MANUAL OF PETROLEUM MEASUREMENT STANDARDS

CHAPTER 12 - CALCULATION OF PETROLEUM QUANTITIES

Section 4 - Determination of Base Prover Volume

Part 2 - Master Meter Method

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1. Scope

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

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

1.1 Application

1.1.1. General

The BPV of a prover (displacement or open tank) may be determined by one of three methods: waterdraw, master meter, or gravimetric.

This document specifies the equations, rules for rounding, sequence of the calculations, and discrimination levels for the ***'master meter volumetric method'***.

The operational procedures and acceptance criteria employed to calibrate a displacement prover by the master meter volumetric method are specified in API *MPMS* Chapter 4.9.3. The master prover may be a displacement prover or open tank prover.

1.1.2. Applicable Fluids

For displacement provers (free or captive displacer design), the application of this standard shall be limited to hydrocarbon liquids which are assumed to be clean, air/gas free, low vapor pressure, homogeneous, single-phase, and Newtonian at operating conditions.

To properly implement the procedures to correct measured quantities at flowing temperatures and pressures to corresponding quantities at base (reference or standard) conditions, the liquid density correlations specified in API *MPMS* Chapter 11.1 shall be utilized to perform the complex calculations.

For open tank provers as a master prover, the application of this standard shall be limited to potable water, which is assumed to be clean, air/gas free, low vapor pressure, homogeneous, single-phase, and Newtonian at operating conditions.

1.1.3. Base Conditions

Historically, the measurement of hydrocarbon liquids for custody transfer and process control have 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 pressure at the base temperature are as follows.

- International System (SI) of Units.
    - Pressure: 101.325 kPa (14.696 psia).
    - Temperature: 15.00 °C (59.0 °F).
- U.S. Customary (USC) units.
    - Pressure: 14.696 psia (101.325 kPa).
    - Temperature: 60.0 °F (15.556 °C).

Base conditions may change based on contractual, regulatory, or national requirements. Therefore, it is necessary that the base conditions be identified and specified in all standardized volumetric flow measurements by all the parties involved in the measurement.

2. Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the following referenced documents (including any addenda) applies.

API *Manual of Petroleum Measurement Standards (MPMS)* Chapter 4.8, *Operation of Proving Systems*

API *Manual of Petroleum Measurement Standards (MPMS)* Chapter 4.9.1, *Introduction to the Determination of the Volume of Displacement and Tank Provers*

API *Manual of Petroleum Measurement Standards (MPMS)* Chapter 4.9.2, *Determination of the Volume of Displacement and Tank Provers by the Waterdraw Method of Calibration*

API *Manual of Petroleum Measurement Standards (MPMS)* Chapter 4.9.3, *Determination of the Volume of Displacement Provers by the Master Meter Method of Calibration*

API *Manual of Petroleum Measurement Standards (MPMS)* Chapter 11.1, *Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils*

API *Manual of Petroleum Measurement Standards (MPMS)* Chapter 11.4.1, *Density of Water and Water Volumetric correction Factors for Water Calibration of Volumetric Provers*

API *Manual of Petroleum Measurement Standards (MPMS)* Chapter 12.4.1, *Calculation of Petroleum Quantities Determination of Base Prover Volume Using Waterdraw Volumetric Method*

3. Terms, Definitions, Acronyms, Abbreviations, and Symbols

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply. Terms of more general use may be found in API *MPMS* Chapter 1, *Online Terms and Definitions Database.*

3.1.1
base conditions
Reference pressure and temperature conditions, as defined by standards, regulations, or contracts, used in custody transfer measurement calculations of fluid volumes and other calculations.

3.1.2
base prover volume
BPV
The volume of the prover at base conditions as shown on the calibration certificate.

3.1.3
calibrated prover volume
CPV
The volume of the prover at base conditions is determined from a prover calibration run (or roundtrip).

3.1.4
calibration certificate
A report documenting the calibration of a measurement device such as a flowmeter prover, a thermometer, or pressure gauge and its traceability to a national metrological institute [e.g., National Institute of Standards and Technology (NIST)].

3.1.5
calibration set (or set)
A calibration set consists of three (3) to six (6) consecutive CPV determinations at a defined stable flowrate.

3.1.6
correction for temperature on liquid
CTL
Compensates for the effect of temperature on a liquid.

3.1.7
correction for pressure on liquid
CPL
Compensates for the effect of pressure on a liquid.

3.1.8
correction for temperature and pressure on liquid
CTPL
Compensates for the combined effect of temperature and pressure on a liquid.

3.1.9

correction for pressure on steel
CPS
Correction for changes in volume of a steel container - prover, tank, tank car, or other vessel - due to changes in the internal pressure between its reference pressure and its operating pressure.

3.1.10
correction for temperature on steel
CTS
Correction for changes in length, area, or volume of a steel container - prover, tank, tank car, or other vessel - due to changes in the steel temperature between its reference temperature and its operating temperature.

3.1.11
densitometer meter factor
DMF
A dimensionless term equal to the ratio of the density as determined by a reference device to the corresponding density of the density meter.

NOTE The densitometer's reading (ρ_{ind}) is multiplied by a DMF to obtain the observed density (ρ_{obs}) at the temperature (T_{dm}) and pressure (P_{dm}) conditions of the densitometer.

3.1.12
displacement prover
Displacement provers operate on the principle of the repeatable displacement of a known volume of liquid from a calibrated section of pipe between two detectors. Displacement of the volume of liquid is achieved by a sphere or a piston traveling through the pipe. A corresponding volume of liquid is simultaneously measured by a flowmeter installed in series with the displacement prover.

3.1.13
displacement prover – free displacer design
A displacement prover that employs a free displacer design, employs a sphere or piston that moves freely with the flow when the displacer is launched. This design employs integrally installed displacer detectors.

3.1.14
displacement prover – captive displacer design
A displacement prover that employs a captive displacer design, employs a piston that is attached to a rod that moves freely with the flow when the displacer is launched. This design employs externally installed displacer detectors mounted on a rod that is in the atmosphere.

3.1.15
flowrate
Q
The rate of flow as measured by a flowmeter.

3.1.16
gauge pressure
Pressure measured relative to atmospheric pressure with one atmosphere taken as zero.

3.1.17
low vapor pressure liquid

A liquid with a vapor pressure less than or equal to atmospheric pressure at operating conditions (P_E ≤ 0.0 kPag or 0.0 psig).

3.1.18
NIST traceability
A property of a measurement result whereby the result can be traced back to the National Institute of Standards and Technology (NIST) by an unbroken chain of calibrations.

3.1.19
open tank prover
An open tank prover is an atmospheric volumetric vessel that has a reduced cross section or neck located at both the top and bottom or, in some cases, at the top only. The necks are equipped with gauge glasses and graduated scales.

3.1.20
pass
A single movement of the displacer in a displacement prover that activates the start-stop detectors.

3.1.21
primary standard
A measurement standard whose value is determined by NIST or appropriate national metrological institute.

3.1.22
prover calibration certificate
A document package stating the BPV, which includes the physical and run data used to calculate the BPV, and the traceability documentation.

3.1.23
prover with external detectors
Captive displacer prover designs employ a piston attached to a shaft. The displacement of the shaft is constant except that it moves into and out of the calibrated section during a calibration run. Usually, there is one or two externally mounted detectors and/or guide rods attached to the captive piston displacer. Since provers have externally mounted detectors, the thermal effect on the steel may not be the same for the area aspect as for the linear aspect. In a prover calibration, as well as a flowmeter calibration, it is necessary to obtain both a prover barrel temperature and a detector shaft temperature.

3.1.24
prover with integral detectors
Free displacer prover designs, both unidirectional and bidirectional applications, employ a sphere or piston displacer in a circular conduit or pipe. The detectors are integral to the pipe. In other words, the detectors are mounted directly to the pipe through which the free displacer passes.

3.1.25
reference conditions
The base conditions of temperature and pressure (e.g., 60.0 °F and 0 psig, 60.0 °F and equilibrium vapor pressure, 15.00 °C and 101.325 kPa, or 15.00 °C and equilibrium vapor pressure) to which measured volumes are to be corrected.

3.1.26
reference pressure
P_B
The base conditions of pressure (e.g., 0 psig, 14.696 psia, 101.325 kPa, and equilibrium vapor pressure) to which measured volumes are to be corrected.

3.1.27
reference temperature
T_B
The base conditions of temperature (e.g., 60.0 °F, 15.00 °C, 20.00 °C) to which measured volumes are to be corrected.

3.1.28
run
For a bidirectional displacement prover, the combination of a single pass of the displacer in one direction (e.g., forward) followed by a single pass of the displacer in the opposite direction (e.g., back).

For a unidirectional prover, one pass of the displacer between detectors.

For an open tank prover, one filling (or emptying) between the upper neck scale level reading and the lower neck scale level reading or zero reference on an open tank prover.

3.1.29
trips per run
The number of runs of a displacer in a pipe prover for calculating a single calibration run.

3.2 Acronyms, Abbreviations, and Symbols

3.2.1 General

Symbols have been defined to aid in clarity of the mathematical treatments. Notations at the end of a symbol such as “P” refers to a prover, “M” refers to a flowmeter, “MM” refers to a master meter, “MP” refers to a master prover, “FP” refers to a field prover (prover to be calibrated), “dm” refers to a densitometer, and “B” refers to base conditions.

3.2.2 Units

SI International System of Units (kPa, cubic meter, kilogram, °C)

USC U.S. customary units (psi, cubic inch, gallon, barrel, pound, °F)

3.2.3 Steel Pipe Dimensions and Properties

ID_P inside diameter of displacement prover

WT_P wall thickness of displacement prover

E modulus of elasticity of steel

GL linear coefficient of thermal expansion of steel

E_P modulus of elasticity of prover wall material

GL_D GL for detector mounting shaft (external detectors)

GL_P GL for prover wall material

3.2.4 Flowmeter Terms, Flowrate, Pulses, Repeatability, and Reproducibility

T_{F_Comp} Temperature Compensated Flowmeter

T_{P_Comp} Pressure Compensated (CMF) Flowmeter

NKF Nominal K-Factor (pulses per Bbl, pulses per M^3)

Q flowrate (prover report, prover calibration)

Q_{MM_SET} average flowrate for the Selected Runs (CPV_{RUN}) in a Set (prover calibration)

NKF Nominal K-Factor (e.g., pulses per M^3, pulses per Bbl) of the flowmeter

IMF Intermediate Meter Factor (proving report)

MMF Master Meter Factor (prover report, prover calibration)

MMF_{SET} Master Meter Factor for a Set (prover calibration)

ΔMMF Master Meter Factor Deviation (prover report, prover calibration)

N whole pulses

N_{AVG} the average of the whole pulses for the selected runs

N_i interpolated pulses

N_{i_AVG} the average of the interpolated pulses for the selected runs

r repeatability (or range) of flowmeter in % of the Selected Runs (proving report)

(r)_CPV_{RUN} Set repeatability (or range) in % of three (3) Consecutive CPV_{RUN} values in a Calibration Set

R_CPV_{SET} flowrates reproducibility (or range) in % of three (3) Consecutive CPV_{SET} values over three (3) flowrates

3.2.5 Temperature

°C Celsius temperature scale

°F Fahrenheit temperature scale

T temperature (°C or °F)

T_B base temperature (15.00 °C, 20.00 °C, or 60.0 °F)

T_{obs} observed temperature of atmospheric hydrometer (proving report, prover calibration)

T_{dm} temperature in densitometer (proving report, prover calibration)

T_D temperature of detector shaft in prover (proving report, prover calibration)

T_M temperature in meter (proving report, prover calibration)

T_{P_INLET} inlet temperature in prover (proving report, prover calibration)

T_{P_OUTLET} outlet temperature prover (proving report, prover calibration)

T_{P_RUN} average of the inlet and outlet temperature in prover (proving report, prover calibration)

T_{P_SET} average temperature in field prover for a Set (prover calibration)

3.2.6 Pressure

kPag kilopascals in gauge pressure units

psig pounds per square inch in gauge pressure units

P pressure

P_B base pressure in gauge pressure units

P_E equilibrium vapor pressure of liquid (set at 0.0 psig, 0.0 kPag)

P_{obs} observed pressure of atmospheric hydrometer (proving report, prover calibration)

P_{dm} pressure in densitometer (proving report, prover calibration)

P_M pressure in flowmeter (proving report, prover calibration)

P_{P_INLET} inlet pressure in prover (proving report, prover calibration)

P_{P_OUTLET} outlet pressure in prover (proving report, prover calibration)

P_{P_RUN} average of the inlet and outlet pressure in prover for a Run (proving report, prover calibration)

P_{P_SET} average pressure in field prover for a Set (prover calibration)

3.2.7 Fluid Properties

API density (°API)

API_{ind} indicated density of atmospheric hydrometer or thermohydrometer (°API)

API_{obs} observed density of atmospheric hydrometer or thermohydrometer (°API)

API_B base density (°API)

API_{B_RUN} average density at base conditions for a Run (prover calibration, °API)

API_{B_SET} average density at base conditions for a Set (prover calibration, °API)

ρ mass density (kg/m^3)

ρ_B base mass density (kg/m^3)

ρ_{ind} indicated mass density (kg/m^3)

ρ_{obs} observed mass density (proving report, prover calibration, kg/m^3)

ρ_{B_RUN} base mass density for a Run (proving report, prover calibration, kg/m^3)

ρ_{B_START} opening base mass density for a Set from the Proving Report (Spot Sampling, kg/m^3)

ρ_{B_STOP} closing base mass density for a Set from the Proving Report (Spot Sampling, kg/m^3)

ρ_{B_SET} average base mass density for selected Runs in a Set (Spot Sampling, kg/m^3)

3.2.8 Correction Factors

CTS Correction for Temperature on Steel Container

CPS Correction for Pressure on Steel Container

CTL Correction for Temperature on Liquid

CPL Correction for Pressure (compressibility) on Liquid

CTPL Correction for Temperature and Pressure on Liquid

CTS_P Correction for Temperature on Steel Prover (proving report, prover calibration)

CPS_P Correction for Pressure on Steel Prover (proving report, prover calibration)

CTL_P Correction for Temperature on Liquid in Prover (proving report, prover calibration)

CPL_P Correction for Pressure on Liquid in Prover (proving report, prover calibration)

$CTPL_P$ Correction for Temperature and Pressure on Liquid in Prover ((proving report, prover calibration)

CTL_M Correction for Temperature on Liquid in Flowmeter (proving report, prover calibration)

CPL_M Correction for Pressure on Liquid in Flowmeter (proving report, prover calibration)

$CTPL_M$ Correction for Temperature and Pressure on Liquid in Flowmeter (proving report, prover calibration)

CTS_{P_15} Correction for Temperature on Steel Prover to convert BPV_{usc_60} to BPV_{si_15}

CTS_{P_20} Correction for Temperature on Steel Prover to convert BPV_{usc_60} to BPV_{si_20}

CTS_{P_60} Correction for Temperature on Steel Prover to convert BPV_{si_15} to BPV_{usc_60}

DMF Densitometer Meter Factor (proving report, prover calibration)

F Compressibility Factor of fluid (proving report, prover calibration)

HYC Hydrometer Correction Factor

IMF Intermediate Meter Factor (proving report)

MMF Master Meter Factor (proving report, prover calibration)

3.2.9 Calibration Set - Acceptance Criteria

r repeatability (or range) in % - pulse train, or IMF (proving report)

$\Delta ICPV_{RUN}$ ICPV variation over Selected 3 Consecutive Runs in a Set

$r\_\Delta ICPV_{RUN}$ ICPV variation (or repeatability) in % for Selected 3 Consecutive Runs in a Set

ΔMMF_{SET} ΔMMF_{SET} in % for Selected 3 Consecutive Runs in a Set

$(R)\ CPV_{RUN}$ ΔCPV variation (or reproducibility) in % over Selected 3 Consecutive Runs in a Set

$(r)\ CPV_{RUN}$ CPV variation (or repeatability) in % for Selected 3 Consecutive Runs in a Set

3.2.10 Prover Calibration - Set Stability Parameters

ΔMMF_{SET} ΔMMF_{SET} in % in a Calibration Set

$\Delta\rho_{B\_SET}$ base density variation (or range) in a Calibration Set

ΔT_{FP_SET} temperature variation (or range) in a Calibration Set

ΔP_{FP_SET} pressure variation (or range) in a Calibration Set

ΔQ_{MM_SET} flowrate variation (or range) in a Calibration Set

3.2.11 Prover Calibration - Acceptance Criteria

ΔCPV_{SET} ΔCPV variation over three (3) Selected Consecutive Runs in a Calibration Set

$R\_\Delta CPV_{SET}$ CPV reproducibility in % for three (3) Consecutive Calibration Sets (All Methods)

ΔQ_{set} flowrate variation (or range) in % between Consecutive Calibration Sets (All Methods)

3.2.12 Volumes

BPV Base Prover Volume

BPV_{USC} Base Prover Volume at 60 °F and 0.0 psig (cubic inches, Bbl, gal, cubic feet)

BPV_{15} Base Prover Volume at 15 °C and 0.0 kPag (mL, M^3, L)

BPV_{20} Base Prover Volume at 20 °C and 0.0 kPag (mL, M^3, L)

BPV_{OLD} Previous (old or targeted) Base Prover Volume

BPV_{NEW} New Base Prover Volume

CPV Calibrated Prover Volume at base conditions (prover calibration)

CPV_{RUN} CPV for a Run (prover calibration)

CPV_{SET} CPV for three (3) Consecutive Runs in a Set at a constant flowrate (prover calibration)

Avg CPV_{SET} Average of three (3) Consecutive Sets at three different flowrates (prover calibration)

GSV_P Gross Standard Volume of Prover (proving report)

IV_M Indicated Volume of Flowmeter (proving report, prover calibration)

ISV_M Indicated Standard Volume of Flowmeter (proving report)

GSV_M Gross Standard Volume of Meter (proving report, prover calibration)

$ICPV_{RUN}$ Initial CPV for a Run (prover calibration)

4. Precision and Rounding

The minimum precision of the computing hardware shall be 32bit IEEE floating point precision to obtain the same answer in all calculations.

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.

When the figure to the right of last place to be retained is five (5) or greater, the figure in the last place to be retained should be increased by one (1).

If the figure to the right of the last place to be retained is less than five (5), the figure in the last place retained should be unchanged.

5. Discrimination and Reporting Levels

Discrimination and reporting levels ***different than those specified are not permitted.***

The discrimination and reporting levels are stated in tabular format below for clarity (Tables 1 through 9).

In these tables, the number of digits shown as (X) in front of the decimal point are for illustrative purposes only and may have several digits more or less than the number of (Xs) illustrated. The number of digits shown as (x) after the decimal point are very specific, as they define the required discrimination level for each value described.

The objective of this standard is to record the readings, then perform the calculations.

The discrimination levels specified in this section, in many circumstances are greater than the uncertainty of the
field measurements.

The discrimination levels outlined in this section do not imply measurement accuracy of a device or field measurement.

For example, it is not reasonable for a dynamic temperature measurement to be accurate to less than ± 0.1 °F (± 0.05 °C) in a field or laboratory environments. This limitation is due to thermowell heat transfer, transfer medium, temperature lagging, temperature device limitations (design, sensor type, certification limitations), ambient effects, and so forth.

API *MPMS* Chapter 4.9.1 requires a minimum resolution of ± 0.1 °F (± 0.05 °C) and ± 1.0 psig (± 0.069 bar, ± 6.895 kPa) for the temperature and pressure devices involved in the determination of a *BPV*.

All required data and equation results shall be recorded and rounded (reporting) in accordance with the discrimination and reporting levels specified in the section. For detailed guidance, the user should reference the process maps and examples contained in this standard.

This prover calibration method employs a master flowmeter as a transfer standard between the master prover and the field displacement prover.

This method of prover calibration utilizes the Law of Conservation of Mass, a law of physics, which states that ‘assuming no leaks in the system, the mass of the master flowmeter equals the mass of the master prover’ and, the ‘assuming no leaks in the system, mass of the field displacement prover equals the mass of the master flowmeter’.

5.1 Expanded Discrimination of Master Prover’s BPV

The challenge of the methodology is to maintain the calculation discrimination and precision to achieve a six (6) digit base prover volume (BPV) determination of the field displacement prover. This

is accomplished by an approach that is commonly utilized in experimental research -

- increasing the discrimination and precision of the standard (master prover's BPV)
- rigorous and complex calculational specifications (sequence, equations, discrimination, rounding, etcetera)

This prover calibration method necessitates the increased discrimination of the waterdrawn master prover's Base Prover Volume (BPV) as shown below in Table 9.

Decimal Place Color Designation
Device Measured Variable
Fixed Parameter
Calculated Variable
Iteration Output Variable
Correlation Output Variable
Rounded Correlation Value
X digits

Atmospheric Hydrometer or Thermohydrometer

Acronyms	USC Units 12.4.2	USC Units 11.1	Units	SI Units 12.4.2	SI Units 11.1	Units	Parameter	Reference Standards
ρ_{ind}	2	NA	kg/m3	2	NA	kg/m3	Device Measured Variable	Chapters 9.1, 9.3, 12.4.2
API_{ind}	1	NA	°API	1	NA	°API	Device Measured Variable	Chapters 9.1, 9.3, 12.4.2
RD_{ind}	NA	NA	-	NA	NA	-	Device Measured Variable	Chapters 9.1, 9.3, 12.4.2
T_{obs}	2	12	°F	3	12	°C	Device Measured Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
P_{obs}	NA	NA	psig	NA	NA	kPag	Fixed Parameter	Chapters 9.1, 9.3, 12.4.2, 11.1
T_B	0	0	°F	0	0	°C	Fixed Parameter	Chapters 9.1, 9.3, 12.4.2, 11.1
P_B	0	0	psig	0	0	kPag	Fixed Parameter	Chapters 9.1, 9.3, 12.4.2, 11.1
HYC	12	NA	-	12	NA	-	Calculated Variable	Chapters 9.1, 9.3, 12.4.2
ρ_{obs}	12	12	kg/m3	12	12	kg/m3	Calculated Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
API_{obs}	NA	12	°API	NA	12	°API	Calculated Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
RD_{obs}	NA	12	-	NA	12	-	Calculated Variable	Chapters 9.1, 9.3, 12.4.2, 11.1

For thermohydrometer or hydrometer in opaque fluids, ρ_{ind} = (ρ_{rdg} - meniscus correction for opaque fluids) ρ_{ind} = [(141.5 x ρ_{Water}) / (API_{ind} +131.5)]

For thermohydrometer or hydrometer in non-opaque fluids, ρ_{ind} = ρ_{rdg} (at bottom of meniscus) ρ_{ind} = RD_{ind} x ρ_{Water}

For thermohydrometer or hydrometer, ρ_{obs} = ρ_{ind} x HYC ρ_{obs} = ρ_{ind} x HYC

Chapter 11.1 Iteration Routine INPUTS to determine ρ_{60}, CTL_{60_obs}, CPL_{60_obs}, $CTPL_{60\_obs}$

	12.4.2	11.1	Units	12.4.2	11.1	Units	Parameter	Reference Standards
ρ_{obs}	12	12	kg/m3	NA	NA	kg/m3	Iteration Input Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
API_{obs}	NA	NA	°API	NA	NA	°API	Calculated Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
RD_{obs}	NA	NA	-	NA	NA	-	Calculated Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
T_{obs}	2	12	°F	NA	NA	°C	Iteration Input Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
P_{obs}	0	12	psig	NA	NA	kPag	Fixed Parameter	Chapters 9.1, 9.3, 12.4.2, 11.1
T_B	0	0	°F	NA	NA	°C	Fixed Parameter	Chapters 9.1, 9.3, 12.4.2, 11.1
P_B	0	0	psig	NA	NA	kPag	Fixed Parameter	Chapters 9.1, 9.3, 12.4.2, 11.1
P_E	NA	NA	psig	NA	NA	kPag	Fixed Parameter	Chapters 9.1, 9.3, 12.4.2, 11.1

Note: The Chapter 11.1 Iteration Routine is based on a specific set of USC Input units (kg/m^3, °F, and psig) since the empirical data set is recorded in these units of measurement. Therefore, the API_{obs}, RD_{obs}, T_{obs}, P_{obs}, T_{dm}, and P_{dm} values MUST be converted to these specified set of USC units to prior to entering the Chapter 11.1 Iteration Routine (very complex and ridgid in the sequence of steps).

Chapter 11.1 Iteration Routine OUTPUTS - ρ_{60}, CTL_{60_obs}, CPL_{60_obs}, $CTPL_{60\_obs}$

	12.4.2	11.1	Units	12.4.2	11.1	Units	Parameter	Reference Standards
ρ_{60}	12	12	kg/m3	NA	12	kg/m3	Iteration Output Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
API_{60}	12	12	°API	NA	12	°API	Calculated Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
RD_{60}	12	12	-	NA	12	-	Calculated Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
CTL_{60_obs}, CPL_{60_obs}, $CTPL_{60\_obs}$	12	12	-	NA	12	-	Iteration Output Variable	Chapters 9.1, 9.3, 12.4.2, 11.1

Table 1 – Atmospheric Hydrometer or Thermohydrometer

Densitometer - Online or Handheld

Acronyms	USC Units 12.4.2	USC Units 11.1	Units	SI Units 12.4.2	SI Units 11.1	Units	Parameter	Reference Standards
ρ_{ind}	3	NA	kg/m3	3	NA	kg/m3	Device Measured Variable	Chapters 9.4, 12.4.2
API_{ind}	NA	NA	°API	NA	NA	°API	Device Measured Variable	Chapters 9.4, 12.4.2
RD_{ind}	NA	NA	-	NA	NA	-	Device Measured Variable	Chapters 9.4
T_{dm}	2	12	°F	3	NA	°C	Device Measured Variable	Chapters 9.4, 12.4.2, 11.1
P_{dm}	1	12	psig	0	NA	kPag	Device Measured Variable	Chapters 9.4, 12.4.2, 11.1
DMF	4	NA	-	4	NA	-	Fixed Parameter	Chapters 9.4, 12.4.2

$\rho_{obs} = \rho_{ind}$ x DMF

Chapter 11.1 literation Routine INPUTS to determine ρ_{60}, CTL_{60_TdmPdm}, CPL_{60_TdmPdm}, $CTPL_{60\_TdmPdm}$

	12.4.2	11.1	Units	12.4.2	11.1		Parameter	Reference Standards
ρ_{obs}	12	12	kg/m3	NA	NA	kg/m3	Iteration Input Variable	Chapters 9.4, 12.4.2, 11.1
API_{obs}	NA	NA	°API	NA	NA	°API	Calculated Variable	Chapters 9.4, 12.4.2, 11.1
RD_{obs}	NA	NA	-	NA	NA	-	Calculated Variable	Chapters 9.4, 12.4.2, 11.1
T_{dm}	2	12	°F	NA	NA	°C	Iteration Input Variable	Chapters 9.4, 12.4.2, 11.1
P_{dm}	1	12	psig	NA	NA	kPag	Iteration Input Variable	Chapters 9.4, 12.4.2, 11.1
T_B	0	0	°F	NA	NA	°C	Fixed Parameter	Chapters 9.4, 12.4.2, 11.1
P_B	0	0	psig	NA	NA	kPag	Fixed Parameter	Chapters 9.4, 12.4.2, 11.1
P_E	NA	NA	psig	NA	NA	kPag	Fixed Parameter	Chapters 9.4, 12.4.2, 11.1

Note: The Chapter 11.1 Iteration Routine is based on a specific set of USC Input units (kg/m3, °F, and psig) since the empirical data set is recorded in these units of measurement. Therefore, the APIobs, RDobs, Tdm, and Pdm values MUST be converted to these specified set of USC units prior to entering the Chapter 11.1 Iteration Routine (very complex and ridgid in the sequence of steps).

