

**Manual of Petroleum  
Measurement Standards  
Chapter 12—Calculation of Petroleum  
Quantities**

**Section 2—Calculation of Petroleum Quantities  
Using Dynamic Measurement Methods  
and Volumetric Correction Factors**

**Part 2—Measurement Tickets**

THIRD EDITION, JUNE 2003

REAFFIRMED, SEPTEMBER 2010



AMERICAN PETROLEUM INSTITUTE



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**Measurement Coordination**

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## FOREWORD

This five-part publication consolidates and presents standard calculations for metering petroleum liquids using turbine or displacement meters. Units of measure in this publication are in International System (SI) and United States Customary (USC) units consistent with North American industry practices.

This standard has been developed through the cooperative efforts of many individuals from industry under the sponsorship of the American Petroleum Institute and the Gas Processors Association.

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# Chapter 12—Calculation of Petroleum Quantities

## Section 2—Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volumetric Correction Factors

### Part 2—Measurement Tickets

#### 1 Purpose

When most of the older standards were written, mechanical desk calculators were widely used for calculating measurement documentation, and tabulated values were used more widely than is the case today. Rules for rounding and the choice of how many figures to enter in each calculation step were often made on the spot. As a result, different operators obtained different results from the same data.

This five-part publication consolidates and standardizes calculations pertaining to metering petroleum liquids using turbine or displacement meters and clarifies terms and expressions by eliminating local variations of such terms. The purpose of standardizing calculations is to produce the same unbiased answer from the given data. So that different operators can obtain identical results from the same data, the rules for sequence, rounding, and discrimination of figures (or decimal places) have been defined.

#### 2 Scope

This document provides standardized calculation methods for the quantification of liquids and the determination of base prover volumes under defined conditions, regardless of the point of origin or destination or the units of measure required by governmental customs or statute. The criteria contained in this document allow different entities using various computer languages on different computer hardware (or manual calculations) to arrive at identical results using the same standardized input data.

The publication rigorously specifies the equations for computing correction factors, rules for rounding, calculational sequence, and discrimination levels to be employed in the calculations. No deviations from these specifications are permitted since the intent of this document is to serve as a rigorous standard.

#### 3 Application of Part 2

The purpose of standardizing the terms and arithmetical procedures employed in calculating the amount of petroleum liquid on a measurement ticket is to avoid disagreement between the parties involved. The purpose of Part 2, "Measurement Tickets," is to obtain the same unbiased answer from the same measurement data, regardless of who or what does the computing.

Calculations of correction factors and volumes may be done using continuous online integration techniques if agreed between the parties. The results of these calculations may not agree with the methods contained in this standard due to the variability in obtaining flowing parameters. However, the equations for computing correction factors and the rules for rounding, calculation sequence, and discrimination levels for any continuous online integration methods shall be identical to the specifications contained in this standard.

A measurement ticket is a written acknowledgment of a transfer of petroleum liquids and is the legal document of transfer. In addition, it serves as an agreement between the authorized representatives of the parties concerned as to the measured quantities and quality of the liquid. The measurement ticket shall contain all field data required to calculate the metered quantities.

Care must be taken to ensure that all copies of a measurement ticket are legible. Proper fiscal procedures forbid making corrections or erasures on a measurement ticket unless the interested parties agree to do so and initial the ticket to that effect. Should a mistake be made, the ticket should be marked "VOID" and a new ticket prepared. The voided ticket should be attached to the new one to support the validity of the corrected ticket.

#### 4 Organization of Standard

The standard is organized into five separate parts. Part 1 contains a general introduction for dynamic calculations. Part 2 focuses on the calculation of metered quantities for fiscal purposes or measurement tickets. Part 3 applies to meter proving calculations for field operations or proving reports. Parts 4 and 5 apply to the determination of base prover volumes (BPVs).

##### 4.1 PART 1—INTRODUCTION

The base (reference or standard) volumetric determination of metered quantities is discussed along with the general terms required for solution of the equations.

