table provided a larger result than GPA 8217 / TP-27 and “Minus” that the result of the superseded table is smaller than that provided by GPA 8217 / TP-27.

Table	Compared calls	Number of Differences	Average +%	Max +%	Average -%	Max -%
tab33	9.521	8.501	0,0345	1,9865	0,0200-	0,2657-
tab34	1.551	1.539	0,0600	1,2720	0,0620-	0,4872-
tab23b	1.429.923	1.408.763	0,7049	17,4000	1,4178-	13,4701-
tab24b	1.516.179	1.514.218	1,8802	88,6814	1,1240-	11,4943-
tab53b	9.480.361	9.383.997	0,5872	16,9463	3,8485-	33,7464-
tab54b	8.373.033	8.362.456	1,9005	87,0966	1,0832-	11,2294-
tab59b	10.071.095	9.977.902	0.7228	22.0012	4.0414	34.2454
tab60b	8.680.842	8.670.623	1,7343	92,7909	1,4864-	13,5735-

4.3. Analysis of Comparison Statistics

- Tables 33 and 34:

The average differences of these printed tables are in a range that can generally be accepted. If buyer and seller agree to the ranges, accuracy and intervals of the values, these tables could still be used.

- ASTM D1250-80, Tables 23B, 24B, 53B and 54B

The average and maximum differences are in a range which cannot be accepted in a custody transfer. Major differences start to appear when mainly the density (but also the temperature) lies outside of the supported ranges.

- ASTM D1250-80, Tables 59B and 60B

The results are like those of the Tables 53B and 54B for 15 °C. However, these Tables are a modification of the 15 °C Tables and not a "soft conversion"; thus, the differences are slightly larger than at 15 °C.

4.4. Dependencies between Density, Temperature and Accuracy

While Tables 33 and 34 may still be acceptable, usage of the ASTM D1250-80 tables tested above may be critical - dependent on the pressure and temperature ranges being used.

- ASTM D1250-80 all tables with extended ranges

In general, no differences should occur at the base temperature, however when the observed temperature is different from the basis temperature, considerable differences start to emerge.

Lower density has a high impact on the accuracy of calculations when compared to GPA 8217 / TP-27 and the differences increase with distance to the basis temperature.

Thus, the calculation using ASTM D1250-80 will produce the biggest negative difference (smaller values) at the lowest density and temperature, and the biggest positive difference at the lowest density and highest temperatures.

- Lower temperatures lead to lower results than GPA 8217 / TP-27
- Higher temperatures lead to higher results than GPA 8217 / TP-27
- These differences increase with lower densities

5. Conclusion

The values provided by ASTM Tables 33 and 34 are very close to those calculated using GPA 8217 / TP-27; however, the ranges supported by the tables are limited compared to GPA 8217.

If the provided values can coherently reflect the calculations needs of a specific business and buyer and seller agree, these tables can still be used, and the parties can expect to receive relatively realistic calculations results.

The ASTM D1250 tables can technically only be used for calculation of NGL and LPG when their ranges are extended outside of the officially published limits to much lower densities and lower temperatures.

Even with these modifications, many calculations combinations will still exist where no result can be reached, owing to the nature of the procedures used.

The major issue when using ASTM D1250 tables for NGL and LPG is that the calculations inaccuracy increases, the farther density and temperature distance themselves from the original standard ranges.

5.1. The QuantityWare Recommendation

Usage of ASTM Tables 33 and 34 does not reflect the accuracy that one would expect in the 21st century but is still acceptable if the ranges are practicable for the business situation, both business parties and regulatory bodies agree to the standards usage, and the wording of existing contracts does not assume the usage of the latest available standards. With ISO 91:2017 being available now, a well-defined transition process is advisable.

Usage of a “manipulated“ ASTM D1250-80 standard implementation is very difficult to justify because of the inaccuracies in calculation and the existence of an alternate modern, proven standard

Thus, “manipulated” ASTM D1250-80 implementations should be replaced by usage of the GPA 8217 / TP-27 as soon as possible.

More information about the impact on the custody transfer can be found here:

QuantityWare Case Study: LPG Measurement Standard Selection

6. References

1. API MPMS Chapter 11.2.4 - GPA Standard 8217 / Technical Publication TP-27.

2. Manual of Petroleum Measurement Standards, Chapter 11 – Physical Properties Data

Section 1 - Temperature and Pressure Volume Correction Factors for Generalized Crude Oils,

Refined Products, and Lubricating Oils, API 2004

3. Manual of Petroleum Measurement Standards Chapter 11.1, Volume X – Background.

4. Petroleum Measurement Tables, Volume XII.

5. ASTM D1250 – Historical Edition 1952

5. THE USE OF THE PETROLEUM MEASUREMENT TABLES – Manual of Petroleum Measurement Standards, Chapter 11.1 (API Std. 2540, ASTM D1250, IP200, ISO 91-1), revised October 1995, API 1995

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