Chapter 11.1 literation Routine OUTPUTS - ρ_{60}, CTL_{60_Tdm}, CPL_{60_TdmPdm}, $CTPL_{60\_TdmPdm}$

	12.4.2	11.1	Units	12.4.2	11.1		Parameter	Reference Standards
ρ_{60}	12	12	kg/m3	NA	NA	kg/m3	Iteration Output Variable	Chapters 9.4, 12.4.2, 11.1
API_{60}	12	12	°API	NA	NA	°API	Calculated Variable	Chapters 9.4, 12.4.2, 11.1
RD_{60}	12	12	-	NA	NA	-	Calculated Variable	Chapters 9.4, 12.4.2, 11.1
CTL_{Tdm}, CPL_{TdmPdm}, $CTPL_{TdmPdm}$	12	12	-	NA	NA	-	Iteration Output Variable	Chapters 9.4, 12.4.2, 11.1

Table 2 – Online or Handheld Densitometer

Chapter 11.1 Correlation Routine - ρ_{SI}, $CTL_{60\_to\_SI}$, $CTPL_{60\_to\_SI}$, $CTPL_{60\_to\_SI}$

	USC Units 12.4.2	USC Units 11.1	Units	SI Units 12.4.2	SI Units 11.1		Parameter	Reference Standards
ρ_{60}	12	12	kg/m3	NA	NA	kg/m3	Iteration Output Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
T_{15_B}	0	0	°F	0	0	°C	Fixed Parameter	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
T_{20_B}	0	0	°F	0	0	°C	Fixed Parameter	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
P_B	0	0	psig	0	0	kPag	Fixed Parameter	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
P_E	NA	NA	psig	NA	NA	kPag	Fixed Parameter	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1

Chapter 11.1 Correlation Routine INPUTS to determine ρ_{SI}, $CTL_{60\_to\_SI}$, $CPL_{60\_to\_SI}$, $CTPL_{60\_to\_SI}$

	12.4.2	11.1	Units	12.4.2	11.1		Parameter	Reference Standards
ρ_{60}	12	12	kg/m3	NA	NA	kg/m3	Iteration Output Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
T_{15_B}	0	0	°F	NA	NA	°C	Fixed Parameter	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
T_{20_B}	0	0	°F	NA	NA	°C	Fixed Parameter	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
P_B	0	0	psig	NA	NA	kPag	Fixed Parameter	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
P_E	NA	NA	psig	NA	NA	kPag	Fixed Parameter	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1

Chapter 11.1 Correlation Routine OUTPUTS - ρ_{SI}, $CTL_{60\_to\_SI}$, $CPL_{60\_to\_SI}$, $CTPL_{60\_to\_SI}$

	12.4.2	11.1	Units	12.4.2	11.1		Parameter	Reference Standards
ρ_{15}	NA	NA	kg/m3	12	12	kg/m3	Correlation Output Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
API_{15}	NA	NA	°API	12	12	°API	Calculated Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
RD_{15}	NA	NA	-	NA	12	-	Calculated Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
$CTL_{60\_to\_15}$, $CPL_{60\_to\_15}$, $CTPL_{60\_to\_15}$	NA	NA	-	12	12	-	Correlation Output Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
ρ_{20}	NA	NA	kg/m3	12	12	kg/m3	Correlation Output Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
API_{20}	NA	NA	°API	12	12	°API	Calculated Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
RD_{20}	NA	NA	-	NA	12	-	Calculated Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
$CTL_{60\_to\_20}$, $CPL_{60\_to\_20}$, $CTPL_{60\_to\_20}$	NA	NA	-	12	12	-	Correlation Output Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1

Table 3 – API *MPMS* Chapter 11.1 Correlation Routine for ρ_{SI}

Chapter 11.1 Correlations of CTL, CPL and CTPL - Prover and Meter

	USC Units			SI Units				
Acronyms	**12.4.2**	**11.1**	**Units**	**12.4.2**	**11.1**	**Units**	**Parameter**	**Reference Standards**
ρ_{60}	12	12	kg/m3	12	12	kg/m3	Iteration Output Variable	Chapters 12.4.2, 11.1
T_{P_INLET}	2	12	°F	3	12	°C	Device Measured Variable	Chapter 12.4.2, 11.1
T_{P_OUTLET}	2	12	°F	3	12	°C	Device Measured Variable	Chapter 12.4.2, 11.1
P_{P_INLET}	1	12	psig	0	12	kPag	Device Measured Variable	Chapter 12.4.2, 11.1
P_{P_OUTLET}	1	12	psig	0	12	kPag	Device Measured Variable	Chapter 12.4.2, 11.1
T_M	2	12	°F	3	12	°C	Device Measured Variable	Chapter 12.4.2, 11.1
P_M	1	12	psig	0	12	kPag	Device Measured Variable	Chapter 12.4.2, 11.1

Chapter 11.1 Correlation Routine INPUTS to determine CTL_P, CPL_P, and $CTPL_P$

Acronyms	**12.4.2**	**11.1**	**Units**	**12.4.2**	**11.1**	**Units**	**Parameter**	**Reference Standards**
ρ_{60}	12	12	kg/m3	NA	NA	kg/m3	Iteration Output Variable	Chapters 12.4.2, 11.1
T_{P_RUN}	12	12	°F	NA	NA	°C	Calculated Variable	Chapter 12.4.2, 11.1 - varies w Std
P_{P_RUN}	12	12	psig	NA	NA	kPag	Calculated Variable	Chapter 12.4.2, 11.1 - varies w Std

Note: The Chapter 11.1 Correlation Routine is based on a specific set of USC Input units (kg/m^3, °F, and psig) since the empirical data set is recorded in these units of measurement. Therefore, the ρ_{60}, T_P, P_P values MUST be converted to these specified set of USC units prior to entering the Chapter 11.1 Correlation Routine (very complex and ridgid in the sequence of steps).

Chapter 11.1 Correlation Routine OUTPUTS - CTL_P, CPL_P, $CTPL_P$

	12.4.2	**11.1**		**12.4.2**	**11.1**		**Parameter**	**Reference Standards**
CTL_{60_P}, CPL_{60_P}, $CTPL_{60\_P}$	12	12	-	NA	NA	-	Correlation Output Variable	Chapters 12.4.2, 11.1
CTL_{15_P}, CPL_{15_P}, $CTPL_{15\_P}$	NA	NA	-	12	12	-	Correlation Output Variable	Chapters 12.4.2, 11.1
CTL_{20_P}, CPL_{20_P}, $CTPL_{20\_P}$	NA	NA	-	12	12	-	Correlation Output Variable	Chapters 12.4.2, 11.1

Chapter 11.1 Correlation Routine INPUTS to determine CTL_M, CPL_M, and $CTPL_M$

Acronyms	**12.4.2**	**11.1**	**Units**	**12.4.2**	**11.1**	**Units**	**Parameter**	**Reference Standards**
ρ_{60}	12	12	kg/m3	NA	NA	kg/m3	Iteration Output Variable	Chapters 12.4.2, 11.1
T_M	2	12	°F	NA	NA	°C	Device Measured Variable	Chapter 12.4.2, 11.1
P_M	1	12	psig	NA	NA	kPag	Device Measured Variable	Chapter 12.4.2, 11.1

Note: The Chapter 11.1 Correlation Routine is based on a specific set of USC Input units (kg/m^3, °F, and psig) since the empirical data set is recorded in these units of measurement. Therefore, the ρ_{60}, T_M, P_M values MUST be converted to these specified set of USC units prior to entering the Chapter 11.1 Correlation Routine (very complex and ridgid in the sequence of steps).

Chapter 11.1 Correlation Routine OUTPUTS - CTL_M, CPL_M, $CTPL_M$

	12.4.2	**11.1**		**12.4.2**	**11.1**		**Parameter**	**Reference Standards**
CTL_{60_M}, CPL_{60_M}, $CTPL_{60\_M}$	12	12	-	NA	NA	-	Correlation Output Variable	Chapters 12.4.2, 11.1
CTL_{15_M}, CPL_{15_M}, $CTPL_{15\_m}$	NA	NA	-	12	12	-	Correlation Output Variable	Chapters 12.4.2, 11.1
CTL_{20_M}, CPL_{20_M}, $CTPL_{20\_M}$	NA	NA	-	12	12	-	Correlation Output Variable	Chapters 12.4.2, 11.1

Chapter 11.1 Rounded Values for Proving Report and BPV Determination Calculations

	12.4.2	**11.1**		**12.4.2**	**11.1**		**Parameter**	**Reference Standards**
Rnd CTL, Rnd CPL, Rnd CTPL	9	NA	-	9	NA	-	Rounded Correlation Value	Chapters 12.4.2, 11.1

Table 4 – API *MPMS* Chapter 11.1 Correlation Routine for CTL, CPL and CTPL

Steel - Dimensions, Properties, Correction Factors (CTS_P, CPS_P)

	USC Units			SI Units				
Acronyms	**12.4.2**	**11.1**	**Units**	**12.4.2**	**11.1**	**Units**	**Parameter**	**Reference Standards**
OD_P	NA	NA	in	NA	NA	mm	Fixed Parameter	Chapters 12.4.1, 12.4.2
ID_P	4	4	in	3	3	mm	Fixed Parameter	Chapters 12.4.1, 12.4.2
WT_P	4	4	in	3	3	mm	Fixed Parameter	Chapters 12.4.1, 12.4.2
E_P	0	0	per psig	0	0	per kPag	Fixed Parameter	Chapters 12.4.1, 12.4.2
GL_P	8	8	per °F	8	8	per °C	Fixed Parameter	Chapters 12.4.1, 12.4.2
GL_D	8	8	per °F	8	8	per °C	Fixed Parameter	Chapters 12.4.1, 12.4.2
Open Tank Prover, GC_P	8	8	per °F	8	8	per °C	Fixed Parameter	Chapters 12.4.1, 12.4.2
T_B	0	0	°F	0	0	°C	Fixed Parameter	Chapters 12.4.2, 11.1
P_B	0	0	psig	0	0	kPag	Fixed Parameter	Chapters 12.4.2, 11.1
CTS_P	12	12	-	12	12	-	Calculated Variable	Chapter 12.4.2
CPS_P	12	12		12	12		Calculated Variable	Chapter 12.4.2
Rnd CTS_P	9	9		9	9		Calculated Variable	Chapter 12.4.2
Rnd CPS_P	9	9	-	9	9	-	Calculated Variable	Chapter 12.4.2

Chapter 12.4.2 calculates the CTS_P and CPS_P terms to 12 decimal places to convert Master CPV to Master BPV (10 digits).
Chapter 12.4.2 rounds the CTS_P and CPS_P terms to 9 decimal places for the report calculations.
Terms not contained in Chapter 11.1 have defaulted to the discriminations stated in Chapter 12.4.2.

Table 5 – Steel Dimensions, Properties and Correction Factors

Chapter 12.4.2 - Master Meter Calibration of Displacement Prover - Proving Report

	USC Units			SI Units				
Acronyms	12.4.2	11.1	Units	12.4.2	11.1	Units	Parameter	Reference Standards
API_{ind}	1	12	°API	1	12	°API	Device Measured Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
RD_{ind}	NA	NA	-	NA	NA	-	Device Measured Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
Hydrometer or Densitometer ρ_{ind}	3	12	kg/m3	3	12	kg/m3	Device Measured Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
Hydrometer T_{obs}	2	12	°F	3	12	°C	Device Measured Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
Densitometer T_{dm}	2	12	°F	3	12	°C	Device Measured Variable	Chapters 9.4, 12.4.2, 11.1
T_{P_Inlet}, T_{P_Outlet}, T_D, T_M	2	12	°F	3	12	°C	Device Measured Variable	Chapters 12.4.2, 11.1
Densitometer P_{dm}	1	12	psig	0	12	kPag	Device Measured Variable	Chapters 12.4.2, 11.1
P_{P_Inlet}, P_{P_Outlet}, P_M	1	12	psig	0	12	kPag	Device Measured Variable	Chapters 12.4.2, 11.1
N	0	0	whole pulses	0	0	whole pulses	Device Measured Variable	Chapters 12.4.2, 11.1
Ni	3	3	interpolated pulses	3	3	interpolated pulses	Device Measured Variable	Chapters 12.4.2, 11.1
Open Tank Provers, SR_{UPPER}	Cert	Cert	Bbl	Cert	NA	M^3	Device Measured Variable	Chapters 12.4.1, 12.4.2
Open Tank Provers, SR_{LOWER}	Cert	Cert	Bbl	Cert	NA	M^3	Device Measured Variable	Chapters 12.4.1, 12.4.2
Q_{av}	5 digits	5 digits	BPH	5 digits	5 digits	MPH	Device Measured Variable	5 digits per Chapter 12.4.2
Hydrometer P_{obs}	0	0	psig	0	0	kPag	Fixed Parameter	Chapters 12.4.2, 11.1
T_B	0	0	°F	0	0	°C	Fixed Parameter	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
P_B	0	0	psig	0	0	kPag	Fixed Parameter	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
DMF	4	4	-	4	4	-	Fixed Parameter	Chapters 9.4, 12.4.2, 11.1
ID_P	4	4	inch	3	3	mm	Fixed Parameter	Chapters 12.4.2, 11.1
WT_P	4	4	inch	3	3	mm	Fixed Parameter	Chapters 12.4.2, 11.1
E_P	0	0	per psig	0	0	per kPag	Fixed Parameter	Chapters 12.4.2, 11.1
GL_P	8	8	per °F	8	8	per °C	Fixed Parameter	Chapters 12.4.2, 11.1
GL_D	8	8	per °F	8	8	per °C	Fixed Parameter	Chapters 12.4.2, 11.1
Master Prover BPV_P	4	4	cubic inches	3	3	mL	Fixed Parameter	Chapters 12.4.2, 11.1
NKF	7 digits	7 digits	Pulses / Bbl	7 digits	7 digits	Pulses / M^3	Fixed Parameter	7 digits per Chapter 12.4.2
Base - CTS_{60}, CTS_{15}, CTS_{20}	9	9	-	9	9	-	Calculated Parameter	Chapter 12.4.2
Master - BPV_{60}, BPV_{15}, BPV_{20}	10 digits	10 digits	Bbl	10 digits	10 digits	M^3	Calculated Parameter	10 digits per Ch 12.4.2
ρ_{60}	12	12	kg/m^3	12	12	kg/m^3	Iteration Output Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
ρ_{60}	12	12	kg/m^3	12	12	kg/m^3	Correlation Input Variable	Chapters 12.4.2, 11.1
ρ_{15}, ρ_{20}	12	12	kg/m^3	12	12	kg/m^3	Correlation Output Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
API_B, API_{60}, API_{15}, API_{20}	12	12	°API	12	12	°API	Calculated Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
Navg	7 digits	7 digits	pulses	7 digits	7 digits	pulses	Calculated Variable	7 digits per Chapters 12.4.2, 11.1
N_i_avg	7 digits	7 digits	pulses	7 digits	7 digits	pulses	Calculated Variable	7 digits per Chapters 12.4.2, 11.1
T_{P_RUN}	12	12	°F	12	12	°C	Calculated Variable	Chapter 12.4.2, 11.1 - varies w Std
P_{P_RUN}	12	12	psig	12	12	kPag	Calculated Variable	Chapter 12.4.2, 11.1 - varies w Std
CTS_P	9	9	-	9	9	-	Calculated Variable	Chapter 12.4.2
CPS_P	9	9	-	9	9	-	Calculated Variable	Chapter 12.4.2
CTL_{obs}, CTL_{TdmPdm}, CTL_P, CTL_M	12	12	-	12	12	-	Correlation Output Variable	Chapters 12.4.2, 11.1
CPL_{obs}, CPL_{TdmPdm}, CPL_P, CPL_M	12	12	-	12	12	-	Correlation Output Variable	Chapters 12.4.2, 11.1
$CTPL_{obs}$, $CTPL_{TdmPdm}$, $CTPL_P$, $CTPL_M$	12	12	-	12	12	-	Correlation Output Variable	Chapters 12.4.2, 11.1
Rnd'd - CTL_P, CTL_M	9	9	-	9	9	-	Rounded Correlation Output	Chapters 12.4.2
Rnd'd - CPL_P, CPL_M	9	9	-	9	9	-	Rounded Correlation Output	Chapters 12.4.2
Rnd'd - $CTPL_P$, $CTPL_M$	9	9	-	9	9	-	Rounded Correlation Output	Chapters 12.4.2
Proving Repeatability (r)	3	3	%	3	3	%	Calculated Variable	Chapters 12.4.2, 11.1
IMF	8	8	-	8	8	-	Calculated Variable	Chapters 12.4.2, 11.1
MMF	7	7	-	7	7	-	Calculated Variable	Chapters 12.4.2, 11.1
GSV	10 digits	10 digits	Bbl	10 digits	10 digits	M^3	Calculated Variable	10 digits per Ch 12.4.2, 11.1
IV, ISV	10 digits	10 digits	Bbl	10 digits	10 digits	M^3	Calculated Variable	10 digits per Ch 12.4.2, 11.1

Chapter 12.4.2 specifies **only** one (1) trip per proving run. Multiple trips as a single proving run is **NOT** allowed.
Terms not contained in Chapter 11.1 have been assigned a discrimination by Chapter 12.4.2.

Table 6 – Master Meter Proving Report

Chapter 12.4.2 - Master Meter Calibration of Displacement Prover - BPV Report Determination

	USC Units			SI Units				
Acronyms	**12.4.2**	**11.1**	**Units**	**12.4.2**	**11.1**	**Units**	**Parameter**	**Reference Standards**
Densitometer ρ_{ind}	3	12	kg/m3	3	12	kg/m3	Device Measured Variable	Chapters 9.1, 9.3, 12.4.2, 11.1
Densitometer T_{dm}	2	12	°F	3	12	°C	Device Measured Variable	Chapters 9.4, 12.4.2, 11.1
T_D, T_{P_INLET}, T_{P_OUTLET}	2	12	°F	3	12	°C	Device Measured Variable	Chapters 12.4.2, 11.1
P_{P_INLET}, P_{P_OUTLET}	1	12	psig	0	12	kPag	Device Measured Variable	Chapters 12.4.2, 11.1
T_M	2	12	°F	3	12	°C	Device Measured Variable	Chapters 12.4.2, 11.1
P_M	1	12	psig	0	12	kPag	Device Measured Variable	Chapters 12.4.2, 11.1
Q_{av}	**5 digits**	**5 digits**	BPH	**5 digits**	**5 digits**	MPH	Device Measured Variable	**5 digits per Chapter 12.4.2**
N	0	0	whole pulses	0	0	pulses	Device Measured Variable	Chapters 12.4.2, 11.1
Ni	3	3	interpolated pulses	3	3	pulses	Device Measured Variable	Chapters 12.4.2, 11.1
Open Tank Provers, SR_{UPPER}	**Cert**	**Cert**	Bbl	**Cert**	**NA**	M^3	Device Measured Variable	Chapters 12.4.1, 12.4.2
Open Tank Provers, SR_{LOWER}	**Cert**	**Cert**	Bbl	**Cert**	**NA**	M^3	Device Measured Variable	Chapters 12.4.1, 12.4.2
Hydrometer P_{obs}	0	0	psig	0	0	kPag	Fixed Parameter	Chapters 9.1, 9.3 12.4.2
T_B	0	0	°F	0	0	°C	Fixed Parameter	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
P_B	0	0	psig	0	0	kPag	Fixed Parameter	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
DMF	4	4	-	4	4	-	Fixed Parameter	Chapters 9.4, 12.4.2, 11.1
ID_P	4	4	inch	3	3	mm	Fixed Parameter	Chapters 12.4.1, 12.4.2, 11.1
WT_P	4	4	inch	3	3	mm	Fixed Parameter	Chapters 12.4.1, 12.4.2, 11.1
E_P	8	8	per psig	8	8	per kPag	Fixed Parameter	Chapters 12.4.1, 12.4.2, 11.1
GL_P	8	8	per °F	8	8	per °C	Fixed Parameter	Chapters 12.4.1, 12.4.2, 11.1
NKF	**7 digits**	**7 digits**	P / Bbl	**7 digits**	**7 digits**	P / M3	Fixed Parameter	**7 digits per Chapter 12.4.1**
BPV_{OLD} or BPV_{TARGET}	4	4	cubic inches	3	3	mL	Fixed Parameter	Chapters 12.4.1, 12.4.2, 11.1
BPV_{OLD} or BPV_{TARGET}	**6 digits**	**6 digits**	Bbl	**6 digits**	**6 digits**	M^3	Fixed Parameter	**6 digits per Chapters 12.4.1, 12.4.2**
Base - CTS_{60}, CTS_{15}, CTS_{20}	9	9	-	9	9	-	Calculated Parameter	Chapter 12.4.2, Converts Master BPV_P to 10 digits
ρ_{obs}	12	12	kg/m^3	12	12	kg/m^3	Iteration Input Variable	Chapters 9.4, 12.4.2, 11.1
ρ_{60}	12	12	kg/m^3	12	12	kg/m^3	Iteration Output Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
ρ_{60}	12	12	kg/m^3	12	12	kg/m^3	Correlation Input Variable	Chapters 12.4.2, 11.1
ρ_{15}, ρ_{20}	12	12	kg/m^3	12	12	kg/m^3	Correlation Output Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
API_B, API_{60}, API_{15}, API_{20}	12	12	°API	12	12	°API	Calculated Variable	Chapters 9.1, 9.3, 9.4, 12.4.2, 11.1
ρ_{60_START}, ρ_{60_STOP}, ρ_{60_SET}	12	12	kg/m^3	12	12	kg/m^3	Calculated Variable	Chapters 12.4.2, 11.1
MMF_{START}, MMF_{STOP}, MMF_{SET}	7	7	-	7	7	-	Calculated Variable	Chapter 12.4.2
Navg	**7 digits**	**7 digits**	pulses	**7 digits**	**7 digits**	pulses	Calculated Variable	**7 digits per Chapters 12.4.2, 11.1**
N_i avg	**7 digits**	**7 digits**	pulses	**7 digits**	**7 digits**	pulses	Calculated Variable	**7 digits per Chapters 12.4.2, 11.1**
T_{P_RUN}	12	12	°F	12	12	°C	Calculated Variable	Chapter 12.4.2, 11.1 - varies w Std
P_{P_RUN}	12	12	psig	12	12	kPag	Calculated Variable	Chapter 12.4.2, 11.1 - varies w Std
CTS_P	9	9	-	9	9	-	Calculated Variable	Chapter 12.4.2
CPS_P	9	9	-	9	9	-	Calculated Variable	Chapter 12.4.2
CTL_{obs}, CTL_{TdmPdm}, CTL_P, CTL_M	12	12	-	12	12	-	Correlation Output Variable	Chapters 12.4.2, 11.1
CPL_{obs}, CPL_{TdmPdm}, CPL_P, CPL_M	12	12	-	12	12	-	Correlation Output Variable	Chapters 12.4.2, 11.1
$CTPL_{obs}$, $CTPL_{TdmPdm}$, $CTPL_P$, $CTPL_M$	12	12	-	12	12	-	Correlation Output Variable	Chapters 12.4.2, 11.1
Rnd'd - CTL_P, CTL_M	9	9	-	9	9	-	Rounded Correlation Output	Chapters 12.4.2
Rnd'd - CPL_P, CPL_M	9	9	-	9	9	-	Rounded Correlation Output	Chapters 12.4.2
Rnd'd - $CTPL_P$, $CTPL_M$	9	9	-	9	9	-	Rounded Correlation Output	Chapters 12.4.2
GSV	**10 digits**	**10 digits**	Bbl	**10 digits**	**10 digits**	M^3	Calculated Variable	**10 digits** per Ch 12.4.2, 11.1
IV, ISV	**10 digits**	**10 digits**	Bbl	**10 digits**	**10 digits**	M^3	Calculated Variable	**10 digits** per Ch 12.4.2, 11.1
Proving Repeatability (r)	3	3	%	3	3	%	Calculated Variable	Chapters 12.4.2, 11.1
$ICPV_{RUN}$	**9 digits**	**9 digits**	Bbl	**9 digits**	**9 digits**	M^3	Calculated Variable	**9 digits per Chapter 12.4.2**
CPV_{RUN}, CPV_{SET}	**9 digits**	**9 digits**	Bbl	**9 digits**	**9 digits**	M^3	Calculated Variable	**9 digits per Chapter 12.4.2**
Average CPV_{SET}	**9 digits**	**9 digits**	Bbl	**9 digits**	**9 digits**	M^3	Calculated Variable	**9 digits per Chapter 12.4.2**
Repeatability (r) in a Set - $ICPV_{RUN}$, CPV_{RUN}	3	3	%	3	3	%	Calculated Variable	Chapter 12.4.2
ΔMMF (MMF_{START}, MMF_{STOP}) in a Set	3	3	%	3	3	%	Calculated Variable	Chapter 12.4.2
Reproducibility (R) of CPV_{SET} between Sets	3	3	%	3	3	%	Calculated Variable	Chapter 12.4.2
ΔQ_{SET}	3	3	%	3	3	%	Calculated Variable	Chapter 12.4.2
BPV_{NEW}	4	4	cubic inches	3	3	mL	Calculated Variable	Chapters 12.4.1,12.4.2
BPV_{NEW}	**6 digits**	**6 digits**	Bbl	**6 digits**	**6 digits**	M^3	Calculated Variable	**6 digits per Chapters 12.4.1, 12.4.2**
BPV_{NEW}	**6 digits**	**6 digits**	gal	**6 digits**	**6 digits**	L	Calculated Variable	**6 digits per Chapters 12.4.1, 12.4.2**
BPV_{NEW}	**6 digits**	**6 digits**	ft^3	**NA**	**NA**	-	Calculated Variable	**6 digits per Chapters 12.4.1, 12.4.2**

Chapter 12.4.2 specifies **only** one (1) trip per proving run. Multiple trips as a single proving run is **NOT** allowed.
Terms not contained in Chapter 11.1 have been assigned a discrimination by Chapter 12.4.2.