General rules for rounding of numbers, including field data, intermediate calculational numbers, and discrimination levels, are specified.

For the proper use of this standard, prediction of the density of the liquid in both flowing and base conditions is discussed.

An explanation of the principal correction factors associated with dynamic measurement is presented.

#### 4.2 PART 2—MEASUREMENT TICKETS

The application of this standard to the calculation of metered quantities is presented for base volumetric calculations in conformance with North American industry practices.

Recording of field data, rules for rounding, discrimination levels, calculation sequences, along with a detailed explanation with appropriate flow charts and a set of example calculations. The examples can be used to aid in checkout procedures for any computer calculation routines that are developed on the basis of the requirements stated in this standard.

#### 4.3 PART 3—PROVING REPORTS

The application of this standard to the calculation of meter factors is presented for base volumetric calculations in conformance with North American industry practices. Proving reports are utilized to calculate the meter correction and/or performance indicators. The determination of the appropriate term is based on both the hardware and the user's preference.

Recording of field data and rules for rounding, calculation sequences, and discrimination levels are specified, along with a set of example calculations. The examples are designed to aid in checkout procedures for any routines that are developed using the requirements stated in this standard.

#### 4.4 PART 4—CALCULATION OF BASE PROVER VOLUMES BY WATERDRAW METHOD

The waterdraw method uses the displacement (or drawing) of water from the prover into certified volumetric field test measures. Alternatively, for open tank provers, the waterdraw method may also use the displacement (or drawing) of water from field standard test measures into the open tank prover. Certification of the field standard test measures must be traceable to the appropriate national weights and measures organization.

Recording of field data, rules for rounding, calculation sequences, and discrimination levels are specified, along with a set of example calculations. The examples are designed to aid in checkout procedures for any routines that are developed using the requirements stated in this standard.

#### 4.5 PART 5—CALCULATION OF BASE PROVER VOLUMES BY MASTER METER METHOD

The master meter method uses a transfer meter (or transfer standard). The transfer meter is proved under actual operating

conditions by a prover that has been previously calibrated by the waterdraw method., and is designated the master meter. This master meter is then used to determine the base volume of a field operating prover.

Recording of field data, rules for rounding, calculation sequences, and discrimination levels are specified, along with a set of example calculations. The examples are designed to aid in checkout procedures for any routines that are developed using the requirements stated in this standard.

## 5 References

Several documents served as references for the revisions of this standard. In particular, past editions of API *MPMS* Chapter 12.2 (ANSI/API 12.2) provided a wealth of information. The following are other publications that served as a resource of information for this revision:

### API

*Manual of Petroleum Measurement Standards (MPMS)*

Chapter 4	“Proving Systems”
Chapter 5	“Metering”
Chapter 6	“Metering Assemblies”
Chapter 7	“Temperature Determination”
Chapter 9	“Density Determination”
Chapter 10	“Sediment and Water”
Chapter 11	“Physical Properties Data”
Chapter 13	“Statistical Analysis”

### ASTM<sup>1</sup>

D1250	<i>Petroleum Measurement Tables</i> , current edition
D1250	<i>Petroleum Measurement Tables</i> (historical edition-1952)
D1550	<i>ASTM Butadiene Measurement Tables</i>
D1555	<i>Calculation of Volume and Weight of Industrial Aromatic Hydrocarbons</i>

### NIST<sup>2</sup>

Handbook 105-3	<i>Specifications and Tolerances for Reference Standards and Field Standards</i>
Handbook 105-7	<i>Small Volume Provers</i>
Monograph 62	<i>Testing of Metal Volumetric Standards</i>

<sup>1</sup>American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, USA.

<sup>2</sup>U.S. Department of Commerce, National Institute of Standards and Technology, Washington, D.C. 20234 (formerly National Bureau of Standards).