Table 7 – Field Prover's BPV Calibration Report

	Base Unit Volume	
BPV_{60}	XXX XXX XXX.xxx x	cubic inches at 60.0 °F, 0.0 psig
BPV_{15}	XXX XXX XXX.xxx	mL at 15.0 °C and 0.0 kPag
BPV_{20}	XXX XXX XXX.xxx	mL at 20.0 °C and 0.0 kPag

Table 8 – Base Unit Volumes

Base Prover Volume (BPV)				
USC			SI	
Barrels (Bbl)	U.S. Gallons (gal)	Cubic Feet (ft^3)	Cubic Meters (M^3)	Liters (L)
XX XXX.x0	XX XXX.x0	XX XXX.x0	XX XXX.x0	XX XXX.x0
X XXX.xx 0	X XXX.xx 0	X XXX.xx 0	X XXX.xx 0	X XXX.xx 0
XXX.xxx 0	XXX.xxx 0	XXX.xxx 0	XXX.xxx 0	XXX.xxx 0
XX.xxx x0	XX.xxx x0	XX.xxx x0	XX.xxx x0	XX.xxx x0
X.xxx xx0	X.xxx xx0	X.xxx xx0	X.xxx xx0	X.xxx xx0
0.xxx xxx 0	0.xxx xxx 0	0.xxx xxx 0	0.xxx xxx 0	0.xxx xxx 0
0.0xx xxx x0	0.0xx xxx x0	0.0xx xxx x0	0.0xx xxx x0	0.0xx xxx x0

Note: The BPV Volumes shown above are specified based on 6 significant digits (10 ppm, or 0.001 %).

Table 9 – BPV Reporting

6. Correction for Temperature on Steel (CTS)

Any container (displacement prover, tank prover) when subjected to a change in temperature will change its volume accordingly. The volume change, regardless of shape, is proportional to the coefficient of thermal expansion of the single construction material(s).

The linear coefficient of thermal expansion (GL) is required for displacement provers.

The linear or cubical coefficient of thermal expansion (GL, GC) may be used for an open tank prover.

For displacement prover and open tank provers, the equations to calculate CTS are specified in API *MPMS* Chapter 12.4.1.

7. Correction for Pressure on Steel (CPS)

If a metal pressurized container (displacement prover) is subjected to an internal pressure, the walls of the container will stretch elastically, and the volume of the container will change accordingly.

The modulus of elasticity (E) shall be determined for the materials used in the construction of the calibrated section. If the modulus of elasticity (E) is unknown, the values contained in Table 4 through Table 6 shall be used.

For displacement provers, the equations to calculate CPS are specified in API *MPMS* Chapter 12.4.1.

Since an open tank prover operates at atmospheric pressure, this prover design is not subjected to internal pressure. Therefore, the CPS = 1.000 000 for an open tank prover.

8. Correction for Temperature and Pressure on Hydrocarbon Liquid (CTL, CPL, CTPL)

For displacement provers (free or captive displacer), the application of this standard shall be limited to low vapor pressure hydrocarbon liquids, which are assumed to be clean and air/gas free. To properly implement the procedures to correct measured quantities at flowing temperatures and pressures to corresponding quantities at base (reference or standard) conditions, the hydrocarbon liquid density correlations specified in API *MPMS* Chapter 11.1 shall be utilized to perform the complex calculations.

8.1 Correction for Effect of Temperature on Hydrocarbon Liquid (CTL)

If a hydrocarbon liquid is subjected to a change in temperature, its density will decrease as the temperature rises or increase as the temperature falls. This density change is proportional to the thermal coefficient of expansion of the liquid and temperature.

The correction factor for the effect of temperature on the liquid's density (CTL) is a function of the following correlation:

$$CTL \sim f\ (\ \rho_B\ , T\ )$$

8.2 Correction for Effect of Pressure on Hydrocarbon Liquid (CPL)

If a hydrocarbon liquid is subjected to a change in pressure, the liquid density will increase as the pressure rises or decrease as the pressure falls.

The correction factor for the effect of pressure on the liquid's density (CPL) is a function of the following correlation:

$$CPL \sim f\ (\ \rho_B\ , F\ , P_E\ , P\ )$$

8.3 Correction for Effect of Temperature and Pressure on Hydrocarbon Liquid (CTPL)

If a hydrocarbon liquid is subjected to a change in temperature and pressure, the liquid density is a function of the following correlations:

$$CTPL = CTL \times CPL = \frac{\rho_{TP}}{\rho_B}$$

9. Correction for Temperature and Pressure on Water (CTL, CPL, CTPL)

For any open tank provers that are utilized as a master prover, the application of this standard shall be limited to potable water, which is assumed to be clean, air/gas free. To properly implement the procedures to correct measured volumes at flowing temperatures and pressures to corresponding volumes at base (reference or standard) conditions, the water density correlations specified in API *MPMS* Chapters 12.4.1 and 11.4.1 shall be utilized to perform the complex calculations.

10. Measurement Readings

There are two approaches for the **measurement of temperature and pressure** - automated or manual.

There are two methods for the measurement of **fluid density** - continuous sampling (online densitometer) or spot sampling.

10.1 Measurement of Temperature and Pressure - Automated

For systems employing **automated measurements**, the readings associated with the master prover, master meter and field prover (T_P, T_D, P_P, T_M, P_M) shall be a snapshot or averaged (flow-weighted or time-based) when the displacer is between detector switches for each proving run (roundtrip) **of the master prover** in accordance with API *MPMS* Chapter 4.8 **to determine a Master Meter Factor (MMF)**.

For systems employing **automated measurements**, the readings of T_P, T_D, P_P, T_M, and P_M shall be a snapshot or averaged (flow-weighted or time-based) when the displacer is between detector switches for each proving run (roundtrip) **of the field prover** in accordance with API *MPMS* Chapter 4.9.2 **to determine a CPV_{RUN}**.

10.2 Measurement of Temperature and Pressure - Manual

For systems employing **manual measurements**, the readings associated with the master prover and master meter (T_P, T_D, P_P, T_M, P_M) shall be recorded when the displacer is between detector switches for each proving run (roundtrip) of **the master prover** in accordance with API *MPMS* Chapter 4.8 t**o determine a Master Meter Factor (MMF)**.

For systems employing **manual measurements**, the readings associated with the master meter and field prover (T_M, P_M, T_P, T_D, P_P) shall be recorded when the displacer is between detector switches for each proving run (roundtrip) of **the field prover** in accordance with API *MPMS* Chapter 4.9.2 t**o determine a CPV_{RUN}**.

10.3 Density Measurement – Continuous or Online

The Continuous (or Online) Sampling Method requires an online densitometer to determine the base density (ρ_B) for each proving run. The values of ρ_{obs}, T_{dm}, and P_{dm} shall be a snapshot or averaged (flow-weighted or time-based) when the displacer is between detector switches for each proving run (roundtrip) **of the master prover** in accordance with API *MPMS* Chapter 4.8 **to determine a Master Meter Factor (MMF)**.

10.4 Density Measurement – Spot Sample

The Spot Sampling Method requires a density determination at the START of a Proving Report using atmospheric density devices (hydrometer, thermohydrometer, handheld densitometer) or laboratory analysis to determine the base density (ρ_B). This method assumes the base density (ρ_B) is constant for the proving report (all proving runs) in accordance with API *MPMS* Chapter 4.8 **to determine a Master Meter Factor (MMF)**.

The Spot Sampling Method requires a density determination at the START of a CPV_{RUN} using atmospheric density devices (hydrometer, thermohydrometer, handheld densitometer) or laboratory analysis to determine the base density (ρ_B) of **the master meter and field prover** in accordance with

API *MPMS* Chapter 4.9.2 t**o determine a CPV_{RUN}**. This method assumes the base density (ρ_B) is constant for a calibration run of the field prover (CPV_{RUN}) and any fluid properties' variation (ρ_B, υ_{TP}) between the START and STOP Proving Reports and associated Calibration Runs (CPV_{RUN}) will have a minimal impact of the calibration of the field prover.

11. MMF Methods

There are two methods to establish a **Master Meter Factor (MMF)** - Intermediate Meter Factor (IMF) and Average Data.

The **Intermediate Meter Factor (IMF) Method** uses the GSV_P and ISV_M to calculate the IMF for each proving run. The average of the selected proving runs' IMF values that satisfy the repeatability criteria (r%) determines the MF or MMF.

The Intermediate Factor Method (IMF) is the preferred method as variations in temperature, pressure, and if employing an online densitometer - base density, are accounted for in the evaluation of the proving results.

The **Average Data Method** uses the average of the measurements (ρ_B, T_P, T_D, P_P, N or N_i, T_M, P_M) from the selected proving runs' that satisfy a Fixed Range (r%) criteria (5 consecutive runs) to calculate a single value for GSV_P, ISV_M, and MF or MMF. The proving runs' pulses (N or N_i) are evaluated to satisfy the repeatability ($r \leq 0.020$ %) criteria.

The **Multiple Run Sets Method** *shall not be applied to generate a MMF for calibration of a field prover*. This method is applied to unstable process conditions (flowrates, fluid density, temperature, pressure, viscosity) or use of an inappropriately sized prover for challenging applications.

12. Repeatability (r%) Methods

The Master Meter Repeatability Criteria is, as specified in API *MPMS* Chapter 4.9.3, r% ≤ 0.020 % for a MMF using the Fixed Range Method.

The maximum number of consecutive proving runs is ten (10) by industry practice.

There are two methods to determine flowmeter repeatability (r%) - Moving Range and Fixed Range.

To restate, API *MPMS* Chapter 12.2 states: "Historically, the Average Data Method has been used since it only requires a single calculation at the end to determine the Meter Factor. *The Intermediate Factor Method (IMF) is the preferred method as variations in temperature and pressure are accounted for in the evaluation of the proving results.*"

The ***Moving Range (or Standard Deviation) Method*** requires three (3) or more consecutive proving runs' IMF to satisfy the repeatability criteria. The maximum number of consecutive proving runs is ten (10) according to industry practice.

r% for Allowable α(MF)of 0.00016

The following Table calculates the Allowable Repeatability (Allowable r%) for 3 through 10 consecutive proving runs. The 1σ allowable random uncertainty about the mean is set at 0.0105% at U95, or an Allowable α(MF) of 0.000105. This equates to a 2σ maximum allowable random uncertainty of 0.020 % at U95. To summarize, the allowable repeatability tolerance for (n) runs equates to a 2σ allowable random uncertainty of 0.020 % at U95 for 5 out of 5 consecutive runs.

Run No.	IMF	Max IMF	Min IMF	Actual r%	Allowable r%	pass / (FAIL)
1	1.000 000	*NA*	*NA*	*NA*	*NA*	*NA*
2	1.000 050	*NA*	*NA*	*NA*	*NA*	*NA*
3	1.000 204	1.000 204	1.000 000	0.020	0.007	FAIL
4	1.000 180	1.000 204	1.000 000	0.020	0.014	FAIL
5	1.000 162	1.000 204	1.000 000	0.020	0.020	pass
6		-	-	-	0.025	-
7		-	-	-	0.031	-
8		-	-	-	0.036	-
9		-	-	-	0.041	-
10		-	-	-	0.045	-

MMF 1.000 119

Table 10 – Moving Range Repeatability (r%)

The 1σ allowable random uncertainty about the mean is set at 0.01050 % at U^{95}, or an Allowable α(MF) of 0.000105. This equates to a 2σ maximum allowable random uncertainty of 0.020 % at U^{95}. To summarize, the maximum repeatability tolerance for (n) runs equates to a 2σ allowable random uncertainty of 0.020 % at U^{95} for five (5) consecutive proving runs (as shown in Table 10).

The **Fixed Range Method**, outlined in API *MPMS* Chapter 4, requires five (5) consecutive proving runs demonstrate a repeatability (r%) for a flowmeter using one of the following:

[1] five (5) consecutive runs' IMF values
[2] five (5) consecutive runs' flowmeter's pulses (N, N_i)

For the **Fixed Range Method**, MMF repeatability is determined by five (5) consecutive proving runs using the IMF or pulse (N, N_i) values and the following equation:

$$r\% = \left[\frac{(Max - Min)}{Min}\right] \times 100 \tag{1}$$

13. Calibration of the Master Meter

The multitude of approaches to calibrate (or prove) a flowmeter (or master meter) is shown in Figure 1.

Matrixes A and B will provide the calibration system's highest discrimination for repeatability and reproducibility.

Matrixes C, D, and E are applicable to stable process conditions (flowrates, base density, viscosity, temperature, pressure). These Matrixes will produce a calibration system's discriminations approximating Matrixes A and B values for repeatability and reproducibility.

The Multiple Run Sets Method *shall not be applied to generate a MMF for calibration of a field prover*. This method is applied to unstable process conditions (flowrates, fluid density, temperature, pressure, viscosity) or use of an inappropriately sized prover for challenging applications.

	MMF Proving Matrixes					
Matrix	**A**	**B**	**C**	**D**	**E**	
ρ_{obs} Methods	x	x	-	-	-	**Continuous Sampling**
	-	-	x	x	x	**Spot Sample**
Meter Factor Methods	x	x	x	x	-	**Intermediate (IMF)**
	-	-	-	-	x	**Average Data**
	NA	NA	NA	NA	NA	**Multiple Run Sets**
(r%) Methods	x	-	x	-	-	**Moving Range (or Std Dev)**
	-	x	-	x	x	**Fixed Range**

Figure 1 – MMF Proving Report Matrixes

14. Prover Calibration Method Using a Master Meter

The Master Meter Method for Calibrating a Prover consists of the matrixes shown in Figure 2.

Matrix A will provide the calibration system's highest discrimination for repeatability and reproducibility.

Matrix B is applicable to stable process conditions (flowrates, base density, viscosity, temperature, pressure). This Matrix will produce a calibration system's discriminations approximating Matrix A values for repeatability and reproducibility.

Three (3) methods for prover calibration using the master meter volumetric method are specified in API *MPMS* Chapter 4.9.3 and shown in Figure 3.

14.1 Master Meter Criteria

For the Standard Method, the ΔMMF_{SET} shall be ≤ 0.020 % for Selected Three (3) Consecutive Runs for a Set.

For Alternate "A" Method, the ΔMMF_{RUN} shall be ≤ 0.020 % for Selected Three (3) Consecutive Runs in a Set.

For Alternate "B" Method, ΔMMF_{START}, ABS(MMF_1 – MMF_2, ABS(MMF2– MM3), shall be ≤ 0.020 % for Selected Three (3) Consecutive Runs in a Set.

	BPV Determination - Matrixes		
	A	B	
ρ_b Methods	x	-	Continuous Sampling
	-	x	Spot Sample
BPV Determination	x	x	Standard Method
	x	x	Alternate Method "A"
	x	x	Alternate Method "B"
(r%) Method	x	x	Fixed Range

Figure 2 – Master Meter Method Matrix for Prover Calibration

14.2 Field Prover Calibration Criteria

For All Methods, a Calibration Set (CPV_{SET}) consists of a minimum of three (3) consecutive and a maximum of six (6) consecutive Calibration Runs (CPV_{RUN}), in accordance with API *MPMS* Chapter 4.9.3.

14.2.1 Flowrate Variation in a Calibration Set Criteria (ΔQ_{SET})

The flow rate during a calibration run set should be stable. Maintaining the flow rate of each pass of a calibration run set within a range of 5 % will aid in fulfilling the other repeatability criteria.

14.2.2 Repeatability in a Calibration Set ($r\_\Delta CPV_{SET}$)

API *MPMS* Chapter 4.9.3, the prover calibration shall demonstrate a **Calibration Set Repeatability** ($r\_\Delta CPV_{SET}$) ≤ 0.020 % for three (3) consecutive calibration runs out of a maximum of six (6) consecutive calibration runs in a Calibration Set.

14.2.3 Reproducibility of Three (3) Calibration Sets Criteria ($R\_\Delta CPV_{SET}$)

For All Methods, in accordance with API *MPMS* Chapter 4.9.3, the $r\_\Delta CPV_{RUN}$ shall be ≤ 0.020 % for Selected three (3) Consecutive Runs in a Set.

14.3 CPV Determinations

For All Methods, in accordance with API *MPMS* Chapter 4.9.3, a Calibration Set (CPV_{SET}) is calculated using the following equation:

$$CPV_{SET} = \frac{\sum^3 CPV_{RUN}}{3} \tag{2}$$

For All Methods, the following criteria shall be met:

- three (3) Consecutive Calibration Sets (CPV_{SET}) shall be performed at three (3) different flowrates.

- the flowrate for the 2nd Calibration Set (CPV_{SET_II}) shall be at least ± 25.0 % different from 1st Calibration Set (CPV_{SET_I}).
- the flowrate for the 3rd Calibration Set (CPV_{SET_III}) shall be at least 25.0 % greater than the highest flowrate of the two previous Consecutive Calibration Sets.
- Three (3) Consecutive Calibration Sets to satisfy the reproducibility criteria ($R\_\Delta CPV_{SET}$) ≤ 0.020 % over three (3) different flowrates.
- the ΔCPV_{SET} reproducibility (R) shall be ≤ 0.020 % for the three (3) Consecutive Calibration Sets.

For the Standard Method, the $r\_\Delta ICPV_{RUN}$ shall be ≤ 0.020 % for Selected 3 Consecutive Runs in a Set.

Standard Method		Alternate Method A		Alternate Method B	
		Uses MMF_{stop} as the MMF_{start} for next run		Simultaneous MMF and Field Prover Calibration	
Calibration Run Set I		Calibration Run Set I		Calibration Run Set I	
MMF_{start}	MMF1	MMF_{start}	MMF1		
Calibration Run 1	1st consecutive	Calibration Run 1	1st consecutive	MMF	MMF1
		MMF_{stop}	MMF2	and Calibration Run 1	1st consecutive
		MMF_{start}	Same as MMF2		
Calibration Run 2	2nd consecutive	Calibration Run 2	2nd consecutive	MMF	MMF2
		MMF_{stop}	MMF3	and Calibration Run 2	2nd consecutive
		MMF_{start}	Same as MMF3		
Calibration Run 3	3rd consecutive	Calibration Run 3	3rd consecutive	MMF	MMF3
MMF_{stop}	MMF2	MMF_{stop}	MMF4	and Calibration Run 3	3rd consecutive
:					
Above pattern can be continued up to a maximum of six consecutive calibration runs		Above pattern can be continued up to a maximum of six consecutive calibration runs		Above pattern can be continued up to a maximum of six consecutive calibration runs.	
:					
Allowable for Calibration Runs		Allowable for Calibration Runs		Allowable for Calibration Runs	
Three consecutive runs, within a range of 0.020 %, out of a maximum of six consecutive calibration runs		Three consecutive runs, within a range of 0.020 %, out of a maximum of six consecutive calibration runs		Three consecutive runs, within a range of 0.020 %, out of a maximum of six consecutive calibration runs	
Allowable for Each MMF		Allowable for Each MMF		Allowable for Each MMF	
Five consecutive runs, within a range of 0.020 %, out of a maximum of ten consecutive proving runs		Five consecutive runs, within a range of 0.020 %, out of a maximum of ten consecutive proving runs		Seven consecutive runs, within a range of 0.020 %, out of a maximum of 14 consecutive proving runs	
MMF1 shall be within 0.020 % of MMF2		MMF1 shall be within 0.020 % of MMF2		MMF1 shall be within 0.020 % of MMF2	
		MMF2 shall be within 0.020 % of MMF3		MMF2 shall be within 0.020 % of MMF3	
		MMF3 shall be within 0.020 % of MMF4			
Calibration Run Set II		Calibration Run Set II		Calibration Run Set II	
Conduct the same as calibration run set I except at different flow rate		Conduct the same as calibration run set I except at different flow rate		Conduct the same as calibration run set I except at different flow rate	
Calibration Run Set III		Calibration Run Set III		Calibration Run Set III	
Conduct the same as calibration run set II except at different flow rate		Conduct the same as calibration run set II except at different flow rate		Conduct the same as calibration run set II except at different flow rate	

Figure 3 – Master Meter Methods for Prover Calibration

14.4 CPV_{SET} Stability Parameters

Analysis of the stability in each CPV_{SET} will assist in analyzing the prover calibration system

performance (master meter, master prover), presence of a homogeneous and stable base density (ρ_B), stable fluid properties (T_P, P_P), stable flow conditions (Q), and the prover's physical condition.

The following parameters demonstrate stability in a CPV_{SET} determination:

- ΔMMF_{SET} Variation of calibration system performance over a CPV_{SET}
- $\Delta\rho_{B\_SET}$ Variation of ρ_B over a CPV_{SET}
- ΔT_{FP_SET} Variation of T_{FP} over a CPV_{SET}
- ΔP_{FP_SET} Variation of P_{FP} over a CPV_{SET}
- ΔQ_{MM_SET} Variation of Q_{MM} over a CPV_{SET}

15. Standard Method for Calibrating a Prover Using Master Meter

The Standard Method specifies the calibration of the Master Meter a*t the START and STOP of each* ***Calibration Set*** *(MMF_{START}, MMF_{STOP})*. This will result in six (6) MMF determinations and three (3) MMF_{SET} values to determine the Base Prover Volume (BPV).

The calibration sequence is shown in the Process Maps (Figures 6 or 7).

The flowrate for a Calibration Set is established and the system shall exhibit a homogeneous, stable flow regime (temperature, flowrate, base density).

At the 'START' of a Calibration Set, the master meter is calibrated using the master prover to generate a MMF_{START} proving report.

A Calibration Run of the field prover is performed using the master meter as a transfer standard.

An Initial Calibrated Prover Volume ($ICPV_{RUN}$) is determined for each Calibration Run using the following equations:

$$GSV_M = MMF_{START} \times IV_M \times CTL_M \times CPL_M \tag{3}$$

$$ICPV_{RUN} = \frac{GSV_M}{(CTS_P \times CPS_P \times CTL_P \times CPL_P)} \tag{4}$$

A 'STOP' of the Calibration Set is initiated when a minimum of three (3) consecutive Calibration Runs out of a maximum of six (6) consecutive Calibration Runs demonstrate a $ICPV_{RUN}$ repeatability tolerance, r_ΔICPV ≤ 0.020 %.

The master meter is calibrated using the master prover to generate a MMF_{STOP} proving report.

The Master Meter shall demonstrate a reproducibility tolerance, ΔMMF (r%) ≤ 0.020 %, between the MMF_{START} and MMF_{STOP} values, for each CPV_{SET}.

If employing a Spot Sampling Method for calibration of a field prover,

$$\rho_{B\_SET} = \frac{(\rho_{B\_START} + \rho_{B\_STOP})}{2} \tag{5}$$

If employing a continuous Sampling Method (online densitometer),

$$\rho_{B\_SET} = \frac{\Sigma^3(\rho_{B\_RUN}\ of\ three\ consecutive\ selected\ runs\ in\ a\ Set\ )}{3} \tag{6}$$

A Calibrated Prover Volume for each Run (CPV_{RUN}) is determined using the following equations:

$$MMF_{SET} = \frac{(MMF_{START} + MMF_{STOP})}{2} \tag{7}$$

$$CTL \sim f\ (\rho_{B\_SET}, T) \tag{8}$$

$$F \sim f\ (\rho_{B\_SET}, T) \tag{9}$$

$$CPL \sim f\ (F, P) \tag{10}$$

$$GSV_M = MMF_{SET} \times IV_M \times CTL_M \times CPL_M \tag{11}$$

$$CPV_{RUN} = \frac{GSV_M}{(CTS_P \times CPS_P \times CTL_P \times CPL_P)} \tag{12}$$

The Fixed Range Method criteria stated in API *MPMS* Chapter 4.9.3, requires a repeatability tolerance, $r\_\Delta CPV_{RUN} \leq 0.020$ % for three (3) consecutive calibration runs out of a maximum of six (6) consecutive calibration runs in each Calibration Set at a constant flowrate.

The Fixed Range Method criteria stated in API *MPMS* Chapter 4.9.3, requires a reproducibility tolerance, $R\_\Delta CPV_{SET} \leq 0.020$ %, for three (3) consecutive Calibration Sets over the three (3) different flowrates.

16. Alternate Method "A" for Calibrating a Prover Using Master Meter

Alternate Method "A" specifies the calibration of the Master Meter *at the START and STOP of each* ***Calibration Run*** *(MMF_{START}, MMF_{STOP})*. This will result in four (4) to seven (7) MMF determinations for each Calibration Set and three (3) MMF_{SET} values to determine the Base Prover Volume (BPV).

The calibration and calculation sequences are shown in the Process Maps (Figures 8 or 9).

The flowrate for a Calibration Set is established and the system shall exhibit a homogeneous, stable flow regime (temperature, flowrate, base density).

At the 'START' of each Calibration Run, the master meter is calibrated using the master prover to generate a MMF_{START} proving report.

A Calibration Run of the field prover is performed using the master meter as a transfer standard.

At the 'STOP' of each Calibration Run, the master meter is calibrated using the master prover to generate a MMF_{STOP} proving report. The MMF_{STOP} value is the MMF_{START} value for the next consecutive Run in a Calibration Set.

The Master Meter shall demonstrate a reproducibility tolerance, ΔMMF (r%) ≤ 0.020 %, between the MMF_{START} and MMF_{STOP} values, for each CPV_{RUN}.

A Calibrated Prover Volume for each Run (CPV_{RUN}) is determined using the following equations:

$$MMF_{RUN} = \frac{(MMF_{START} + MMF_{STOP})}{2} \tag{13}$$

$$\rho_{B\_RUN} = \frac{(\rho_{B\_START} + \rho_{B\_STOP})}{2} \tag{14}$$

$$CTL \sim f\,(\rho_{B\_RUN}, T) \tag{15}$$

$$F \sim f\,(\rho_{B\_RUN}, T) \tag{16}$$

$$CPL \sim f\,(F, P) \tag{17}$$

$$GSV_M = MMF_{RUN} \times IV_M \times CTL_M \times CPL_M \tag{18}$$

$$CPV_{RUN} = \frac{GSV_M}{(CTS_P \times CPS_P \times CTL_P \times CPL_P)} \tag{19}$$

A 'STOP' of the Calibration Set is initiated when a minimum of three (3) consecutive Calibration Runs out of a maximum of six (6) consecutive Calibration Runs demonstrate a CPV_{RUN} repeatability tolerance, ΔCPV(r%) ≤ 0.020 %.

The Fixed Range Method criteria stated in API *MPMS* Chapter 4.9.3, requires a repeatability tolerance, r_ΔCPV_{RUN} ≤ 0.020 % for three (3) consecutive calibration runs out of a maximum of six (6) consecutive calibration runs in each Calibration Set at a constant flowrate.

The Fixed Range Method criteria stated in API *MPMS* Chapter 4.9.3, requires a reproducibility tolerance, R_ΔCPV_{SET} ≤ 0.020 %, for three (3) consecutive Calibration Sets over the three (3) different flowrates.

17. Alternate Method "B" for Calibrating a Prover Using Master Meter

The Alternate Method "B" specifies a single calibration of the Master Meter simultaneously *at the START of each* ***Calibration Run*** (MMF_{RUN}). This will result in three (3) to six (6) MMF determinations for each Calibration Set and three (3) MMF_{SET} values to determine the Base Prover Volume (BPV).

The calibration and calculation sequences are shown in the Process Maps (Figures 10 or 11).

The flowrate for a Calibration Set is established and the system shall exhibit a homogeneous, stable flow regime (temperature, flowrate, base density) prior to initiating a MMF proving report.

At the 'START' of each Calibration Run, the master meter is calibrated using the master prover to generate a MMF_{START} proving report.

A Calibration Run of the field prover is performed using the master meter as a transfer standard.

A Calibrated Prover Volume for each Calibration Run (CPV_{RUN}) is determined using the following equations:

$$GSV_M = MMF_{START} \times IV_M \times CTL_M \times CPL_M \tag{20}$$

$$CPV_{RUN} = \frac{GSV_M}{(\ CTS_P \times CPS_P \times CTL_P \times CPL_P)} \tag{21}$$

The Master Meter shall demonstrate a reproducibility tolerance, ΔMMF (r%) ≤ 0.020 %, between the MMF_{START} values for each consecutive pair of Calibration Runs.

A 'STOP' of the Calibration Set is initiated when a minimum of three (3) consecutive Calibration Runs out of a maximum of six (6) consecutive Calibration Runs demonstrate a CPV_{RUN} repeatability tolerance, r_ΔCPV ≤ 0.020 %.

The Fixed Range Method criteria stated in API *MPMS* Chapter 4.9.3, requires a repeatability tolerance, r_ΔCPV_{RUN} ≤ 0.020 % for three (3) consecutive calibration runs out of a maximum of six (6) consecutive calibration runs in each Calibration Set at a constant flowrate.

The Fixed Range Method criteria stated in API *MPMS* Chapter 4.9.3, requires a reproducibility tolerance, R_ΔCPV_{SET} ≤ 0.020 %, for three (3) consecutive Calibration Sets over the three (3) different flowrates.

18. Average Calibrated Prover Volume for Sets (CPV_{SET})

When the Prover Calibration Criteria have been satisfied for the selected calibration method (Standard, Alternate "A", Alternate "B"), the Average CPV_{SET} is calculated as follows:

$$Average\ CPV_{SET} = \frac{\left(CPV_{SET_I} + CPV_{SET_{II}} + CPV_{SET_{III}} \right)}{3} \tag{22}$$

To convert the Average CPV_{SET} to various BPV to units at base (reference or standard) conditions as shown in Figure 13.

19. Process Maps

Eight (8) Process Maps have been prepared to assist the user of this standard to fully comprehend the complexity associated with the calculations:

- Master Proving Report Using Online Densitometer (Figure 4)
- Master Meter Proving Report Using Spot Sample (Figure 5)
- Standard Method for Displacement Prover Using Online Densitometer (Figure 6)
- Standard Method for Displacement Prover Using Spot Sample (Figure 7)
- Alternate A Method for Displacement Prover Using Densitometer (Figure 8)
- Alternate A Method for Displacement Prover Using Spot Sample (Figure 9)
- Alternate B Method for Displacement Prover Using Online Densitometer (Figure 10)
- Alternate B Method for Displacement Prover Using Spot Sample (Figure 11)
- Expanded Discrimination of Master Prover's BPV (Figure 12)
- Conversion of Average CPV_{SET} to BPV (Figure 13)

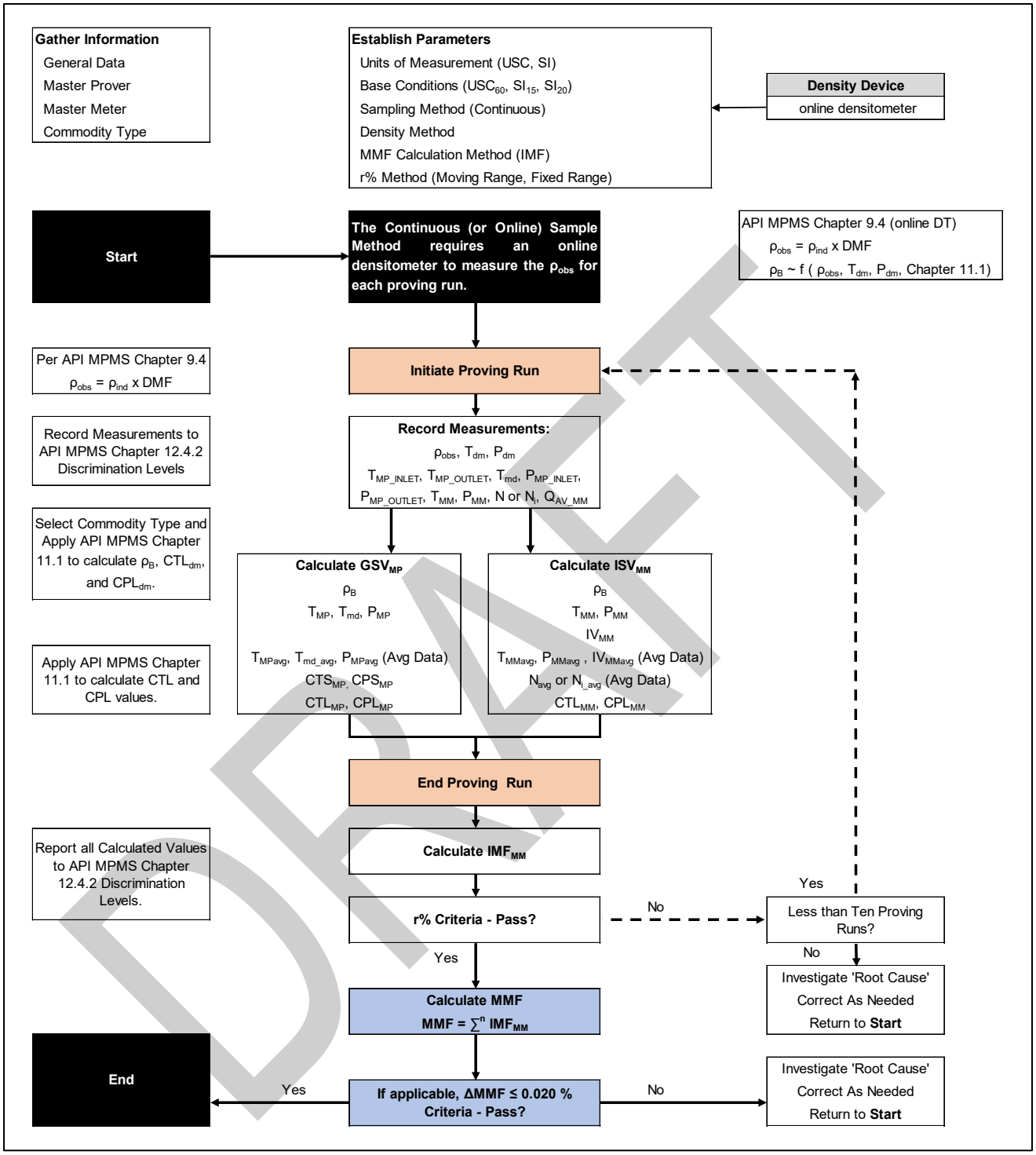

Figure 4 – Master Meter Proving Using Online Densitometer

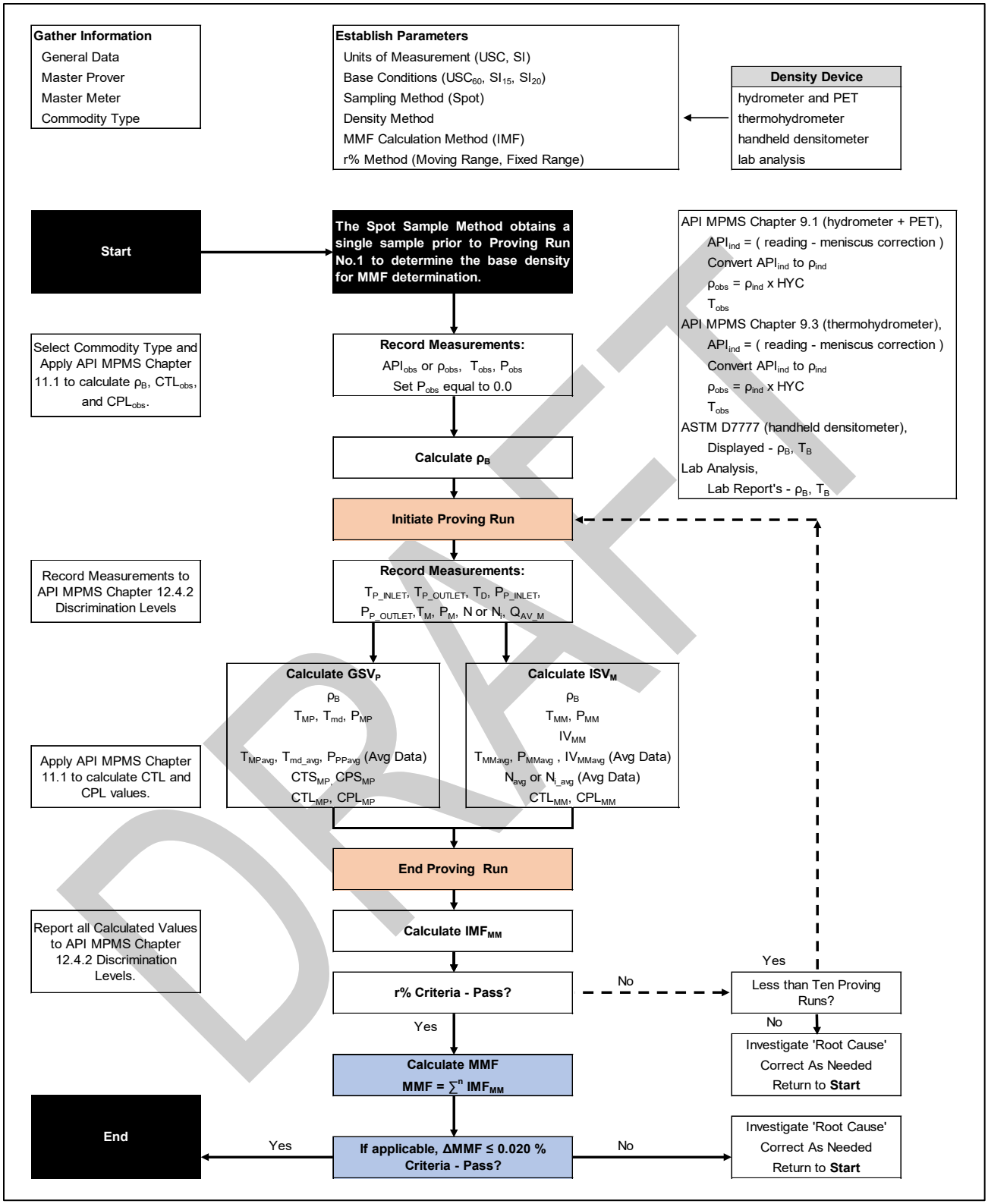

Figure 5 – Master Meter Proving Using Spot Sample

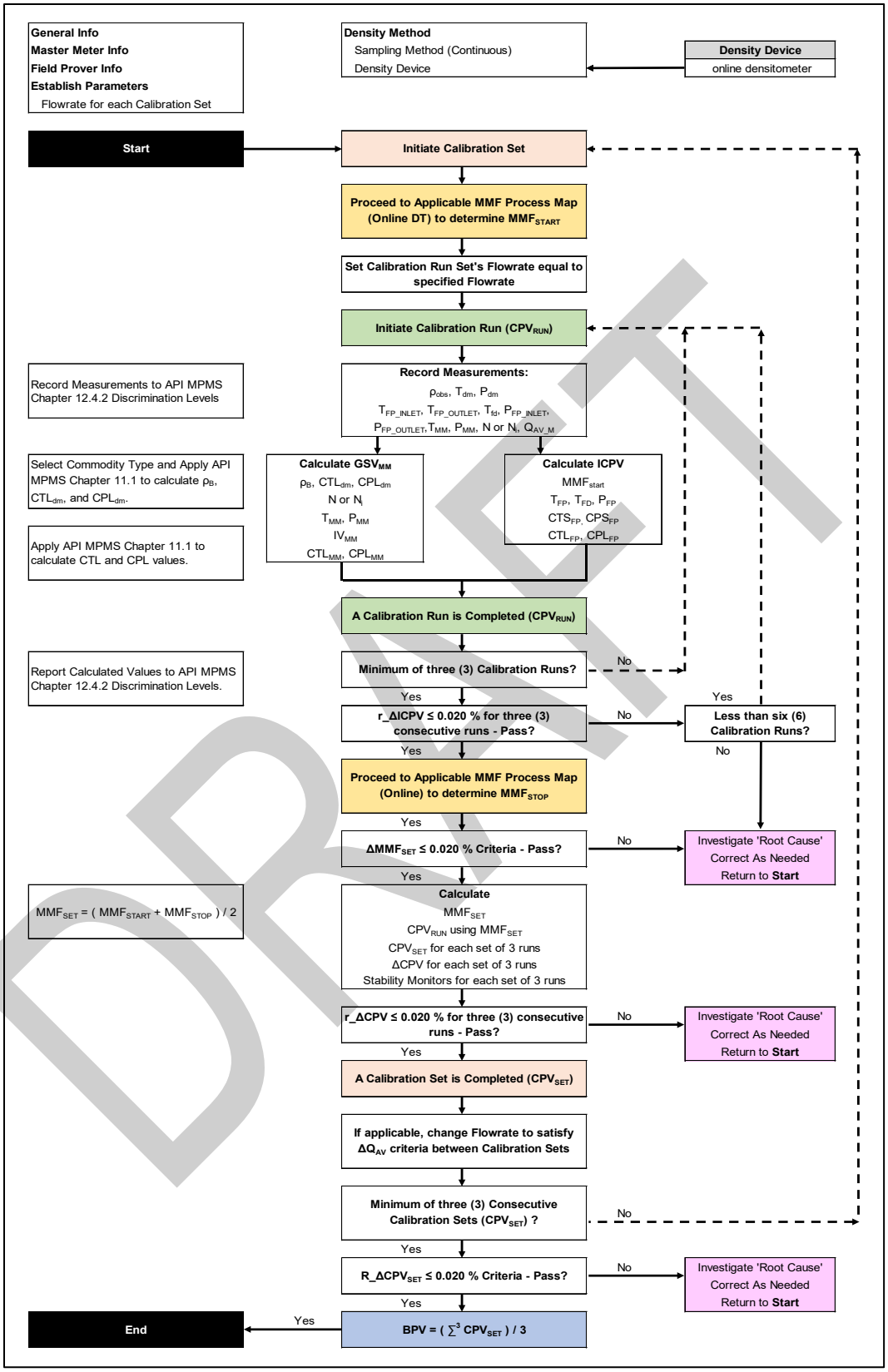

Figure 6 – Standard Method for Displacement Prover Using Online Densitometer

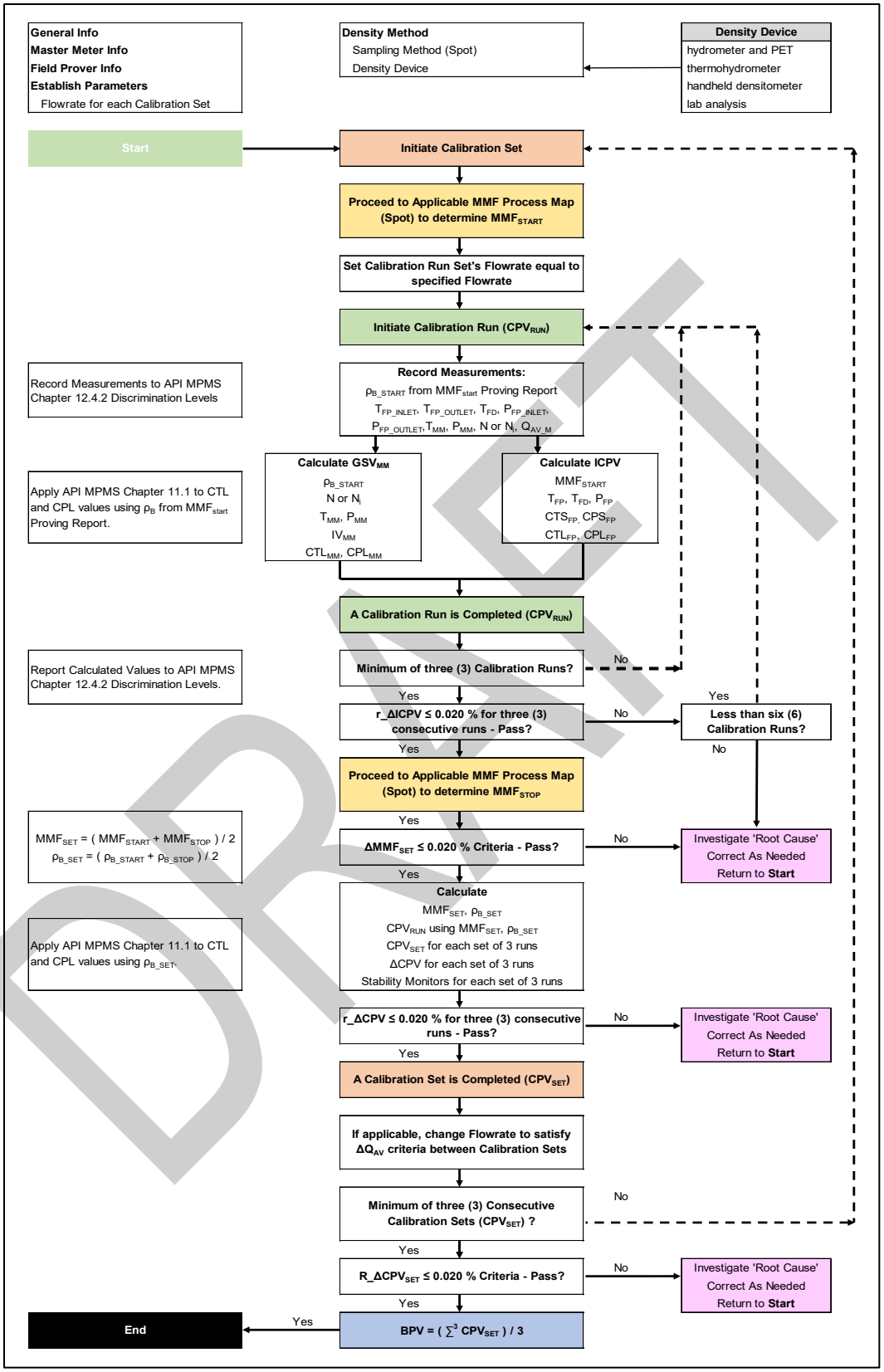

Figure 7 – Standard Method for Displacement Prover Using Spot Sample

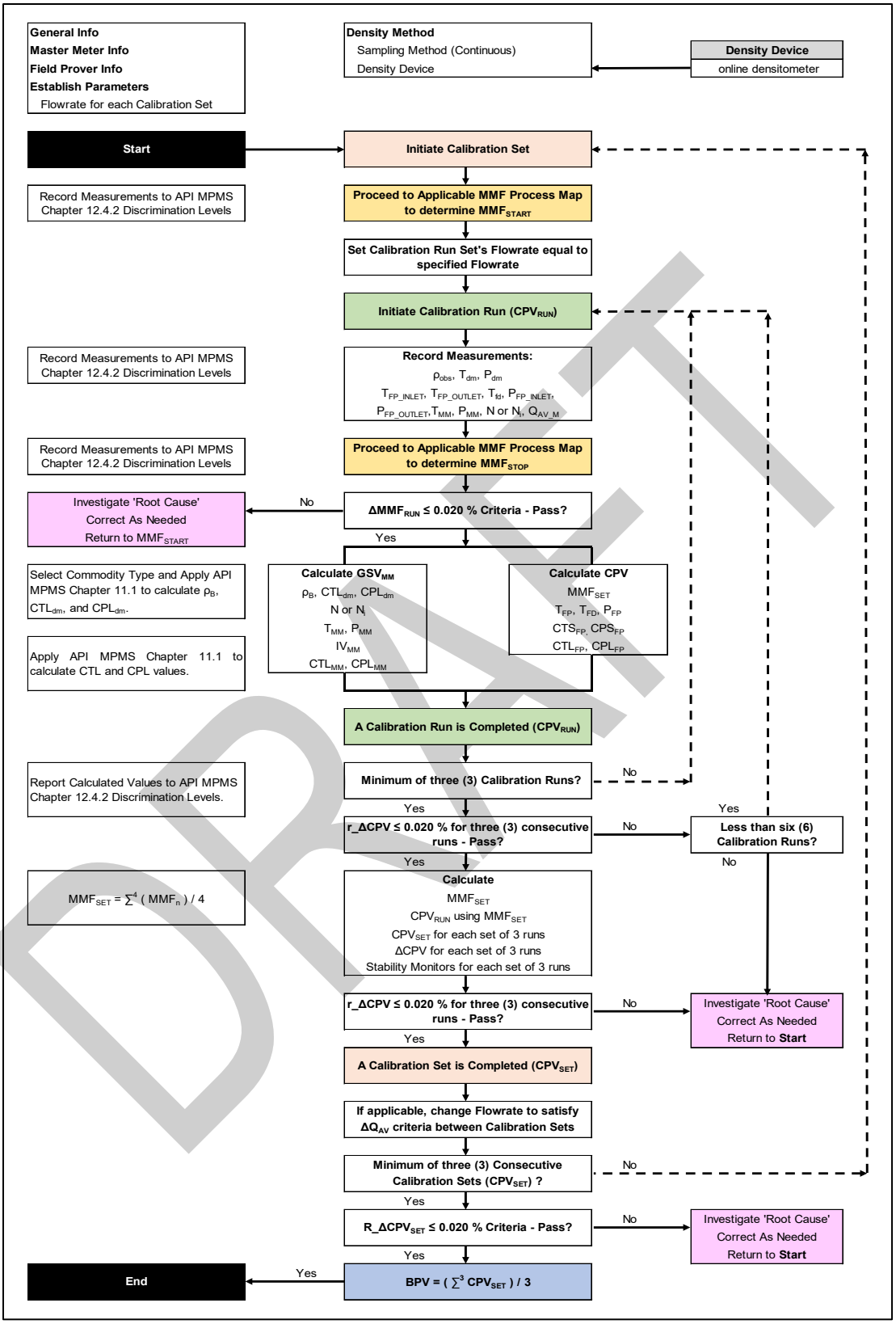

Figure 8 – Alternate Method "A" for Displacement Prover Using Online Densitometer

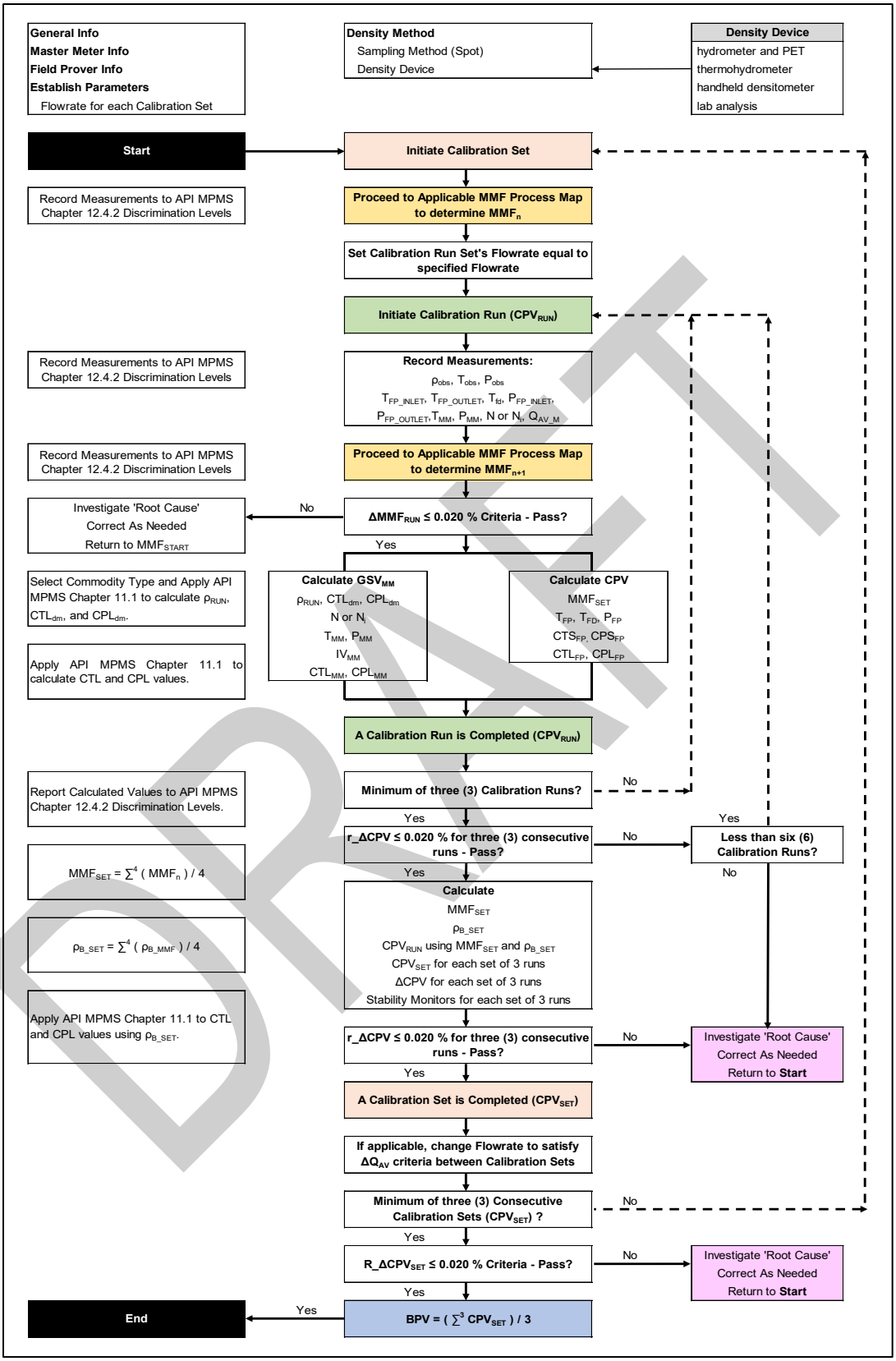

Figure 9 – Alternate Method "A" for Displacement Prover Using Spot Sample

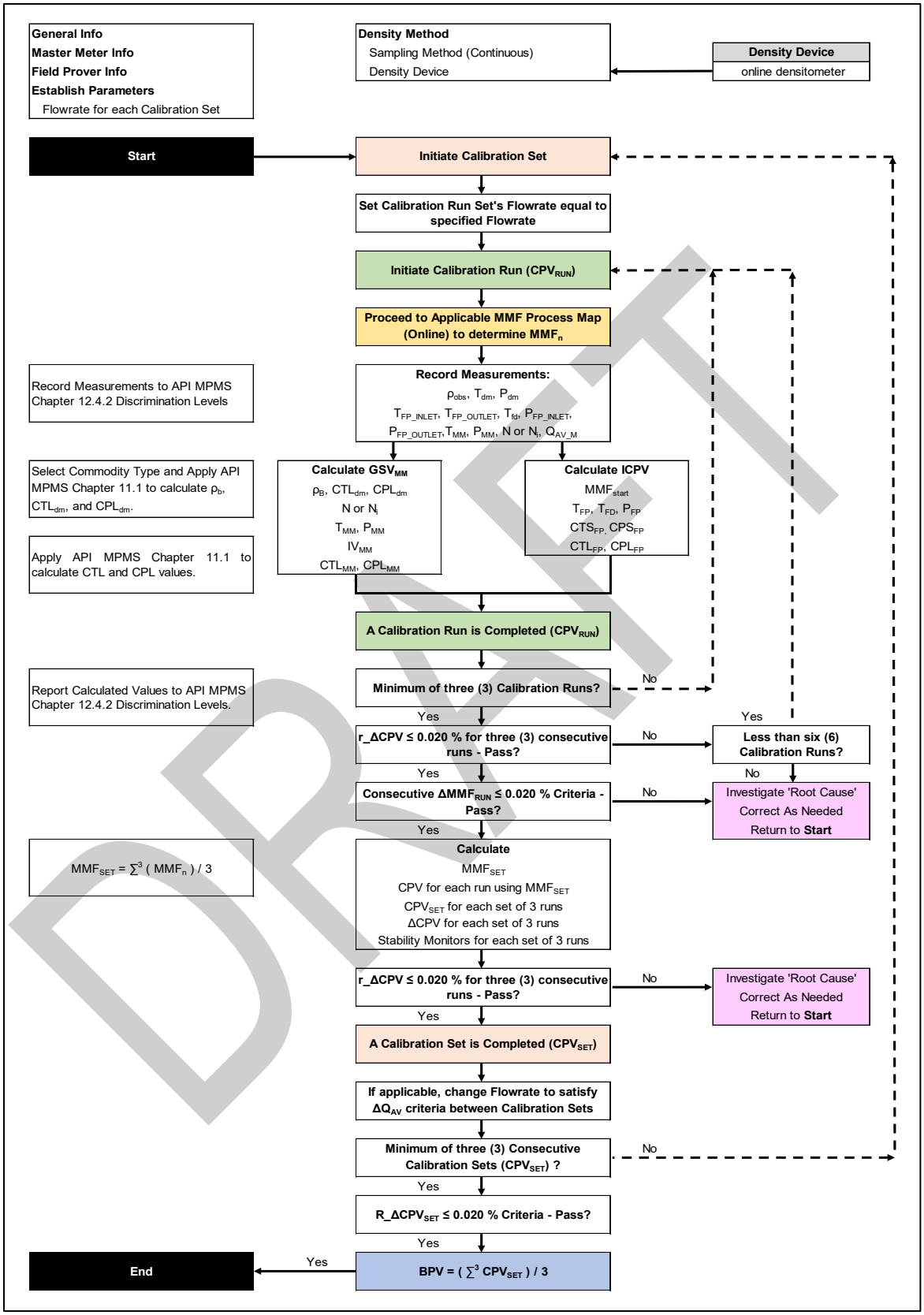

Figure 10 – Alternate Method "B" for Displacement Prover Using Online Densitometer