## 6 Field of Application

### 6.1 APPLICABLE LIQUIDS

This standard applies to liquids that, for all practical purposes, are considered to be clean, single-phase, homogeneous, and Newtonian at metering conditions. Most liquids and dense phase liquids associated with the petroleum and petrochemical industries are usually considered to be Newtonian.

The application of this standard is limited to liquids that utilize tables and/or implementation procedures to correct metered volumes at flowing temperatures and pressures to corresponding volumes at base (reference or standard) conditions. To accomplish this, the density of a liquid shall be determined by the appropriate technical standards, or, alternatively, by use of the proper density correlations, or, if necessary, by the use of the correct equations of state. If multiple parties are involved in the measurement, the method for determining the density of the liquid shall be mutually agreed upon by all concerned.

### 6.2 BASE CONDITIONS

Historically the measurement of petroleum liquids, for custody transfer and process control has been stated in volume units at base (reference or standard) conditions.

The base conditions for the measurement of liquids, such as crude petroleum and its liquid products, having a vapor pressure equal to or less than atmospheric at base temperature are as follows:

United States Customary (USC) Units:

Pressure: 14.696 psia (101.325 kPa<sub>a</sub>)

Temperature: 60.0°F (15.56°C)

International System (SI) Units:

Pressure: 101.325 kPa (14.696 psia)

Temperature: 15.00°C (59.00°F)

For liquids, such as liquid hydrocarbons, having a vapor pressure greater than atmospheric pressure at base temperature, the base pressure shall be the equilibrium vapor pressure at base temperature.

For liquid applications, base conditions may change from one country to the next due to governmental regulations or national standards requirements. Therefore, it is necessary that the base conditions be identified and specified for standardized volumetric flow measurement by all parties involved in the measurement.

## 7 Precision, Rounding, and Discrimination Levels

The minimum precision of the computing hardware must be equal to or greater than a ten-digit calculator to obtain the same answer in all calculations.

The general rounding rules and discrimination levels are described in the following subsections.

### 7.1 ROUNDING OF NUMBERS

When a number is to be rounded to a specific number of decimals, it shall always be rounded off in one step to the number of figures that are to be recorded and shall not be rounded in two or more steps of successive rounding. The rounding procedure shall be in accordance with the following:

- a. When the figure to the right of the last place to be retained is 5 or greater, the figure in the last place to be retained should be increased by 1.
- b. If the figure to the right of the last place to be retained is less than 5, the figure in the last place retained should be unchanged.

For example using USC units, if the temperature is measured to  $-0.14^{\circ}\text{F}$ , then the value should be rounded to  $-0.1^{\circ}\text{F}$ . If the temperature is measured to  $54.66^{\circ}\text{F}$ , then the value should be rounded to  $54.7^{\circ}\text{F}$ .

For example using SI units, if the temperature is measured to  $-14.561^{\circ}\text{C}$ , then the value should be rounded to  $-14.55^{\circ}\text{C}$ . If the temperature is measured to  $12.576^{\circ}\text{C}$ , then the value should be rounded to  $12.60^{\circ}\text{C}$ .

### 7.2 DISCRIMINATION LEVELS

For field measurements of temperature and pressure, the levels specified in the various tables are maximum discrimination levels.

For example, if the parties agree to use a thermometer graduated in whole  $^{\circ}\text{F}$  or  $1/2^{\circ}\text{C}$  increments, then the device is normally read to levels of  $0.5^{\circ}\text{F}$ , or  $0.25^{\circ}\text{C}$  resolution. Likewise, if the parties agree to use a "smart" temperature transmitter, which can indicate to  $0.01^{\circ}\text{F}$  or  $0.005^{\circ}\text{C}$ , then the reading shall be rounded to the nearest  $0.1^{\circ}\text{F}$  or  $0.05^{\circ}\text{C}$  value prior to recording for calculation purposes.

The volume discrimination levels specified are in many circumstances beyond the uncertainty of the measurements. The discrimination levels specified are not technically based, but comply with the historical accounting practices for the petroleum industry.