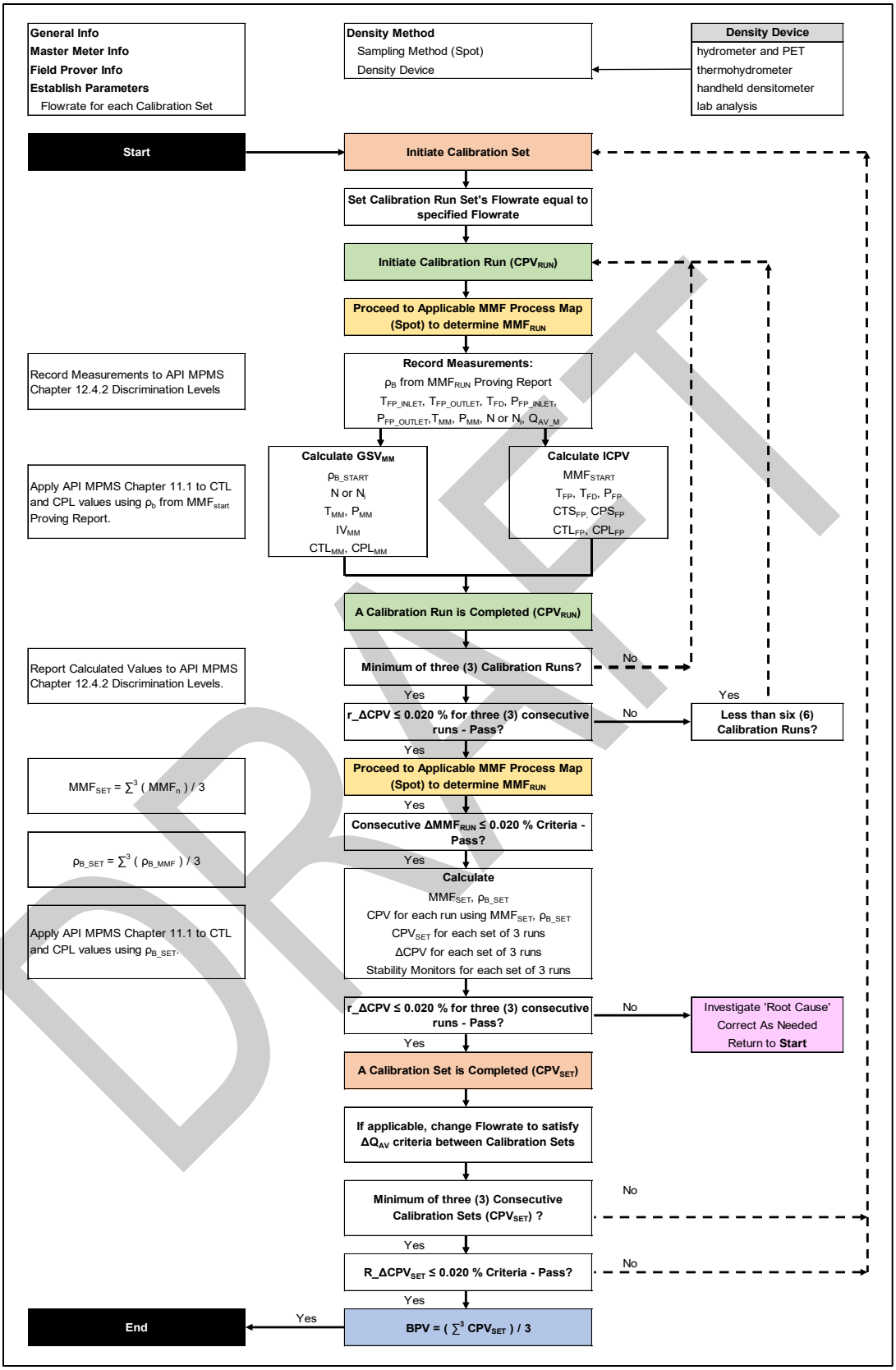

Figure 11 – Alternate Method "B" for Displacement Prover Using Spot Sample

	Field Prover	
Measurement Units	0	(0-USC_{60}, 1-SI_{15}, 2-SI_{20})
Detector Design	0	(0-Internal, 1-External)
Wall Material	1	(1-CS, 2-304SS, 3-316SS, 4-17-4PH)
Rod Material	0	(0-NA, 1-CS, 2-304SS, 3-316SS, 4-17-4PH, 5-Invar)
Source for GL_{MP}, GL_{md}, E_{MP}	1	(0-Prover Manufacturer, 1-API Table)
BPV_P	30,030.795 3	cubic inches at 60.0 °F, 0.0 psig

	Base Prover Volume (BPV)		
	BPV_{60} Barrels	**BPV_{15} Cubic Meters**	**BPV_{20} Cubic Meters**
	3. 095 320 068 027	0. 492 107 411 000	0. 492 189 795 000
Decimals	9	10	10
Conversion	in^3 / Bbl 9.702E+03	mL / M^3 1.00E+06	mL / M^3 1.00E+06
Rnd'd BPV	3.095 320 068 000	0.492 107 411 000	0.492 189 795 000

in^3 = mL / 16.387 064
U.S. Gallons = in^3 / 2.31E+02
Bbl = in^3 / 9.702E+03
Cubic Feet = in^3 / 1.728E+03

mL = M^3 x 1E+06
mL = in^3 x 16.387 064

M^3 = mL x 1E-06
L = mL x 1E-03

Note: This Worksheet produces a BPV_{60} or BPV_{SI} to **10 digits** (the appropriate decimal place) to increase the precision of the Master Prover's BPV, not the uncertainty of the Master Prover's BPV.

T_B	60.0	°F
Decimal Base CTS	9	-
Decimal BPV_{60}	4	cubic inches at 60.0 °F, 0.0 psig
Decimal BPV_{SI}	3	mL at 15.0 °C and 0.0 kPag
Decimal BPV	9	Barrels
Decimal BPV	10	Cubic Meters

API Properties

Linear Coefficient of Thermal Expansion, GL

	SI Unit[2,4] (per °C)	**USC Unit[2,3,5]** (per °F)
Mild Carbon	0.000 011 16	**0.000 006 20**
304 SS	**0.000 017 28**	0.000 009 60
316 SS	**0.000 016 02**	0.000 008 90
17-4PH	0.000 010 80	**0.000 006 00**
Invar™	0.000 001 44	**0.000 000 80**

Detector Design,

$CTS_P = [1 + (T_P - T_B) \times GL_P]^3$, for detectors mounted in calibrated section

$CTS_P = [1 + (T_P - T_B) \times GL_P]^2 \times [1 + (T_D - T_B) \times GL_d]$, for detectors mounted on external shaft

If Measurement Units = 0, then BPV in cubic inches, T_B is 60.0 °F

BPV_{60} = cubic inches at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 1, then BPV in mL, T_B is 15.0 °C

BPV_{60} = ROUND(BPV_{15} / 16.387 064 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(BPV_{15} x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 2, then BPV in mL, T_B is 20.0 °C

BPV_{60} = ROUND(BPV_{20} / 16.387 064 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(CPV_{20} x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = mL at 20.0 °C, 0.0 kPag

Notes:

(1) The User/Owner should obtain GL values from the prover manufacturer.

(2) The GL values shown above are a function of the materials, operating temperature range, calibration temperature range. Values in **bold face** were obtained from American Society of Metals (ASM) International, 2020 edition.

(3) GL values shown above are applicable from 0 °C to 100 °C (32 °F to 212 °F). If operating outside this range, the GL values depicted are not appropriate.

(4) The SI values of GL per °C **not in bold face**, was obtained by multiplying the USC values, GL per °F, times 1.8.

(5) The USC values per °F **not in bold face**, was obtained by dividing the SI values, GL per °C, by 1.8.

	per °F	per °C	per °C
GL_P	0.000 006 20	0.000 011 16	0.000 011 16
GL_D	NA	NA	NA
	Base Temperature (T_B)		
	60.0	15.0	20.0
Base CTS_{60}	1.000 000 000	1.000 018 600	0.999 851 207
Base CTS_{15}	0.999 981 400	1.000 000 000	0.999 832 609
Base CTS_{20}	1.000 148 807	1.000 167 409	1.000 000 000

Base Unit Volume

BPV_{60}	30,030.795 3	cubic inches at 60.0 °F, 0.0 psig
BPV_{15}	492,107.411	mL at 15.0 °C and 0.0 kPag
BPV_{20}	492,189.795	mL at 20.0 °C and 0.0 kPag

Figure 12 – Expanded Discrimination of Master Prover's BPV

Step 1 **Average CPV_{SET} = [$\sum^3$ (CPV_{SET})] / 3** **0.000 000 000 0** Bbls or M^3 rounded to 9 digits

Detector Design,

CTS = [1 + (T_P - T_B) x GL_P]^3, for detectors mounted in calibrated section

CTS = [1 + (T_P - T_B) x GL_P]^2 x [1 + (T_D - T_B) x GL_d], for detectors mounted on external shaft

All CTS values are rounded to nine (9) decimal places.

Step 2

If Average CPV_{SET} is in Bbls and T_B is 60.0 °F, Proceed to Step 2A.
If Average CPV_{SET} is in M^3 and T_B is 15.0 °C, Proceed to Step 2B.
If Average CPV_{SET} is in M^3 and T_B is 20.0 °C, Proceed to Step 2C.

Step 2A **If Average CPV_{SET} is in Bbls and T_B is 60.0 °F**

BPV_{60} = ROUND(Average CPV_{SET} x 9,702 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(Average CPV_{SET} x 9,702 x 16.387 064 x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(Average CPV_{SET} x 9,702 x 16.387 064 x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

Step 2B **If Average CPV_{SET} is in M^3 and T_B is 15.0 °C**

BPV_{60} = ROUND(Average CPV_{SET} x 1.0E+06 / 16.387 064 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(Average CPV_{SET} x 1.0E+06 x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(Average CPV_{SET} x 1.0E+06 x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

Step 2C **If Average CPV_{SET} is in M^3 and T_B is 20.0 °C**

BPV_{60} = ROUND(Average CPV_{SET} x 1.0E+06 / 16.387 064 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(Average CPV_{SET} x 1.0E+06 x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(Average CPV_{SET} x 1.0E+06 x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

Step 3 **Convert BPV values (in^3, mL) using following equations and round the results to six (6) significant digits.**

BPV_{60}
Bbl = (in^3 at 60.0 °F and 0.0 psig) / 9.702E+03
U.S. Gallons = (in^3 at 60.0 °F and 0.0 psig) / 2.31E+02
Cubic Feet = (in^3 at 60.0 °F and 0.0 psig) / 1.728E+03

BPV_{15}
M^3 = (mL at 15.0 °C and 0.0 kPag) x 1E-06
L = (mL at 15.0 °C and 0.0 kPag) x 1E-03

BPV_{20}
M^3 = (mL at 20.0 °C and 0.0 kPag) x 1E-06
L = (mL at 20.0 °C and 0.0 kPag) x 1E-03

Example **Average CPV_{SET}** **11.903 072 600 0** Bbls at 60 degF rounded to 9 digits

BPV_{60}	115,483.610 4	in^3 at 60.0 °F and 0.0 psig	4 decimal places per Ch 12.4
BPV_{15}	1,892,402.115	mL at 15.0 °C and 0.0 kPag	3 decimal places per Ch 12.4
BPV_{20}	1,892,718.922	mL at 20.0 °C and 0.0 kPag	3 decimal places per Ch 12.4

Decimal Places	Base Prover Volume (BPV)						
	BPV_{60}			BPV_{15}		BPV_{20}	
	Barrels	U.S. Gallons	Cubic Feet	Liters	Cubic Meters	Liters	Cubic Meters
1	-	-	-	-	-	-	-
2	-	-	-	-	1,892.40	-	1,892.72
3	-	499.929	-	-	-	-	-
4	11.903 1	-	66.830 8	-	-	-	-
5	-	-	-	1.892 40	-	1.892 72	-
6	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-

Note: The BPV Volumes shown above are specified based on 6 significant digits (10 ppm, or, 0.001%).

Figure 13 - Conversion of Average CPV_{SET} to BPV

20. Examples[1]

Four (4) examples using the Standard Method for displacement provers have been prepared to clarify the process: two (2) in SI Units (see Annex A) and two (2) in USC units (see Annex B).

The presented examples depict the required proper calculations and documentation.

		Transfer Standard													
Units		Sampling		Master Prover			Master Meter		MF (r %)		MF Method		Field Prover		
SI	USC	Online	Spot	Bidi Free	Uni Free	Uni Captive	Turbine	PD	Moving Range	Fixed Range	IMF	Avg Data	Bidi Free	Uni Free	Uni Captive
x	-	x	-	x	-	-	-	x	x	-	x	-	x	-	-
x	-	-	x	-	-	x	x	-	-	x	x	-	-	-	x
-	x	x	-	-	-	x	x	-	x	-	x	-	x	-	-
-	x	-	x	x	-	-	-	x	-	x	x	-	-	-	x

From API Chapter 12.2 Section 12.2.1, page 24, wrt Proving Reports -
"Historically, the Average Data Method has been used since it only requires a single calculation at the end to determine the Meter Factor. ***The Intermediate Factor Method (IMF) is the preferred method*** as variations in temperature and pressure are accounted for in the evaluation of the proving results."

Four (4) BPV Examples for Displacement Prover

1 SI Units, Continuous Sampling, Master Prover - Bidirectional Free Displacer, Master Meter - PD, MF r% - Fixed Range, MF Method - IMF, Field Prover - Bidirectional Free Displacer
2 SI Units, Spot Sampling, Master Prover - Unidirectional Captive Displacer, Master Meter - Turbine, MF r% - Moving Range, MF Method - IMF, Field Prover - Unidirectional Captive Displacer

3 USC Units, Continuous Sampling, Master Prover - Bidirectional Free Displacer, Master Meter - PD, MF r% - Fixed Range, MF Method - IMF, Field Prover - Bidirectional Free Displacer
4 USC Units, Spot Sampling, Master Prover - Unidirectional Captive Displacer, Master Meter - Turbine, MF r% - Moving Range, MF Method - IMF, Field Prover - Unidirectional Captive Displacer

Figure 14 – Standard Method Examples

Examples have not been presented using Alternate Method "A", Alternate Method "B", or when using an Open Tank Prover as a Master Prover.

[1] The following examples are for illustration purposes only. Each company should develop its own approach. They are not to be considered exclusive or exhaustive in nature. API makes no warranties, express or implied, for reliance on or any omissions from the information contained in this document.

Annex A
(informative)
SI Unit Examples[2]

Example A.1 – Standard Method

SI Units, Continuous Sampling, Master Prover - Bidirectional Free Displacer, Master Meter - PD, MF r% - Fixed Range, MF Method - IMF, Field Prover - Bidirectional Free Displacer

[2] The following examples are for illustration purposes only. Each company should develop its own approach. They are not to be considered exclusive or exhaustive in nature. API makes no warranties, express or implied, for reliance on or any omissions from the information contained in this document.

	Master Prover	
Measurement Units	1	(0-USC_{60}, 1-SI_{15}, 2-SI_{20})
Detector Design	0	(0-Internal, 1-External)
Wall Material	1	(1-CS, 2-304SS, 3-316SS, 4-17-4PH)
Rod Material	0	(0-NA, 1-CS, 2-304SS, 3-316SS, 4-17-4PH, 5-Invar)
Certificate BPV	492,107.411 0	mL at 15.0 °C and 0.0 kPag

	Base Prover Volume (BPV)		
	BPV_{60} Barrels	**BPV_{15} Cubic Meters**	**BPV_{20} Cubic Meters**
	3. 095 320 068 027	0. 492 107 411 000	0. 492 189 794 000
Decimals	9	10	10
Conversion	in^3 / Bbl 9.702E+03	mL / M^3 1.00E+06	mL / M^3 1.00E+06
Rnd'd BPV	3.095 320 068 000	0.492 107 411 000	0.492 189 794 000

in^3 = mL / 16.387 064
U.S. Gallons = in^3 / 2.31E+02
Bbl = in^3 / 9.702E+03
Cubic Feet = in^3 / 1.728E+03

mL = M^3 x 1E+06
mL = in^3 x 16.387 064

M^3 = mL x 1E-06
L = mL x 1E-03

Note: This Worksheet produces a BPV_{60} or BPV_{SI} to **10 digits** (the appropriate decimal place) to increase the precision of the Master Prover's BPV, not the uncertainty of the Master Prover's BPV.

T_B	15.0	°C
Decimal Base CTS	9	-
Decimal BPV_{60}	4	cubic inches at 60.0 °F, 0.0 psig
Decimal BPV_{SI}	3	mL at 15.0 °C and 0.0 kPag
Decimal BPV	10	Cubic Meters

Detector Design,

$CTS_P = [1 + (T_P - T_B) \times GL_P]^3$, for detectors mounted in calibrated section

$CTS_P = [1 + (T_P - T_B) \times GL_P]^2 \times [1 + (T_D - T_B) \times GL_d]$, for detectors mounted on external shaft

If Measurement Units = 0, then BPV in cubic inches, T_B is 60.0 °F

BPV_{60} = cubic inches at 60.0 °F, 0.0 psig

BPV_{15} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag

BPV_{20} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 1, then BPV in mL, T_B is 15.0 °C

BPV_{60} = ROUND(BPV_{15} / 16.387 064 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig

BPV_{15} = mL at 15.0 °C, 0.0 kPag

BPV_{20} = ROUND(BPV_{15} x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 2, then BPV in mL, T_B is 20.0 °C

BPV_{60} = ROUND(BPV_{20} / 16.387 064 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig

BPV_{15} = ROUND(CPV_{20} x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag

BPV_{20} = mL at 20.0 °C, 0.0 kPag

API Properties

Linear Coefficient of Thermal Expansion, GL

	SI Unit[2,4] (per °C)	**USC Unit[2,3,5]** (per °F)
Mild Carbon	0.000 011 16	**0.000 006 20**
304 SS	**0.000 017 28**	0.000 009 60
316 SS	**0.000 016 02**	0.000 008 90
17-4PH	0.000 010 80	**0.000 006 00**
Invar™	0.000 001 44	**0.000 000 80**

Notes:

(1) The User/Owner should obtain GL values from the prover manufacturer.

(2) The GL values shown above are a function of the materials, operating temperature range, calibration temperature range. Values in **bold face** were obtained from American Society of Metals (ASM) International, 2020 edition.

(3) GL values shown above are applicable from 0 °C to 100 °C (32 °F to 212 °F). If operating outside this range, the GL values depicted are not appropriate.

(4) The SI values of GL per °C **not in bold face**, was obtained by multiplying the USC values, GL per °F, times 1.8.

(5) The USC values per °F **not in bold face**, was obtained by dividing the SI values, GL per °C, by 1.8.

T_B	60.0 °F	15.0 °C	20.0 °C
GL_P	0.000 006 20	0.000 011 16	0.000 011 16
GL_D	NA	NA	NA
Base CTS_{60}	1.000 000 000	1.000 018 600	0.999 851 207
Base CTS_{15}	0.999 981 400	1.000 000 000	0.999 832 609
Base CTS_{20}	1.000 148 807	1.000 167 409	1.000 000 000

Base Unit Volume

BPV_{60}	30,030.795 3	cubic inches at 60.0 °F, 0.0 psig
BPV_{15}	492,107.411	mL at 15.0 °C and 0.0 kPag
BPV_{20}	492,189.794	mL at 20.0 °C and 0.0 kPag

Example A.1 - Expanded Discrimination of Master Prover's BPV

Washington, D.C., USA

Master Meter Proving Report

General Data

Operator	API Midstream	-
Station Name	MPMS	-
Ch 11.1	Tables 5B/6B	-
T_B	15.0	°C
P_B	0.0	kPag

Master Meter

Flowmeter ID	200	-
Manufacturer	PD	-
Model	0	-
Nominal Size	100	mm
Type	PD	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	52,834.410 5	P / M3
Cartridge No.	API-0011	-

Density Method

Sample Method	Continuous	-
ρ_{obs} Device	Densitometer	-
DMF	0.999 8	-
HYC Factor	NA	-

Displacement Prover

Manufacturer	API	-
Prover Type	Displacement	-
Flow Design	Bidirectional	-
Wall Design	Single	-
Detector	Internal	-
Displacer	Free Sphere	-
Wall Material	Carbon Steel	-
Rod Material	NA	-
GL_P	0.000 011 16	per °C
GL_D	NA	per °C
E_P	206 842 710	per kPag
ID_P	202.717 4	mm
WT_P	8.178 8	mm
Calibration Date	2021-09-04	-
Serial No.	8904-01	-
Certificate No.	10101010	-
Switches	9201 to 9202	-
BPV	0.492 107 411 0	M3

Spot Sample

API_{ind}		°API
ρ_{ind}		kg/m³
T_{obs}		°C
P_{obs}	NA	kPag

Report Summary

	Start	Stop	
Report No.	Start I	Stop I	-
Date	14-Feb-24	14-Feb-24	-
Time	8:21:18	11:21:18	-
Totalizer	2,342,501.020	2,343,601.020	M3
Fluid, Batch No.	Products	Products	-
API_{60}	60.8	60.6	°API
ρ_{60}	735.210	735.710	kg/m³
API_{15}	60.7	60.5	°API
ρ_{15}	735.715	736.216	kg/m³
API_{20}	61.7	61.5	°API
ρ_{20}	731.158	731.660	kg/m³
Flowrate, Q	111.350	111.350	MPH
T_{P_AVG}	22.830	22.829	°C
P_{P_AVG}	1176.0	1210.0	kPag
Trips per Run	1	1	-
Roundtrips	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.018	0.017	%
Allowable (r)	0.020	0.020	%
(r) Pass/Fail	Pass	Pass	-
MMF	0.999 900 0	0.999 904 0	-
ΔMMF	NA	0.000	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-

Prior vs Current

ΔQ	0.0	%
ΔT_P	(0.001)	°C

API MPMS Chapter 12.4.2
Measurement Units - SI_15
Sampling Method - Continuous (or Online)
Meter Factor Method - Intermediate (or IMF)
Repeatability Method (r%) - Fixed, 5 out of 5 Runs
API MPMS Chapter 11.1 - Tables 5B/6B

Base Density	Roundtrip Measurements							Base Density	
API_B °API	ρ_{ind} kg/m³	T_{dm} °C	P_{dm} kPag	T_{P_INLET} °C	T_{P_OUTLET} °C	T_M °C	T_D °C	ρ_B kg/m³	Run
60.6	729.543	23.244	1,273.0	22.817	22.889	22.994		735.817	1
60.5	729.745	23.739	1,275.0	22.806	22.844	22.983		736.465	2
60.5	729.543	23.761	1,284.0	22.822	22.856	23.000		736.276	3
60.5	729.545	23.750	1,281.0	22.811	22.817	22.972		736.270	4
60.5	729.512	23.767	1,281.0	22.806	22.828	22.922		736.252	5
NA									6
NA									7
NA									8
NA									9
NA									10
60.5	729.578	23.652	1,279.0	NA	NA	22.974	NA	736.216	Runs 1-5

Commodity Type	Roundtrip Measurements					T_P and P_P Values		
	N or N_i Pulses	Q_M MPH	P_{P_INLET} kPag	P_{P_OUTLET} kPag	P_M kPag	T_{P_RUN} °C	P_{P_RUN} kPag	Run
Gasoline, Napthene	26,020.000	111.308 6	1,227.0	1,194.0	1,196.0	22.853 0	1,210.50	1
Gasoline, Napthene	26,016.000	111.310 2	1,229.0	1,192.0	1,196.0	22.825 0	1,210.50	2
Gasoline, Napthene	26,018.000	111.330 9	1,222.0	1,196.0	1,193.0	22.839 0	1,209.00	3
Gasoline, Napthene	26,020.000	111.453 3	1,225.0	1,198.0	1,196.0	22.814 0	1,211.50	4
Gasoline, Napthene	26,018.000	111.329 3	1,222.0	1,193.0	1,198.0	22.817 0	1,207.50	5
NA								6
NA								7
NA								8
NA								9
NA								10
Runs 1-5	26,018.400 0	111.350 0	NA	NA	1,196.0	22.829 0	1,210.03	Runs 1-5

Example A.1 - Calibration Set I - Stop Proving Report - 1 of 2

Washington, D.C., USA

Master Meter Proving Report

API MPMS Chapter 12.4.2
Measurement Units - SI_15
Sampling Method - Continuous (or Online)
Meter Factor Method - Intermediate (or IMF)
Repeatability Method (r%) - Fixed, 5 out of 5 Runs
API MPMS Chapter 11.1 - Tables 5B/6B

Report Summary

	Prior	*Current*
Report No.	Start I	Stop I
Date	14-Feb-24	14-Feb-24
Time	08:21:18	11:21:18
Fluid, Batch No.	Products	Products

Run	BPV M3	CTS_P	CPS_P	Rnd CTL_P	Rnd CPL_P	Rnd $CTPL_P$	GSV_P M3	Run
1	0.492 107 411 0	1.000 262 941	1.000 145 053	0.990 262 343	1.001 436 834	0.991 685 185	0.488 214 755 3	1
2	0.492 107 411 0	1.000 262 004	1.000 145 053	0.990 309 872	1.001 432 007	0.991 728 002	0.488 235 377 1	2
3	0.492 107 411 0	1.000 262 473	1.000 144 873	0.990 288 827	1.001 431 681	0.991 706 605	0.488 224 983 8	3
4	0.492 107 411 0	1.000 261 636	1.000 145 173	0.990 319 771	1.001 434 377	0.991 740 264	0.488 241 291 9	4
5	0.492 107 411 0	1.000 261 736	1.000 144 693	0.990 315 273	1.001 429 798	0.991 731 224	0.488 236 656 3	5
6								6
7								7
8								8
9								9
10								10
Runs 1-5	0.492 107 411 0	1.000 262 158	1.000 144 969	0.990 299 217	1.001 432 939	0.991 718 256	0.488 230 612 9	Runs 1-5

Run	N or N_i	NKF P / M3	IV_M	Rnd CTL_M	Rnd CPL_M	Rnd $CTPL_M$	ISV_M M3	Run
1	26,020.000	52,834.410 5	0.492 482 072 8	0.990 086 861	1.001 421 227	0.991 494 000	0.488 293 019 9	1
2	26,016.000	52,834.410 5	0.492 406 364 6	0.990 113 931	1.001 416 638	0.991 516 564	0.488 229 066 7	2
3	26,018.000	52,834.410 5	0.492 444 218 7	0.990 088 666	1.001 414 532	0.991 489 178	0.488 253 113 7	3
4	26,020.000	52,834.410 5	0.492 482 072 8	0.990 123 062	1.001 417 858	0.991 526 916	0.488 309 230 8	4
5	26,018.000	52,834.410 5	0.492 444 218 7	0.990 184 822	1.001 419 787	0.991 590 673	0.488 303 094 5	5
6								6
7								7
8								8
9								9
10								10
Runs 1-5	26,018.400 0	52,834.410 5	0.492 451 789 5	0.990 119 468	1.001 418 008	0.991 523 466	0.488 277 505 1	Runs 1-5

Run	'1' indicates Repeatability (r%) criteria satisifed	Repeatability (r%) Actual	Repeatability (r%) Allowable
NA		NA	NA
NA		NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
Runs 1-5	1	0.017	0.020
Runs 2-6			0.020
Runs 3-7			0.020
Runs 4-8			0.020
Runs 5-9			0.020
Runs 6-10			0.020
	Pass	0.017	

Meter Factor Method - Intermediate (or IMF)

Repeatability Method (r%) - Fixed, 5 out of 5 Runs

IMF	Run
0.999 839 72	1
1.000 012 93	2
0.999 942 39	3
0.999 860 87	4
0.999 863 94	5
	6
	7
	8
	9
	10
0.999 904 00	MMF

MMF Rounded to 7 decimal places

		API Midstream Representative

Example A.1 - Calibration Set I - Stop Proving Report - 2 of 2

	Field Prover	
Measurement Units	1	(0-USC_{60}, 1-SI_{15}, 2-SI_{20})
Detector Design	0	(0-Internal, 1-External)
Wall Material	1	(1-CS, 2-304SS, 3-316SS, 4-17-4PH)
Rod Material	0	(0-NA, 1-CS, 2-304SS, 3-316SS, 4-17-4PH, 5-Invar)
Source for GL_{MP}, GL_{md}, E_{MP}	1	(0-Prover Manufacturer, 1-API Table)
BPV_P	1,892,370.578 0	mL at 15.0 °C and 0.0 kPag

	Base Prover Volume (BPV)		
	BPV_{60} Barrels	**BPV_{15} Cubic Meters**	**BPV_{20} Cubic Meters**
	11. 902 874 232 117	1. 892 370 578 000	1. 892 687 378 000
Decimals	4	5	5
Conversion	in^3 / Bbl 9.702E+03	mL / M^3 1.00E+06	mL / M^3 1.00E+06
Rnd'd BPV	11.902 900 000 000	1.892 370 000 000	1.892 690 000 000

in^3 = mL / 16.387 064
U.S. Gallons = in^3 / 2.31E+02
Bbl = in^3 / 9.702E+03
Cubic Feet = in^3 / 1.728E+03

mL = M^3 x 1E+06
mL = in^3 x 16.387 064

M^3 = mL x 1E-06
L = mL x 1E-03

Note: This Worksheet produces a BPV_{60} or BPV_{SI} to **6 digits** (the appropriate decimal place).

T_B	15.0	°C
Decimal Base CTS	9	-
Decimal BPV_{60}	4	cubic inches at 60.0 °F, 0.0 psig
Decimal BPV_{SI}	3	mL at 15.0 °C and 0.0 kPag
Decimal BPV	5	Cubic Meters
Decimal BPV	4	Barrels

Detector Design,

$CTS_P = [1 + (T_P - T_B) \times GL_P]^3$, for detectors mounted in calibrated section

$CTS_P = [1 + (T_P - T_B) \times GL_P]^2 \times [1 + (T_D - T_B) \times GL_d]$, for detectors mounted on external shaft

If Measurement Units = 0, then BPV in cubic inches, T_B is 60.0 °F

BPV_{60} = cubic inches at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{15}, 12) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{20}, 12) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 1, then BPV in mL, T_B is 15.0 °C

BPV_{60} = ROUND(BPV_{15} / 16.387 064 x Base CTS_{60}, 12) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(BPV_{15} x Base CTS_{20}, 12) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 2, then BPV in mL, T_B is 20.0 °C

BPV_{60} = ROUND(BPV_{20} / 16.387 064 x Base CTS_{60}, 12) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(CPV_{20} x Base CTS_{15}, 12) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = mL at 20.0 °C, 0.0 kPag

GL_P	0.000 006 20	0.000 011 16	0.000 011 16
GL_D	NA	NA	NA
T_B	60.0	15.0	20.0
Base CTS_{60}	1.000 000 000	1.000 018 600	0.999 851 207
Base CTS_{15}	0.999 981 400	1.000 000 000	0.999 832 609
Base CTS_{20}	1.000 148 807	1.000 167 409	1.000 000 000

API Properties

Linear Coefficient of Thermal Expansion, GL

	SI Unit[2,4] (per °C)	**USC Unit[2,3,5]** (per °F)
Mild Carbon	0.000 011 16	**0.000 006 20**
304 SS	**0.000 017 28**	0.000 009 60
316 SS	**0.000 016 02**	0.000 008 90
17-4PH	0.000 010 80	**0.000 006 00**
Invar™	0.000 001 44	**0.000 000 80**

Notes:

(1) The User/Owner should obtain GL values from the prover manufacturer.

(2) The GL values shown above are a function of the materials, operating temperature range, calibration temperature range. Values in **bold face** were obtained from American Society of Metals (ASM) International, 2020 edition.

(3) GL values shown above are applicable from 0 °C to 100 °C (32 °F to 212 °F). If operating outside this range, the GL values depicted are not appropriate.

(4) The SI values of GL per °C **not in bold face**, was obtained by multiplying the USC values, GL per °F, times 1.8.

(5) The USC values per °F **not in bold face**, was obtained by dividing the SI values, GL per °C, by 1.8.

Base Unit Volume

BPV_{60}	115,481.685 8	cubic inches at 60.0 °F, 0.0 psig
BPV_{15}	1,892,370.578	mL at 15.0 °C and 0.0 kPag
BPV_{20}	1,892,687.378	mL at 20.0 °C and 0.0 kPag

Example A.1 - Field Prover's BPV Conversion

Washington, D.C., USA

BPV Determination using a Master Meter - Standard Method

General Data		Master Meter			Field Prover		
API Midstream	Operator	Flowmeter ID	200	-	Manufacturer	API	-
Headquarters	Station Name	Manufacturer	API	-	Prover Design	Displacement	-
Washington	City, Town	Model	API-PD	-	Flow Design	Bidirectional	-
D.C.	State, Province	Nominal Size	100	mm	Wall Design	Single	-
USA	Country	Type	PD	-	Detector	Internal	-
RBOB	Fluid, Batch No.	Proving Result	MMF	-	Displacer	Free Sphere	-
Products	Ch 11.1	T_F Comp	No	-	Wall Material	Carbon Steel	-
15.0	T_B	P_F Comp	No	-	Rod Material	NA	-
0.0	P_B	NKF	52,834.410 5	P / M3	GL_P	0.000 011 16	per °C
14-Feb-2024	Start Calibration	Cartridge No.	API-0011	-	GL_D	NA	per °C
14-Feb-2024	Stop Calibration	**Density Method**			E_P	206 842 710	per kPag
API Chapter 12.4.2		ρ_{obs} Method	Continuous	-	ID_P	547.675 0	mm
SI_15 Measurement Units		ρ_{obs} Device	Online Density	-	WT_P	30.963 0	mm
Sampling Method - Continuous		DMF	0.999 8	-	Trips per Run	1	-
BPV - Standard Method		HYC Factor	No	-	Serial No.	Bidi-SI-001	-
Fixed Range Method, r ≤ 0.02%, for 3 consecutive Calibration Sets					Switches	9206 to 9236	-
Refined Product - Tables 5B/6B							

	Calibration Set I		Calibration Set II		Calibration Set III		
	Start	**Stop**	**Start**	**Stop**	**Start**	**Stop**	
Report No.	Start 1	Stop 1	Start 2	Stop 2	Start 3	Stop 3	-
Date	14-Feb-24	14-Feb-24	14-Feb-24	14-Feb-24	14-Feb-24	14-Feb-24	-
Products	Products	Products	84RBOB	84RBOB	Products	Products	-
API_B	60.7	60.5	60.9	60.9	60.7	60.5	°API
ρ_B	735.715	736.216	734.963	734.924	735.715	736.216	kg/m^3
Q_{MM}	111.347	111.347	83.332	83.434	140.250	140.222	MPH
T_{MP_AVG}	22.828	21.163	21.506	21.517	22.833	22.911	°C
P_{MP_AVG}	1,176.2	1,209.3	1,303.8	1,306.6	1,294.1	1,298.3	kPag
Roundtrips	Runs 1-5	Runs 1-5	Runs 1-5	Runs 1-5	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.018	0.017	0.011	0.008	0.018	0.017	%
MMF	0.999 900 0	0.999 904 1	0.999 974 0	0.999 999 0	1.000 099 0	1.000 154 0	-
MMF_{SET}	NA	0.999 902 1	NA	0.999 986 5	NA	1.000 126 5	-
ΔMMF	NA	0.000	NA	0.003	NA	0.006	%
	ΔMMF_{SET}	**Pass**		**Pass**		**Pass**	
	(r) CPV_{RUN}	**Pass**	-	**Pass**	-	**Pass**	-
	(R) CPV_{SET}	NA	-	**Pass**	-	**Pass**	-
	ΔQ_{SET}	NA	-	**Pass**	-	**Pass**	-
	Selected Set	**Runs 4-6**	-	**Runs 1-3**	-	**Runs 1-3**	-
	CPV_{SET}	**1.892 503 6**	M3	**1.892 305 3**	M3	**1.892 397 2**	M3
	API_{B_SET}	60.6	°API	61.0	°API	60.6	°API
	ρ_{B_SET}	735.962	kg/m^3	734.522	kg/m^3	735.889	kg/m^3
	T_{FP_SET}	22.820	°C	21.442	°C	22.839	°C
	P_{FP_SET}	1,212.0	kPag	1,280.0	kPag	1,208.0	kPag
	Q_{MM_SET}	111.456	MPH	83.332	MPH	140.247	MPH
CPV_{SET} Stability Parameters	ΔMMF_{SET}	0.000	%	0.003	%	0.006	%
	$\Delta\rho_{B\_SET}$	0.073	kg/m^3	0.292	kg/m^3	0.278	kg/m^3
	ΔT_{P_SET}	0.005	°C	0.028	°C	0.028	°C
	ΔP_{P_SET}	2.0	kPag	7.0	kPag	3.0	kPag
	ΔQ_{MM_SET}	0.0	%	0.0	%	0.0	%
	$\Delta Q_{between\ SETS}$	NA	%	(25.2)	%	40.6	%
	(r) CPV_{RUN}	0.004	%	0.015	%	0.005	%
	(R) CPV_{SET}	NA	%	0.011	%	0.005	%

Example A.1 - Calibration Report Summary - 1 of 2

Washington, D.C., USA

BPV Determination using a Master Meter - Standard Method

General Data

API Midstream	Operator
Headquarters	Station Name
Washington	City, Town
D.C.	State, Province
USA	Country
RBOB	Fluid, Batch No.
Products	Ch 11.1
15.0	T_B
0.0	P_B
14-Feb-2024	Start Calibration
14-Feb-2024	Stop Calibration

API Chapter 12.4.2
SI_15 Measurement Units
Sampling Method - Continuous
BPV - Standard Method
Fixed Range Method, r ≤ 0.02 %, for 3 consecutive Calibration Sets
Refined Product - Tables 5B/6B

Field Prover

Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Bidirectional	-
Wall Design	Single	-
Detector	Internal	-
Displacer	Free Sphere	-
Wall Material	Carbon Steel	-
Rod Material	NA	-
GL_P	0.000 011 16	per °C
GL_D	NA	per °C
E_P	206 842 710	per kPag
ID_P	547.675 0	mm
WT_P	30.963 0	mm
Serial No.	Bidi-SI-001	-
Switches	9206 to 9236	-

BPV_{NEW}	1.892 400 0	M3
BPV_{OLD}	1.892 370 0	M3
ΔBPV	0.000 030 0	M3
ΔBPV	0.001 6	% BPV_{NEW} Bigger / (Smaller)
Average CPV_{SET}	1.892 402 020	M3
BPV_{60}	115,483.604 6	in^3 at 60.0 °F and 0.0 psig
BPV_{15}	1,892,402.020	mL at 15.0 °C and 0.0 kPag
BPV_{20}	1,892,718.825	mL at 20.0 °C and 0.0 kPag

Base Prover Volume (BPV_{NEW})

BPV_{60}			BPV_{15}		BPV_{20}	
Barrels	**U.S. Gallons**	**Cubic Feet**	**Cubic Meters**	**Liters**	**Cubic Meters**	**Liters**
-	-	-	-	-	-	-
-	-	-	-	1,892.40	-	1,892.72
-	499.929	-	-	-	-	-
11.903 1	-	66.830 8	-	-	-	-
-	-	-	1.892 40	-	1.892 72	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

Note: The BPV_{NEW} values (BPV_{60}, BPV_{15}, BPV_{20}) shown are reported to 6 significant digits (10 ppm, or, 0.001%).

Signature	Date	Company
		API Midstream Representative

Example A.1 - Calibration Report Summary - 2 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set I

General Data

Operator	API Midstream	
Station Name	Headquarters	
Fluid or Batch	RBOB	-
Ch 11.1	Products	-
T_B	15.0	°C
P_B	0.0	kPag

Master Meter

Flowmeter ID	200	-
Manufacturer	API	-
Model	API-PD	-
Nominal Size	100	mm
Type	PD	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	52,834.410 5	P / M3
Cartridge No.	API-0011	-

Density Method

ρ_{obs} Method	Continuous	-
ρ_{obs} Device	Online Density	-
DMF	0.999 8	-
HYC Factor	No	-

API Chapter 12.4.2
SI_15 Measurement Units
Sampling Method - Continuous
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Refined Product - Tables 5B/6B

Field Prover

Prover Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Bidirectional	-
Wall Design	Single	-
Detector	Internal	-
Displacer	Free Sphere	-
Wall Material	300 SS	-
Rod Material	NA	-
GL_P	0.000 011 16	per °C
GL_D	NA	per °C
E_P	206 842 710	per kPag
ID_P	547.675 0	mm
WT_P	30.963 0	mm
Serial No.	Bidi-SI-001	-
Switches	9206 to 9236	-

Calibration Set Criteria

ΔMMF_{SET}	≤ 0.02	%
(r) $ICPV_{RUN}$	≤ 0.02	%
(r) CPV_{RUN}	≤ 0.02	%

Spot Sample

ρ_{60_START}	NA	kg/m³
ρ_{60_STOP}	NA	kg/m³
ρ_{60_SET}	NA	kg/m³
MMF_{SET}	0.999 902 1	-

Report Summary

	Start	Stop	
Report No.	Start 1	Stop 1	-
Date	14-Feb-24	14-Feb-24	-
Time	8:21:18 AM	11:21:18 AM	-
Totalizer	2,342,501.020	2,343,601.020	M3
Fluid, Batch No.	Products	Products	-
API_{60}	60.8	60.6	°API
ρ_{60}	735.210	735.710	kg/m3
API_{15}	60.7	60.5	°API
ρ_{15}	735.715	736.216	kg/m3
API_{20}	61.7	61.5	°API
ρ_{20}	731.158	731.660	kg/m3
Flowrate, Q_{av}	111.347	111.347	MPH
T_{MP_AVG}	22.828	21.163	°C
P_{MP_AVG}	1176.2	1209.3	kPag
Trips per Run	1	1	-
Roundtrips	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.018	0.017	%
Allowable (r)	0.020	0.020	%
(r) Pass/Fail	Pass	Pass	-
MMF	0.999 900 0	0.999 904 1	-
ΔMMF	NA	0.000	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-

Prior vs Current

ΔQ_{av}	0.02	%
ΔT_P	0.036	°C

Roundtrip Measurements							Base Density	
ρ_{obs} kg/m³	T_{dm} °C	P_{dm} kPag	T_{P_INLET} °C	T_{P_OUTLET} °C	T_M °C	T_D °C	ρ_B kg/m³	Run
729.748	22.906	1,203.0	22.817	22.889	22.994		735.921	1
729.843	22.906	1,208.0	22.806	22.844	22.994		736.011	2
729.545	22.928	1,208.0	22.822	22.856	23.000		735.734	3
729.748	22.911	1,210.0	22.817	22.817	23.000		735.919	4
729.799	22.911	1,205.0	22.811	22.828	23.056		735.975	5
729.823	22.906	1,207.0	22.811	22.833	23.011		735.992	6
729.751	22.911	1,207.0	22.814	22.845	23.009		735.925	Avg

Ch 11.1 Iteration Results	Roundtrip Measurements							
	N or N_i Pulses	Q_M MPH	P_{P_INLET} kPag	P_{P_OUTLET} kPag	P_M kPag	T_{P_RUN} °C	P_{P_RUN} kPag	Run
Gasoline, Napthene	100,015.000	111.468	1,214.0	1,198.0	1,278.0	22.853 0	1,206.00	1
Gasoline, Napthene	100,001.000	111.447	1,218.0	1,200.0	1,282.0	22.825 0	1,209.00	2
Gasoline, Napthene	100,022.000	111.449	1,215.0	1,200.0	1,285.0	22.839 0	1,207.50	3
Gasoline, Napthene	100,051.000	111.452	1,219.0	1,202.0	1,285.0	22.817 0	1,210.50	4
Gasoline, Napthene	100,054.000	111.450	1,220.0	1,204.0	1,287.0	22.819 5	1,212.00	5
Gasoline, Napthene	100,052.000	111.466	1,220.0	1,205.0	1,279.0	22.822 0	1,212.50	6
	100,032.500 0	111.456	1,218.0	1,202.0	1,283.0	22.829 0	1,210.00	Avg

Example A.1 - Calibration Set I - 1 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set I

API Chapter 12.4.2
SI_15 Measurement Units
Sampling Method - Continuous
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Refined Product - Tables 5B/6B

ΔMMF_{SET}	Pass	-
(r) $ICPV_{RUN}$	Pass	-
(r) CPV_{RUN}	Pass	-

Report Summary

	Prior	*Current*
Report No.	Start	Stop
Date	14-Feb-24	14-Feb-24
Time	08:21:18	11:21:18
Fluid, Batch No.	Products	Products

N or N_i Pulses	NKF P / M3	IV_M	CTL_M	CPL_M	$CTPL_M$	GSV_M M3	Run
100,015.000	52,834.410 5	1.892 989 8	0.990 088 855	1.001 518 008	0.991 591 818	1.876 889 430	1
100,001.000	52,834.410 5	1.892 724 8	0.990 090 711	1.001 522 097	0.991 597 725	1.876 637 860	2
100,022.000	52,834.410 5	1.893 122 3	0.990 077 557	1.001 527 798	0.991 590 195	1.877 017 730	3
100,051.000	52,834.410 5	1.893 671 2	0.990 081 364	1.001 526 420	0.991 592 644	1.877 566 600	4
100,054.000	52,834.410 5	1.893 728 0	0.990 012 875	1.001 529 073	0.991 526 678	1.877 498 010	5
100,052.000	52,834.410 5	1.893 690 1	0.990 069 185	1.001 518 877	0.991 572 979	1.877 548 100	6
100,032.500 0	52,834.410 5	1.893 321 0	0.990 070 091	1.001 523 712	0.991 578 673	1.877 192 960	Avg

Iteraton Results	CTS_P	CPS_P	CTL_P	CPL_P	$CTPL_P$	CPV_run M3	Run
Gasoline, Napthene	1.000 262 941	1.000 103 130	0.990 264 161	1.001 430 750	0.991 680 981	1.891 941 650	1
Gasoline, Napthene	1.000 262 004	1.000 103 387	0.990 300 787	1.001 433 363	0.991 720 247	1.891 614 450	2
Gasoline, Napthene	1.000 262 473	1.000 103 259	0.990 277 805	1.001 433 674	0.991 697 540	1.892 040 030	3
Gasoline, Napthene	1.000 261 736	1.000 103 515	0.990 308 886	1.001 435 693	0.991 730 666	1.892 530 990	4
Gasoline, Napthene	1.000 261 820	1.000 103 644	0.990 306 886	1.001 437 118	0.991 730 074	1.892 462 580	5
Gasoline, Napthene	1.000 261 903	1.000 103 686	0.990 304 133	1.001 437 617	0.991 727 811	1.892 517 150	6
	1.000 262 146	1.000 103 437	0.990 293 776	1.001 434 703	0.991 714 553	1.892 184 480	Avg

1 means ΔCPV Passed	$\Delta\rho_{B\_SET}$ kg/m³	ΔT_{P_SET} °C	ΔP_{P_SET} kPag	ΔQ_{M_SET} %	r% CPV	CPV_set	CPV_set M3	
	0.278	0.028	3.00	0.0	0.022	-	1.891 865 380	Runs 1-3
	0.278	0.022	3.00	0.0	0.048	-	1.892 061 820	Runs 2-4
	0.241	0.022	4.50	0.0	0.026	-	1.892 344 530	Runs 3-5
1	0.073	0.005	2.00	0.0	0.004	Pass	1.892 503 570	Runs 4-6

Signature	Date	Company
		API Midstream Representative

Example A.1 - Calibration Set I - 2 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set II

General Data

Operator	API Midstream	
Station Name	Headquarters	
Fluid or Batch	RBOB	-
Ch 11.1	Products	-
T_B	15.0	°C
P_B	0.0	kPag

Master Meter

Flowmeter ID	200	-
Manufacturer	API	-
Model	API-PD	-
Nominal Size	100	mm
Type	PD	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	52,834.410 5	P / M3
Cartridge No.	API-0011	-

Density Method

ρ_{obs} Method	Continuous	-
ρ_{obs} Device	Online Density	-
DMF	0.999 8	-
HYC Factor	No	-

API Chapter 12.4.2
SI_15 Measurement Units
Sampling Method - Continuous
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Refined Product - Tables 5B/6B

Field Prover

Prover Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Bidirectional	-
Wall Design	Single	-
Detector	Internal	-
Displacer	Free Sphere	-
Wall Material	300 SS	-
Rod Material	NA	-
GL_P	0.000 011 16	per °C
GL_D	NA	per °C
E_P	206 842 710	per kPag
ID_P	547.675 0	mm
WT_P	30.963 0	mm
Serial No.	Bidi-SI-001	-
Switches	9206 to 9236	-

Calibration Set Criteria

ΔMMF_{SET}	≤ 0.02	%
(r) $ICPV_{RUN}$	≤ 0.02	%
(r) CPV_{RUN}	≤ 0.02	%

Spot Sample

ρ_{60_START}	NA	kg/m³
ρ_{60_STOP}	NA	kg/m³
ρ_{60_SET}	NA	kg/m³
MMF_{SET}	0.999 986 5	-

Report Summary

	Start	Stop	
Report No.	Start 2	Stop 2	-
Date	14-Feb-24	14-Feb-24	-
Time	10:53:11 AM	12:40:18 PM	-
Totalizer	2,342,521.020	2,343,841.020	M3
Fluid, Batch No.	84RBOB	84RBOB	-
API_{60}	61.0	61.0	°API
ρ_{60}	734.457	734.419	kg/m3
API_{15}	60.9	60.9	°API
ρ_{15}	734.963	734.924	kg/m3
API_{20}	61.9	61.9	°API
ρ_{20}	730.402	730.364	kg/m3
Flowrate, Q_{av}	83.332	83.434	MPH
T_{MP_AVG}	21.506	21.517	°C
P_{MP_AVG}	1303.8	1306.6	kPag
Trips per Run	1	1	-
Roundtrips	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.011	0.008	%
Allowable (r)	0.020	0.020	%
(r) Pass/Fail	Pass	Pass	-
MMF	0.999 974 0	0.999 999 0	-
ΔMMF	NA	0.003	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-

Prior vs Current

ΔQ_{av}	0.1	%
ΔT_P	0.120	°C

Roundtrip Measurements							Base Density	
ρ_{obs} kg/m³	T_{dm} °C	P_{dm} kPag	T_{FP_INLET} °C	T_{FP_OUTLET} °C	T_{MM} °C	T_{FD} °C	ρ_B kg/m³	Run
729.748	21.506	1,300.0	21.494	21.394	21.400		734.568	1
729.843	21.494	1,308.0	21.500	21.411	21.422		734.645	2
729.545	21.494	1,301.0	21.494	21.361	21.461		734.353	3
								4
								5
								6
729.712	21.498	1,303.0	21.496	21.389	21.428		734.522	Avg

Ch 11.1 Iteration Results	Roundtrip Measurements					T_{FP} and P_{FP} Values		
	N or N_i Pulses	Q_{MM} MPH	P_{FP_INLET} kPag	P_{FP_OUTLET} kPag	P_{MM} kPag	T_{FP} °C	P_{FP} kPag	Run
Gasoline, Napthene	100,015.000	83.332	1,284.0	1,279.0	1,268.0	21.444 0	1,281.50	1
Gasoline, Napthene	100,001.000	83.331	1,288.0	1,278.0	1,270.0	21.455 5	1,283.00	2
Gasoline, Napthene	100,022.000	83.332	1,284.0	1,268.0	1,257.0	21.427 5	1,276.00	3
								4
								5
								6
	100,012.700 0	83.332	1,285.0	1,275.0	1,265.0	21.442 0	1,280.00	Avg

Example A.1 - Calibration Set II - 1 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set II

API Chapter 12.4.2
SI_15 Measurement Units
Sampling Method - Continuous
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Refined Product - Tables 5B/6B

ΔMMF_{SET}	**Pass**	-
(r) $ICPV_{SET}$	**Pass**	-
(r) CPV_{SET}	**Pass**	-

Report Summary

	Prior	*Current*
Report No.	Start	Stop
Date	Start 2	Stop 2
Time	00:00:00	00:00:00
Fluid, Batch No.	2342521.02	2343841.02

N or N_i Pulses	**NKF** P / M3	**IV_{MM}**	**CTL_{MM}**	**CPL_{MM}**	**$CTPL_{MM}$**	**GSV_{MM}** M3	**Run**
100,015.000	52,834.410 5	1.892 989 8	0.992 047 429	1.001 496 806	0.993 532 331	1.880 721 180	**1**
100,001.000	52,834.410 5	1.892 724 8	0.992 021 304	1.001 498 874	0.993 508 218	1.880 412 260	**2**
100,022.000	52,834.410 5	1.893 122 3	0.991 967 882	1.001 486 077	0.993 442 022	1.880 681 860	**3**
							4
							5
							6
100,012.700 0	52,834.410 5	1.892 945 6	0.992 012 205	1.001 493 919	0.993 494 191	1.880 605 100	**Avg**

Iteraton Results	**CTS_{FP}**	**CPS_{FP}**	**CTL_{FP}**	**CPL_{FP}**	**$CTPL_{FP}$**	**CPV_run** M3	**Run**
Gasoline, Napthene	1.000 215 761	1.000 109 587	0.991 992 627	1.001 513 300	0.993 493 810	1.892 421 900	**1**
Gasoline, Napthene	1.000 216 146	1.000 109 715	0.991 979 587	1.001 514 647	0.993 482 085	1.892 132 420	**2**
Gasoline, Napthene	1.000 215 208	1.000 109 116	0.992 009 625	1.001 508 167	0.993 505 742	1.892 361 550	**3**
							4
							5
							6
	1.000 215 705	1.000 109 473	0.991 993 946	1.001 512 038	0.993 493 879	1.892 305 290	**Avg**

	1 means ΔCPV Passed	**$\Delta\rho_{B\_SET}$** kg/m^3	**ΔT_{P_SET}** °C	**ΔP_{P_SET}** kPag	**ΔQ_{MM_SET}** %	**r% CPV**	**CPV_set**	**CPV_set** M3	
Runs 1-3	1	0.292	0.028	7.00	0.0	0.015	**Pass**	1.892 305 290	**Runs 1-3**
Runs 2-4		NA	NA	NA	NA		-		**Runs 2-4**
Runs 3-5		NA	NA	NA	NA		-		**Runs 3-5**
Runs 4-6		NA	NA	NA	NA		-		**Runs 4-6**

Signature	**Date**	**Company**
		API Midstream Representative

Example A.1 - Calibration Set II - 2 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set III

General Data

Operator	API Midstream	
Station Name	Headquarters	
Fluid or Batch	RBOB	-
Ch 11.1	Products	-
T_B	15.0	°C
P_B	0.0	kPag

Master Meter

Flowmeter ID	200	-
Manufacturer	API	-
Model	API-PD	-
Nominal Size	100	mm
Type	PD	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	52,834.410 5	P / M3
Cartridge No.	API-0011	-

Density Method

ρ_{obs} Method	Continuous	-
ρ_{obs} Device	Online Density	-
DMF	0.999 8	-
HYC Factor	No	-

API Chapter 12.4.2
SI_15 Measurement Units
Sampling Method - Continuous
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Refined Product - Tables 5B/6B

Field Prover

Prover Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Bidirectional	-
Wall Design	Single	-
Detector	Internal	-
Displacer	Free Sphere	-
Wall Material	300 SS	-
Rod Material	NA	-
GL_P	0.000 011 16	per °C
GL_D	NA	per °C
E_P	206 842 710	per kPag
ID_P	547.675 0	mm
WT_P	30.963 0	mm
Serial No.	Bidi-SI-001	-
Switches	9206 to 9236	-

Calibration Set Criteria

ΔMMF_{SET}	≤ 0.02	%
(r) $ICPV_{RUN}$	≤ 0.02	%
(r) CPV_{RUN}	≤ 0.02	%

Spot Sample

ρ_{60_START}	NA	kg/m³
ρ_{60_STOP}	NA	kg/m³
ρ_{60_SET}	NA	kg/m³
MMF_{SET}	1.000 126 5	-

Report Summary

	Start	Stop	
Report No.	Start 3	Stop 3	-
Date	14-Feb-24	14-Feb-24	-
Time	8:21:18 AM	11:21:18 AM	-
Totalizer	2,342,501.020	2,343,601.020	M3
Fluid, Batch No.	Products	Products	-
API_{60}	60.8	60.6	°API
ρ_{60}	735.210	735.710	kg/m3
API_{15}	60.7	60.5	°API
ρ_{15}	735.715	736.216	kg/m3
API_{20}	61.7	61.5	°API
ρ_{20}	731.158	731.660	kg/m3
Flowrate, Q_{av}	140.250	140.222	MPH
T_{MP_AVG}	22.833	22.911	°C
P_{MP_AVG}	1294.1	1298.3	kPag
Trips per Run	1	1	-
Roundtrips	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.018	0.017	%
Allowable (r)	0.020	0.020	%
(r) Pass/Fail	Pass	Pass	-
MMF	1.000 099 0	1.000 154 0	-
ΔMMF	NA	0.006	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-

Prior vs Current

ΔQ_{av}	0.1	%
ΔT_P	0.120	°C

Roundtrip Measurements							Base Density	
ρ_{obs} kg/m³	T_{dm} °C	P_{dm} kPag	T_{FP_INLET} °C	T_{FP_OUTLET} °C	T_{MM} °C	T_{FD} °C	ρ_B kg/m³	Run
729.748	22.906	1,203.0	22.817	22.889	22.994		735.921	1
729.843	22.906	1,208.0	22.806	22.844	22.994		736.011	2
729.545	22.928	1,208.0	22.822	22.856	23.000		735.734	3
								4
								5
								6
729.712	22.913	1,206.0	22.815	22.863	22.996		735.889	Avg

Ch 11.1 Iteration Results	Roundtrip Measurements					T_{FP} and P_{FP} Values		
	N or N_i Pulses	Q_{MM} MPH	P_{FP_INLET} kPag	P_{FP_OUTLET} kPag	P_{MM} kPag	T_{FP} °C	P_{FP} kPag	Run
Gasoline, Napthene	100,015.000	140.247	1,214.0	1,198.0	1,278.0	22.853 0	1,206.00	1
Gasoline, Napthene	100,018.000	140.248	1,218.0	1,200.0	1,282.0	22.825 0	1,209.00	2
Gasoline, Napthene	100,022.000	140.247	1,215.0	1,200.0	1,285.0	22.839 0	1,207.50	3
								4
								5
								6
	100,018.300 0	140.247	1,216.0	1,199.0	1,282.0	22.839 0	1,208.00	Avg

Example A.1 - Calibration Set III - 1 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set III

API Chapter 12.4.2
SI_15 Measurement Units
Sampling Method - Continuous
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Refined Product - Tables 5B/6B

ΔMMF_{SET}	**Pass**	-
(r) $ICPV_{SET}$	**Pass**	-
(r) CPV_{SET}	**Pass**	-

Report Summary

	Prior	*Current*
Report No.	Start	Stop
Date	Start 3	Stop 3
Time	00:00:00	00:00:00
Fluid, Batch No.	2342501.02	2343601.02

N or N_i Pulses	**NKF** P / M3	**IV_{MM}**	**CTL_{MM}**	**CPL_{MM}**	**$CTPL_{MM}$**	**GSV_{MM}** M3	**Run**
100,015.000	52,834.410 5	1.892 989 8	0.990 088 855	1.001 518 008	0.991 591 818	1.877 310 650	**1**
100,018.000	52,834.410 5	1.893 046 6	0.990 090 711	1.001 522 097	0.991 597 725	1.877 378 160	**2**
100,022.000	52,834.410 5	1.893 122 3	0.990 077 557	1.001 527 798	0.991 590 195	1.877 438 980	**3**
							4
							5
							6
100,018.300 0	52,834.410 5	1.893 052 9	0.990 085 708	1.001 522 634	0.991 593 246	1.877 375 930	**Avg**

Iteraton Results	**CTS_{FP}**	**CPS_{FP}**	**CTL_{FP}**	**CPL_{FP}**	**$CTPL_{FP}$**	**CPV_run** M3	**Run**
Gasoline, Napthene	1.000 262 941	1.000 103 130	0.990 264 161	1.001 430 750	0.991 680 981	1.892 366 250	**1**
Gasoline, Napthene	1.000 262 004	1.000 103 387	0.990 300 787	1.001 433 363	0.991 720 247	1.892 360 660	**2**
Gasoline, Napthene	1.000 262 473	1.000 103 259	0.990 277 805	1.001 433 674	0.991 697 540	1.892 464 650	**3**
							4
							5
							6
	1.000 262 473	1.000 103 259	0.990 280 917	1.001 432 596	0.991 699 590	1.892 397 190	**Avg**

	1 means ΔCPV Passed	**$\Delta\rho_{B\_SET}$** kg/m^3	**ΔT_{P_SET}** °C	**ΔP_{P_SET}** kPag	**ΔQ_{MM_SET}** %	**r% CPV**	**CPV_set**	**CPV_set** M3	
Runs 1-3	1	0.278	0.028	3.00	0.0	0.005	**Pass**	1.892 397 190	**Runs 1-3**
Runs 2-4		NA	NA	NA	NA		-		**Runs 2-4**
Runs 3-5		NA	NA	NA	NA		-		**Runs 3-5**
Runs 4-6		NA	NA	NA	NA		-		**Runs 4-6**

Signature	**Date**	**Company**
		API Midstream Representative

Example A.1 - Calibration Set III - 2 of 2

Example A.2 – Standard Method

SI Units, Spot Sampling, Master Prover - Unidirectional Captive Displacer, Master Meter - Turbine, MF r% - Moving Range, MF Method - IMF, Field Prover - Unidirectional Captive Displacer

	Master Prover	
BPV Units	1	(0-USC_{60}, 1-SI_{15}, 2-SI_{20})
Detector Design	1	(0-Internal, 1-External)
Wall Material	3	(1-CS, 2-304SS, 3-316SS, 4-17-4PH)
Rod Material	3	(0-NA, 1-CS, 2-304SS, 3-316SS, 4-17-4PH, 5-Invar)
Certificate BPV	93,818.781 0	mL at 15.0 °C and 0.0 kPag

	Base Prover Volume (BPV)		
	BPV_{60} Barrels	**BPV_{15} Cubic Meters**	**BPV_{20} Cubic Meters**
	0. 590 118 130 282	0. 093 818 781 000	0. 093 841 327 000
Decimals	10	11	11
Conversion	in^3 / Bbl	mL / M^3	mL / M^3
	9.702E+03	1.00E+06	1.00E+06
Rnd'd BPV	0.590 118 130 300	0.093 818 781 000	0.093 841 327 000

in^3 = mL / 16.387 064
U.S. Gallons = in^3 / 2.31E+02
Bbl = in^3 / 9.702E+03
Cubic Feet = in^3 / 1.728E+03

mL = M^3 x 1E+06
mL = in^3 x 16.387 064

M^3 = mL x 1E-06
L = mL x 1E-03

Note: This Worksheet produces a BPV_{60} or BPV_{SI} to **10 digits** (the appropriate decimal place) to increase the precision of the Master Prover's BPV, not the uncertainty of the Master Prover's BPV.

T_B	15.0	°C
Decimal Base CTS	9	-
Decimal BPV_{60}	4	cubic inches at 60.0 °F, 0.0 psig
Decimal BPV_{SI}	3	mL at 15.0 °C and 0.0 kPag
Decimal BPV	11	Cubic Meters

Detector Design,

$CTS_P = [1 + (T_P - T_B) \times GL_P]^3$, for detectors mounted in calibrated section

$CTS_P = [1 + (T_P - T_B) \times GL_P]^2 \times [1 + (T_D - T_B) \times GL_d]$, for detectors mounted on external shaft

If Measurement Units = 0, then BPV in cubic inches, T_B is 60.0 °F

BPV_{60} = cubic inches at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 1, then BPV in mL, T_B is 15.0 °C

BPV_{60} = ROUND(BPV_{15} / 16.387 064 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(BPV_{15} x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 2, then BPV in mL, T_B is 20.0 °C

BPV_{60} = ROUND(BPV_{20} / 16.387 064 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(CPV_{20} x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = mL at 20.0 °C, 0.0 kPag

API Properties

Linear Coefficient of Thermal Expansion, GL

	SI Unit[2,4] (per °C)	USC Unit[2,3,5] (per °F)
Mild Carbon	0.000 011 16	**0.000 006 20**
304 SS	**0.000 017 28**	0.000 009 60
316 SS	**0.000 016 02**	0.000 008 90
17-4PH	0.000 010 80	**0.000 006 00**
Invar™	0.000 001 44	**0.000 000 80**

Notes:

(1) The User/Owner should obtain GL values from the prover manufacturer.

(2) The GL values shown above are a function of the materials, operating temperature range, calibration temperature range. Values in **bold face** were obtained from American Society of Metals (ASM) International, 2020 edition.

(3) GL values shown above are applicable from 0 °C to 100 °C (32 °F to 212 °F). If operating outside this range, the GL values depicted are not appropriate.

(4) The SI values of GL per °C **not in bold face**, was obtained by multiplying the USC values, GL per °F, times 1.8.

(5) The USC values per °F **not in bold face**, was obtained by dividing the SI values, GL per °C, by 1.8.

T_B	60.0 °F	15.0 °C	20.0 °C
GL_P	0.000 008 90	0.000 016 02	0.000 016 02
GL_D	0.000 008 90	0.000 016 02	0.000 016 02
Base CTS_{60}	1.000 000 000	1.000 026 700	0.999 786 415
Base CTS_{15}	0.999 973 300	1.000 000 000	0.999 759 719
Base CTS_{20}	1.000 213 615	1.000 240 319	1.000 000 000

Base Unit Volume

BPV_{60}	5,725.326 1	cubic inches at 60.0 °F, 0.0 psig
BPV_{15}	93,818.781	mL at 15.0 °C and 0.0 kPag
BPV_{20}	93,841.327	mL at 20.0 °C and 0.0 kPag

Example A.2 - Expanded Discrimination of Master Prover's BPV

Washington, D.C., USA

Master Meter Proving Report

General Data		
Operator	API Midstream	-
Station Name	MPMS	-
Ch 11.1	Tables 5A/6A	-
T_B	15.0	°C
P_B	0.0	kPag

Master Meter		
Flowmeter ID	200	-
Manufacturer	API	-
Model	Turbine	-
Nominal Size	75	mm
Type	Coriolis	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	4,382.111 0	P / M3
Cartridge No.	API-0011	-

Density Method		
Sample Method	Spot Sample	-
ρ_{obs} Device	Hydrometer	-
DMF	NA	-
HYC Factor	Yes	-

API MPMS Chapter 12.4.2
Measurement Units - SI_15
Sampling Method - Spot
Meter Factor Method - Intermediate (or IMF)
Repeatability Method (r%) - Moving Range
API MPMS Chapter 11.1 - Tables 5A/6A

Displacement Prover		
Manufacturer	API	-
Prover Type	Displacement	-
Flow Design	Unidirectional	-
Wall Design	Single	-
Detector	External	-
Displacer	Captive Displacer	-
Wall Material	316SS	-
Rod Material	316SS	-
GL_P	0.000 016 02	per °C
GL_D	0.000 016 02	per °C
E_P	193 053 196	per kPag
ID_P	441.960 0	mm
WT_P	46.355 0	mm
Calibration Date	2021-09-04	-
Serial No.	8904-02	-
Certificate No.	10101010	-
Switches	9201 to 9202	-
BPV	0.093 818 781 0	M3

Spot Sample		
API_{ind}		°API
ρ_{ind}	848.619	kg/m³
T_{obs}	15.000	°C
P_{obs}	0.0	kPag

Report Summary	Start	Stop	
Report No.	Start I	Stop I	-
Date	14-Feb-24	14-Feb-24	-
Time	8:21:18	11:21:18	-
Totalizer	2,342,501.020	2,343,601.020	M3
Fluid, Batch No.	Crude	Crude	-
API_{60}	35.1	35.2	°API
ρ_{60}	848.597	848.217	kg/m³
API_{15}	35.0	35.1	°API
ρ_{15}	848.999	848.619	kg/m³
API_{20}	35.6	35.7	°API
ρ_{20}	845.377	844.995	kg/m³
Flowrate, Q	58.025	58.100	MPH
T_{P_AVG}	22.874	23.016	°C
P_{P_AVG}	1210.6	1214.2	kPag
Trips per Run	1	1	-
Roundtrips	Runs 1-3	Runs 1-3	-
Repeatability (r)	0.004	0.002	%
Allowable (r)	0.007	0.007	%
(r) Pass/Fail	Pass	Pass	-
MMF	0.999 997 7	0.999 986 4	-
ΔMMF	NA	(0.001)	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-

Prior vs Current		
ΔQ	0.1	%
ΔT_P	0.142	°C

Base Density	Roundtrip Measurements							Base Density	
API_B °API	ρ_{ind} kg/m³	T_{dm} °C	P_{dm} kPag	T_{P_INLET} °C	T_{P_OUTLET} °C	T_M °C	T_D °C	ρ_B kg/m³	Run
35.1				23.044	22.978	22.894	23.900	848.619	1
35.1				23.061	23.017	22.933	23.967	848.619	2
35.1				23.039	22.956	22.906	23.956	848.619	3
NA									4
NA									5
NA									6
NA									7
NA									8
NA									9
NA									10
35.1	NA	NA	NA	NA	NA	22.911	23.941	848.619	Runs 1-3

Commodity Type	Roundtrip Measurements					T_P and P_P Values		
	N or N_i Pulses	Q_M MPH	P_{P_INLET} kPag	P_{P_OUTLET} kPag	P_M kPag	T_{P_RUN} °C	P_{P_RUN} kPag	Run
Crude Oil, JP-4	411.278	58.112 0	1,227.0	1,201.0	1,196.0	23.011 0	1,214.00	1
Crude Oil, JP-4	411.291	58.069 0	1,227.0	1,202.0	1,197.0	23.039 0	1,214.50	2
Crude Oil, JP-4	411.294	58.118 0	1,227.0	1,201.0	1,196.0	22.997 5	1,214.00	3
NA								4
NA								5
NA								6
NA								7
NA								8
NA								9
NA								10
Runs 1-3	411.287 7	58.100 0	NA	NA	1,196.0	23.015 8	1,214.17	Runs 1-3

Example A.2 - Calibration Set I - Stop Proving Report - 1 of 2

Washington, D.C., USA

Master Meter Proving Report

API MPMS Chapter 12.4.2
Measurement Units - SI_15
Sampling Method - Spot
Meter Factor Method - Intermediate (or IMF)
Repeatability Method (r%) - Moving Range
API MPMS Chapter 11.1 - Tables 5A/6A

Report Summary

	Prior	*Current*
Report No.	Start I	Stop I
Date	14-Feb-24	14-Feb-24
Time	08:21:18	11:21:18
Fluid, Batch No.	Crude	Crude

Run	BPV M3	CTS_P	CPS_P	Rnd CTL_P	Rnd CPL_P	Rnd $CTPL_P$	GSV_P M3	Run
1	0.093 818 781 0	1.000 399 304	1.000 059 955	0.993 153 177	1.000 925 626	0.994 072 465	0.093 305 500 9	1
2	0.093 818 781 0	1.000 401 274	1.000 059 980	0.993 129 388	1.000 926 151	0.994 049 176	0.093 303 500 9	2
3	0.093 818 781 0	1.000 399 768	1.000 059 955	0.993 164 595	1.000 925 551	0.994 083 820	0.093 306 609 9	3
4								4
5								5
6								6
7								7
8								8
9								9
10								10
Runs 1-3	0.093 818 781 0	1.000 400 115	1.000 059 963	0.993 149 053	1.000 925 776	0.994 068 487	0.093 305 203 9	Runs 1-3

Run	N or N_i	NKF P / M3	IV_M	Rnd CTL_M	Rnd CPL_M	Rnd $CTPL_M$	ISV_M M3	Run
1	411.278	4,382.111 0	0.093 853 852 6	0.993 253 560	1.000 911 245	0.994 158 657	0.093 305 620 1	1
2	411.291	4,382.111 0	0.093 856 819 2	0.993 220 258	1.000 912 196	0.994 126 270	0.093 305 529 6	2
3	411.294	4,382.111 0	0.093 857 503 8	0.993 243 094	1.000 911 313	0.994 148 248	0.093 308 273 1	3
4								4
5								5
6								6
7								7
8								8
9								9
10								10
Runs 1-3	411.287 7	4,382.111 0	0.093 856 058 6	0.993 238 971	1.000 911 585	0.994 144 392	0.093 306 474 3	Runs 1-3

Run	'1' indicates Repeatability (r%) criteria satisifed	Repeatability (r%) Actual	Repeatability (r%) Allowable	Meter Factor Method - Intermediate (or IMF)	IMF	Run
1		NA	NA		0.999 998 72	1
2		NA	NA		0.999 978 26	2
3	1	0.002	0.007	Repeatability Method (r%) - Moving Range	0.999 982 17	3
4			0.014			4
5			0.020			5
6			0.025			6
7			0.031			7
8			0.036			8
9			0.041			9
10			0.045			10
	Pass	0.002			0.999 986 40	MMF

MMF Rounded to 7 decimal places

		API Midstream Representative

Example A.2 - Calibration Set I - Stop Proving Report - 2 of 2

	Field Prover	
Measurement Units	1	(0-USC$_{60}$, 1-SI$_{15}$, 2-SI$_{20}$)
Detector Design	1	(0-Internal, 1-External)
Wall Material	3	(1-CS, 2-304SS, 3-316SS, 4-17-4PH)
Rod Material	3	(0-NA, 1-CS, 2-304SS, 3-316SS, 4-17-4PH, 5-Invar)
Source for GL_{MP}, GL_{md}, E_{MP}	1	(0-Prover Manufacturer, 1-API Table)
BPV_P	93,818.781 0	mL at 15.0 °C and 0.0 kPag

	Base Prover Volume (BPV)		
	BPV_{60} Barrels	**BPV_{15} Cubic Meters**	**BPV_{20} Cubic Meters**
	0. 590 118 130 282	0. 093 818 781 000	0. 093 841 327 000
Decimals	6	7	7
Conversion	in^3 / Bbl 9.702E+03	mL / M^3 1.00E+06	mL / M^3 1.00E+06
Rnd'd BPV	0.590 118 000 000	0.093 818 800 000	0.093 841 300 000

in^3 = mL / 16.387 064
U.S. Gallons = in^3 / 2.31E+02
Bbl = in^3 / 9.702E+03
Cubic Feet = in^3 / 1.728E+03

mL = M^3 x 1E+06
mL = in^3 x 16.387 064

M^3 = mL x 1E-06
L = mL x 1E-03

Note: This Worksheet produces a BPV_{60} or BPV_{SI} to **6 digits** (the appropriate decimal place).

T_B	15.0	°C
Decimal Base CTS	9	-
Decimal BPV_{60}	4	cubic inches at 60.0 °F, 0.0 psig
Decimal BPV_{SI}	3	mL at 15.0 °C and 0.0 kPag
Decimal BPV	7	Cubic Meters, 6 digits
Decimal BPV	6	Barrels, 6 digits

API Properties

Linear Coefficient of Thermal Expansion, GL

	SI Unit[2,4] (per °C)	USC Unit[2,3,5] (per °F)
Mild Carbon	0.000 011 16	**0.000 006 20**
304 SS	**0.000 017 28**	0.000 009 60
316 SS	**0.000 016 02**	0.000 008 90
17-4PH	0.000 010 80	**0.000 006 00**
Invar™	0.000 001 44	**0.000 000 80**

Detector Design,

$CTS_P = [1 + (T_P - T_B) \times GL_P]^3$, for detectors mounted in calibrated section

$CTS_P = [1 + (T_P - T_B) \times GL_P]^2 \times [1 + (T_D - T_B) \times GL_d]$, for detectors mounted on external shaft

If Measurement Units = 0, then BPV in cubic inches, T_B is 60.0 °F

BPV_{60} = cubic inches at 60.0 °F, 0.0 psig

BPV_{15} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{15}, 12) = mL at 15.0 °C, 0.0 kPag

BPV_{20} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{20}, 12) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 1, then BPV in mL, T_B is 15.0 °C

BPV_{60} = ROUND(BPV_{15} / 16.387 064 x Base CTS_{60}, 12) = in^3 at 60.0 °F, 0.0 psig

BPV_{15} = mL at 15.0 °C, 0.0 kPag

BPV_{20} = ROUND(BPV_{15} x Base CTS_{20}, 12) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 2, then BPV in mL, T_B is 20.0 °C

BPV_{60} = ROUND(BPV_{20} / 16.387 064 x Base CTS_{60}, 12) = in^3 at 60.0 °F, 0.0 psig

BPV_{15} = ROUND(CPV_{20} x Base CTS_{15}, 12) = mL at 15.0 °C, 0.0 kPag

BPV_{20} = mL at 20.0 °C, 0.0 kPag

Notes:

(1) The User/Owner should obtain GL values from the prover manufacturer.

(2) The GL values shown above are a function of the materials, operating temperature range, calibration temperature range. Values in **bold face** were obtained from American Society of Metals (ASM) International, 2020 edition.

(3) GL values shown above are applicable from 0 °C to 100 °C (32 °F to 212 °F). If operating outside this range, the GL values depicted are not appropriate.

(4) The SI values of GL per °C **not in bold face**, was obtained by multiplying the USC values, GL per °F, times 1.8.

(5) The USC values per °F **not in bold face**, was obtained by dividing the SI values, GL per °C, by 1.8.

GL_P	0.000 008 90	0.000 016 02	0.000 016 02
GL_D	0.000 008 90	0.000 016 020	0.000 016 020
T_B	60.0	15.0	20.0
Base CTS_{60}	1.000 000 000	1.000 026 700	0.999 786 415
Base CTS_{15}	0.999 973 300	1.000 000 000	0.999 759 719
Base CTS_{20}	1.000 213 615	1.000 240 319	1.000 000 000

Base Unit Volume

BPV_{60}	5,725.326 1	cubic inches at 60.0 °F, 0.0 psig
BPV_{15}	93,818.781	mL at 15.0 °C and 0.0 kPag
BPV_{20}	93,841.327	mL at 20.0 °C and 0.0 kPag

Example A.2 - Field Prover's BPV Conversion

Washington, D.C., USA

BPV Determination using a Master Meter - Standard Method

General Data		Master Meter			Field Prover		
API Midstream	Operator	Flowmeter ID	200	-	Manufacturer	API	-
Headquarters	Station Name	Manufacturer	API	-	Prover Design	Displacement	-
Washington	City, Town	Model	Turbine	-	Flow Design	Unidirectional	-
D.C.	State, Province	Nominal Size	75	mm	Wall Design	Single	-
USA	Country	Type	Turbine	-	Detector	External	-
Crude	Fluid, Batch No.	Proving Result	MMF	-	Displacer	Captive Displacer	-
Crude	Ch 11.1	T_F Comp	No	-	Wall Material	316SS	-
15.0	T_B	P_F Comp	No	-	Rod Material	316SS	-
0.0	P_B	NKF	4,382.111 0	P / M3	GL_P	0.000 016 02	per °C
14-Feb-2024	Start Calibration	Cartridge No.	API-0011	-	GL_D	0.000 016 02	per °C
14-Feb-2024	Stop Calibration		**Density Method**		E_P	193 053 196	per kPag
API Chapter 12.4.2		ρ_{obs} Method	Spot Sample	-	ID_P	441.960 0	mm
SI_15 Measurement Units		ρ_{obs} Device	Online Density	-	WT_P	46.355 0	mm
Sampling Method - Spot		DMF	0.000 0	-	Trips per Run	1	-
BPV - Standard Method		HYC Factor	No	-	Serial No.	8904-02	-
Fixed Range Method, r ≤ 0.02%, for 3 consecutive Calibration Sets					Switches	9201 to 9202	-
Crude Oil - Tables 5A/6A							

	Calibration Set I		Calibration Set II		Calibration Set III		
	Start	**Stop**	**Start**	**Stop**	**Start**	**Stop**	
Report No.	Start I	Stop I	Start 2	Stop 2	Start 3	Stop 3	-
Date	14-Feb-24	14-Feb-24	14-Feb-24	14-Feb-24	14-Feb-24	14-Feb-24	-
Crude	Crude	Crude	Crude	Crude	Crude	Crude	-
API_B	35.0	35.1	35.1	35.0	35.1	35.1	°API
ρ_B	848.999	848.619	848.619	848.989	848.829	848.789	kg/m^3
Q_{MM}	58.025	58.100	83.332	83.434	140.250	140.222	MPH
T_{MP_AVG}	22.874	23.016	21.506	21.517	22.833	22.911	°C
P_{MP_AVG}	1,210.6	1,214.2	1,303.8	1,306.6	1,294.1	1,298.3	kPag
Roundtrips	Runs 1-3	Runs 1-3	Runs 1-5	Runs 1-5	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.004	0.002	0.011	0.008	0.008	0.014	%
MMF	0.999 997 7	0.999 986 4	1.000 055 2	1.000 058 6	0.999 845 2	0.999 865 5	-
MMF_{SET}	NA	0.999 992 1	NA	1.000 056 9	NA	0.999 855 4	-
ΔMMF	NA	(0.001)	NA	0.000	NA	0.002	%
ΔMMF_{SET}		**Pass**		**Pass**		**Pass**	
(r) CPV_{RUN}		**Pass**	-	**Pass**	-	**Pass**	-
(R) CPV_{SET}		NA	-	**Pass**	-	**Pass**	-
ΔQ_{SET}		NA	-	**Pass**	-	**Pass**	-
Selected Set		**Runs 4-6**	-	**Runs 1-3**	-	**Runs 1-3**	-
CPV_{SET}		**0.093 817 2**	M3	**0.093 820 1**	M3	**0.093 820 3**	M3
API_{B_SET}		35.1	°API	35.1	°API	35.1	°API
ρ_{B_SET}		848.809	kg/m^3	848.804	kg/m^3	848.809	kg/m^3
T_{FP_SET}		22.820	°C	21.442	°C	22.839	°C
P_{FP_SET}		1,212.0	kPag	1,280.0	kPag	1,208.0	kPag
Q_{MM_SET}		111.456	MPH	83.332	MPH	140.247	MPH
CPV_{SET} Stability Parameters	ΔMMF_{SET}	(0.001)	%	0.000	%	0.002	%
	$\Delta\rho_{B\_SET}$	0.075	kg/m^3	(0.073)	kg/m^3	0.008	kg/m^3
	ΔT_{P_SET}	0.005	°C	0.028	°C	0.028	°C
	ΔP_{P_SET}	2.0	kPag	7.0	kPag	3.0	kPag
	ΔQ_{MM_SET}	0.0	%	0.0	%	0.0	%
	$\Delta Q_{between\ SETS}$	NA	%	(25.2)	%	40.6	%
	(r) CPV_{RUN}	0.006	%	0.007	%	0.001	%
	(R) CPV_{SET}	NA	%	0.003	%	0.000	%

Example A.2 - Calibration Report Summary - 1 of 2

Washington, D.C., USA

BPV Determination using a Master Meter - Standard Method

General Data

API Midstream	Operator
Headquarters	Station Name
Washington	City, Town
D.C.	State, Province
USA	Country
Crude	Fluid, Batch No.
Crude	Ch 11.1
15.0	T_B
0.0	P_B
14-Feb-2024	Start Calibration
14-Feb-2024	Stop Calibration

API Chapter 12.4.2
SI_15 Measurement Units
Sampling Method - Spot
BPV - Standard Method
Fixed Range Method, r ≤ 0.02 %, for 3 consecutive Calibration Sets
Crude Oil - Tables 5A/6A

Field Prover

Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Unidirectional	-
Wall Design	Single	-
Detector	External	-
Displacer	Captive Displacer	-
Wall Material	316SS	-
Rod Material	316SS	-
GL_P	0.000 016 02	per °C
GL_D	0.000 016 02	per °C
E_P	193 053 196	per kPag
ID_P	441.960 0	mm
WT_P	46.355 0	mm
Serial No.	8904-02	-
Switches	9201 to 9202	-

BPV_{NEW}	0.093 819 2	M3
BPV_{OLD}	0.093 818 8	M3
ΔBPV	0.000 000 4	M3
ΔBPV	0.000 4	% BPV_{NEW} Bigger / (Smaller)
Average CPV_{SET}	0.093 819 217	M3
BPV_{60}	5,725.352 8	in^3 at 60.0 °F and 0.0 psig
BPV_{15}	93,819.217	mL at 15.0 °C and 0.0 kPag
BPV_{20}	93,841.764	mL at 20.0 °C and 0.0 kPag

Base Prover Volume (BPV_{NEW})

BPV_{60}			BPV_{15}		BPV_{20}	
Barrels	**U.S. Gallons**	**Cubic Feet**	**Cubic Meters**	**Liters**	**Cubic Meters**	**Liters**
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	24.785 1	-	-	93.819 2	-	93.841 8
-	-	3.313 28	-	-	-	-
0.590 121	-	-	-	-	-	-
-	-	-	0.093 819 2	-	0.093 841 8	-

Note: The BPV_{NEW} values (BPV_{60}, BPV_{15}, BPV_{20}) shown are reported to 6 significant digits (10 ppm, or, 0.001%).

Signature	Date	Company
		API Midstream Representative

Example A.2 - Calibration Report Summary - 2 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set I

General Data

Operator	API Midstream	
Station Name	Headquarters	
Fluid or Batch	Crude	-
Ch 11.1	Crude	-
T_B	15.0	°C
P_B	0.0	kPag

Master Meter

Flowmeter ID	200	-
Manufacturer	API	-
Model	Turbine	-
Nominal Size	75	mm
Type	Turbine	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	4,382.111 0	P / M3
Cartridge No.	API-0011	-

Density Method

ρ_{obs} Method	Spot Sample	-
ρ_{obs} Device	Online Density	-
DMF	0.000 0	-
HYC Factor	No	-

API Chapter 12.4.2
SI_15 Measurement Units
Sampling Method - Spot
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Crude Oil - Tables 5A/6A

Field Prover

Prover Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Unidirectional	-
Wall Design	Single	-
Detector	External	-
Displacer	Captive Displacer	-
Wall Material	316SS	-
Rod Material	Invar	-
GL_P	0.000 016 02	per °C
GL_D	0.000 016 02	per °C
E_P	193 053 196	per kPag
ID_P	441.960 0	mm
WT_P	46.355 0	mm
Serial No.	8904-02	-
Switches	9201 to 9202	-

Calibration Set Criteria

ΔMMF_{SET}	≤ 0.02	%
(r) $ICPV_{RUN}$	≤ 0.02	%
(r) CPV_{RUN}	≤ 0.02	%

Spot Sample

ρ_{60_START}	848.597 000 000 000	kg/m³
ρ_{60_STOP}	848.216 823 342 456	kg/m³
ρ_{60_SET}	848.406 911 671 228	kg/m³
MMF_{SET}	0.999 992 1	-

Report Summary

	Start	Stop	
Report No.	Start I	Stop I	-
Date	14-Feb-24	14-Feb-24	-
Time	8:21:18 AM	11:21:18 AM	-
Totalizer	2,342,501.020	2,343,601.020	M3
Fluid, Batch No.	Crude	Crude	-
API_{60}	35.1	35.2	°API
ρ_{60}	848.597	848.217	kg/m3
API_{15}	35.0	35.1	°API
ρ_{15}	848.999	848.619	kg/m3
API_{20}	35.6	35.7	°API
ρ_{20}	845.377	844.995	kg/m3
Flowrate, Q_{av}	58.025	58.100	MPH
T_{MP_AVG}	22.874	23.016	°C
P_{MP_AVG}	1210.6	1214.2	kPag
Trips per Run	1	1	-
Roundtrips	Runs 1-3	Runs 1-3	-
Repeatability (r)	0.004	0.002	%
Allowable (r)	0.007	0.007	%
(r) Pass/Fail	Pass	Pass	-
MMF	0.999 997 7	0.999 986 4	-
ΔMMF	NA	(0.001)	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-

Prior vs Current

ΔQ_{av}	0.02	%
ΔT_P	0.222	°C

Roundtrip Measurements							Base Density	
ρ_{obs} kg/m³	T_{dm} °C	P_{dm} kPag	T_{P_INLET} °C	T_{P_OUTLET} °C	T_M °C	T_D °C	ρ_B kg/m³	Run
			23.044	22.978	22.894	23.900	848.809	1
			23.061	23.017	22.933	23.967	848.809	2
			23.039	22.956	22.906	23.956	848.809	3
			22.817	22.817	23.000	23.900	848.809	4
			22.811	22.828	23.056	23.967	848.809	5
			22.811	22.833	23.011	23.956	848.809	6
			22.931	22.905	22.967	23.941	848.809	Avg

Ch 11.1 Iteration Results	Roundtrip Measurements							
	N or N_i Pulses	Q_M MPH	P_{P_INLET} kPag	P_{P_OUTLET} kPag	P_M kPag	T_{P_RUN} °C	P_{P_RUN} kPag	Run
Crude Oil, JP-4	411.103	111.468	1,214.0	1,198.0	1,278.0	23.011 0	1,206.00	1
Crude Oil, JP-4	411.174	111.447	1,218.0	1,200.0	1,282.0	23.039 0	1,209.00	2
Crude Oil, JP-4	411.383	111.449	1,215.0	1,200.0	1,285.0	22.997 5	1,207.50	3
Crude Oil, JP-4	411.357	111.452	1,219.0	1,202.0	1,285.0	22.817 0	1,210.50	4
Crude Oil, JP-4	411.353	111.450	1,220.0	1,204.0	1,287.0	22.819 5	1,212.00	5
Crude Oil, JP-4	411.358	111.466	1,220.0	1,205.0	1,279.0	22.822 0	1,212.50	6
	411.288 0	111.456	1,218.0	1,202.0	1,283.0	22.918 0	1,210.00	Avg

Example A.2 - Calibration Set I - 1 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set I

API Chapter 12.4.2
SI_15 Measurement Units
Sampling Method - Spot
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Crude Oil - Tables 5A/6A

ΔMMF_{SET}	**Pass**	-
(r) $ICPV_{RUN}$	**Pass**	-
(r) CPV_{RUN}	**Pass**	-

Report Summary

	Prior	*Current*
Report No.	Start	Stop
Date	14-Feb-24	14-Feb-24
Time	08:21:18	11:21:18
Fluid, Batch No.	Crude	Crude

N or N_i Pulses	**NKF** P / M3	**IV_M**	**CTL_M**	**CPL_M**	**$CTPL_M$**	**GSV_M** M3	**Run**
411.103	4,382.111 0	0.093 813 9	0.993 256 491	1.000 973 171	0.994 223 099	0.093 271 210	**1**
411.174	4,382.111 0	0.093 830 1	0.993 223 109	1.000 976 451	0.994 192 942	0.093 284 486	**2**
411.383	4,382.111 0	0.093 877 8	0.993 246 220	1.000 978 578	0.994 218 188	0.093 334 279	**3**
411.357	4,382.111 0	0.093 871 9	0.993 165 759	1.000 979 136	0.994 138 203	0.093 320 905	**4**
411.353	4,382.111 0	0.093 871 0	0.993 117 823	1.000 980 994	0.994 092 066	0.093 315 679	**5**
411.358	4,382.111 0	0.093 872 1	0.993 156 343	1.000 974 624	0.994 124 298	0.093 319 798	**6**
411.288 0	4,382.111 0	0.093 856 1	0.993 194 291	1.000 977 159	0.994 164 800	0.093 307 726	**Avg**

Iteraton Results	**CTS_P**	**CPS_P**	**CTL_P**	**CPL_P**	**$CTPL_P$**	**CPV_run** M3	**Run**
Crude Oil, JP-4	1.000 399 304	1.000 059 560	0.993 156 343	1.000 918 946	0.994 069 000	0.093 784 665	**1**
Crude Oil, JP-4	1.000 401 274	1.000 059 708	0.993 132 375	1.000 921 390	0.994 047 438	0.093 799 851	**2**
Crude Oil, JP-4	1.000 399 768	1.000 059 634	0.993 167 899	1.000 920 014	0.994 081 628	0.093 846 839	**3**
Crude Oil, JP-4	1.000 393 086	1.000 059 783	0.993 322 397	1.000 921 293	0.994 237 538	0.093 819 290	**4**
Crude Oil, JP-4	1.000 394 240	1.000 059 857	0.993 320 257	1.000 922 450	0.994 236 545	0.093 814 015	**5**
Crude Oil, JP-4	1.000 394 144	1.000 059 881	0.993 318 118	1.000 922 845	0.994 234 796	0.093 818 328	**6**
	1.000 396 969	1.000 059 737	0.993 236 232	1.000 921 156	0.994 151 158	0.093 813 831	**Avg**

1 means ΔCPV Passed	**$\Delta\rho_{B\_SET}$** kg/m³	**ΔT_{P_SET}** °C	**ΔP_{P_SET}** kPag	**ΔQ_{M_SET}** %	**r% ICPV_run**	**CPV_set**	**CPV_set** M3	
	0.000	0.041	3.00	0.0	0.066	-	0.093 810 452	**Runs 1-3**
	0.000	0.222	3.00	0.0	0.050	-	0.093 821 993	**Runs 2-4**
	0.000	0.181	4.50	0.0	0.035	-	0.093 826 714	**Runs 3-5**
1	0.000	0.005	2.00	0.0	0.006	**Pass**	0.093 817 211	**Runs 4-6**

Signature	**Date**	**Company**
		API Midstream Representative

Example A.2 - Calibration Set I - 2 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set II

General Data

Operator	API Midstream	
Station Name	Headquarters	
Fluid or Batch	Crude	-
Ch 11.1	Crude	-
T_B	15.0	°C
P_B	0.0	kPag

Master Meter

Flowmeter ID	200	-
Manufacturer	API	-
Model	Turbine	-
Nominal Size	75	mm
Type	Turbine	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	4,382.111 0	P / M3
Cartridge No.	API-0011	-

Density Method

ρ_{obs} Method	Spot Sample	-
ρ_{obs} Device	Online Density	-
DMF	0.000 0	-
HYC Factor	No	-

API Chapter 12.4.2
SI_15 Measurement Units
Sampling Method - Spot
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Crude Oil - Tables 5A/6A

Field Prover

Prover Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Unidirectional	-
Wall Design	Single	-
Detector	External	-
Displacer	Captive Displacer	-
Wall Material	316SS	-
Rod Material	Invar	-
GL_P	0.000 016 02	per °C
GL_D	0.000 016 02	per °C
E_P	193 053 196	per kPag
ID_P	441.960 0	mm
WT_P	46.355 0	mm
Serial No.	8904-02	-
Switches	9201 to 9202	-

Calibration Set Criteria

ΔMMF_{SET}	≤ 0.02	%
(r) $ICPV_{RUN}$	≤ 0.02	%
(r) CPV_{RUN}	≤ 0.02	%

Spot Sample

ρ_{60_START}	848.216 823 342 456	kg/m³
ρ_{60_STOP}	848.586 998 731 528	kg/m³
ρ_{60_SET}	848.401 911 036 992	kg/m³
MMF_{SET}	1.000 056 9	-

Report Summary

	Start	Stop	
Report No.	Start 2	Stop 2	-
Date	14-Feb-24	14-Feb-24	-
Time	10:53:11 AM	12:40:18 PM	-
Totalizer	2,342,521.020	2,343,841.020	M3
Fluid, Batch No.	Crude	Crude	-
API_{60}	35.2	35.1	°API
ρ_{60}	848.217	848.587	kg/m3
API_{15}	35.1	35.0	°API
ρ_{15}	848.619	848.989	kg/m3
API_{20}	35.7	35.6	°API
ρ_{20}	844.995	845.367	kg/m3
Flowrate, Q_{av}	83.332	83.434	MPH
T_{MP_AVG}	21.506	21.517	°C
P_{MP_AVG}	1303.8	1306.6	kPag
Trips per Run	1	1	-
Roundtrips	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.011	0.008	%
Allowable (r)	0.020	0.020	%
(r) Pass/Fail	Pass	Pass	-
MMF	1.000 055 2	1.000 058 6	-
ΔMMF	NA	0.000	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-

Prior vs Current

ΔQ_{av}	0.1	%
ΔT_P	0.120	°C

Roundtrip Measurements							Base Density	
ρ_{obs} kg/m³	T_{dm} °C	P_{dm} kPag	T_{FP_INLET} °C	T_{FP_OUTLET} °C	T_{MM} °C	T_{FD} °C	ρ_B kg/m³	Run
			21.494	21.394	21.400	23.956	848.804	1
			21.500	21.411	21.422	23.900	848.804	2
			21.494	21.361	21.461	23.967	848.804	3
								4
								5
								6
			21.496	21.389	21.428	23.941	848.804	Avg

Ch 11.1 Iteration Results	Roundtrip Measurements					T_{FP} and P_{FP} Values		
	N or N_i Pulses	Q_{MM} MPH	P_{FP_INLET} kPag	P_{FP_OUTLET} kPag	P_{MM} kPag	T_{FP} °C	P_{FP} kPag	Run
Crude Oil, JP-4	411.277	83.332	1,284.0	1,279.0	1,268.0	21.444 0	1,281.50	1
Crude Oil, JP-4	411.273	83.331	1,288.0	1,278.0	1,270.0	21.455 5	1,283.00	2
Crude Oil, JP-4	411.278	83.332	1,284.0	1,268.0	1,257.0	21.427 5	1,276.00	3
								4
								5
								6
	411.276 0	83.332	1,285.0	1,275.0	1,265.0	21.442 0	1,280.00	Avg

Example A.2 - Calibration Set II - 1 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set II

API Chapter 12.4.2
SI_15 Measurement Units
Sampling Method - Spot
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Crude Oil - Tables 5A/6A

ΔMMF_{SET}	**Pass**	-
(r) $ICPV_{SET}$	**Pass**	-
(r) CPV_{SET}	**Pass**	-

Report Summary

	Prior	*Current*
Report No.	Start	Stop
Date	Start 2	Stop 2
Time	00:00:00	00:00:00
Fluid, Batch No.	2342521.02	2343841.02

N or N_i Pulses	NKF P / M3	IV_{MM}	CTL_{MM}	CPL_{MM}	$CTPL_{MM}$	GSV_{MM} M3	Run
411.277	4,382.111 0	0.093 853 6	0.994 534 730	1.000 956 853	0.995 486 354	0.093 435 294	1
411.273	4,382.111 0	0.093 852 7	0.994 515 913	1.000 958 492	0.995 469 148	0.093 432 783	2
411.278	4,382.111 0	0.093 853 9	0.994 482 555	1.000 948 896	0.995 426 215	0.093 429 948	3
							4
							5
							6
411.276 0	4,382.111 0	0.093 853 4	0.994 511 066	1.000 954 747	0.995 460 573	0.093 432 675	Avg

Iteraton Results	CTS_{FP}	CPS_{FP}	CTL_{FP}	CPL_{FP}	$CTPL_{FP}$	CPV_run M3	Run
Crude Oil, JP-4	1.000 349 981	1.000 063 289	0.994 497 096	1.000 967 309	0.995 459 081	0.093 822 736	1
Crude Oil, JP-4	1.000 349 452	1.000 063 363	0.994 487 259	1.000 968 509	0.995 450 430	0.093 821 072	2
Crude Oil, JP-4	1.000 349 629	1.000 063 017	0.994 511 209	1.000 963 057	0.995 468 979	0.093 816 493	3
							4
							5
							6
	1.000 349 687	1.000 063 223	0.994 498 521	1.000 966 292	0.995 459 497	0.093 820 100	Avg

	1 means ΔCPV Passed	$\Delta\rho_{B\_SET}$ kg/m³	ΔT_{P_SET} °C	ΔP_{P_SET} kPag	ΔQ_{MM_SET} %	r% ICPV_run	CPV_set	CPV_set M3	
Runs 1-3	1	0.000	0.028	7.00	0.0	0.007	**Pass**	0.093 820 100	**Runs 1-3**
Runs 2-4		NA	NA	NA	NA		-		**Runs 2-4**
Runs 3-5		NA	NA	NA	NA		-		**Runs 3-5**
Runs 4-6		NA	NA	NA	NA		-		**Runs 4-6**

Signature	Date	Company
		API Midstream Representative

Example A.2 - Calibration Set II - 2 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set III

General Data

Operator	API Midstream	
Station Name	Headquarters	
Fluid or Batch	Crude	-
Ch 11.1	Crude	-
T_B	15.0	°C
P_B	0.0	kPag

Master Meter

Flowmeter ID	200	-
Manufacturer	API	-
Model	Turbine	-
Nominal Size	75	mm
Type	Turbine	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	4,382.111 0	P / M3
Cartridge No.	API-0011	-

Density Method

ρ_{obs} Method	Spot Sample	-
ρ_{obs} Device	Online Density	-
DMF	0.000 0	-
HYC Factor	No	-

API Chapter 12.4.2
SI_15 Measurement Units
Sampling Method - Spot
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Crude Oil - Tables 5A/6A

Field Prover

Prover Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Unidirectional	-
Wall Design	Single	-
Detector	External	-
Displacer	Captive Displacer	-
Wall Material	316SS	-
Rod Material	Invar	-
GL_P	0.000 016 02	per °C
GL_D	0.000 016 02	per °C
E_P	193 053 196	per kPag
ID_P	441.960 0	mm
WT_P	46.355 0	mm
Serial No.	8904-02	-
Switches	9201 to 9202	-

Calibration Set Criteria

ΔMMF_{SET}	≤ 0.02	%
(r) $ICPV_{RUN}$	≤ 0.02	%
(r) CPV_{RUN}	≤ 0.02	%

Spot Sample

ρ_{60_START}	848.426 922 906 387	kg/m³
ρ_{60_STOP}	848.386 903 945 631	kg/m³
ρ_{60_SET}	848.406 913 426 009	kg/m³
MMF_{SET}	0.999 855 4	-

Report Summary

	Start	Stop	
Report No.	Start 3	Stop 3	-
Date	14-Feb-24	14-Feb-24	-
Time	8:21:18 AM	11:21:18 AM	-
Totalizer	2,342,501.020	2,343,601.020	M3
Fluid, Batch No.	Crude	Crude	-
API_{60}	35.1	35.1	°API
ρ_{60}	848.427	848.387	kg/m3
API_{15}	35.1	35.1	°API
ρ_{15}	848.829	848.789	kg/m3
API_{20}	35.6	35.6	°API
ρ_{20}	845.206	845.166	kg/m3
Flowrate, Q_{av}	140.250	140.222	MPH
T_{MP_AVG}	22.833	22.911	°C
P_{MP_AVG}	1294.1	1298.3	kPag
Trips per Run	1	1	-
Roundtrips	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.008	0.014	%
Allowable (r)	0.020	0.020	%
(r) Pass/Fail	Pass	Pass	-
MMF	0.999 845 2	0.999 865 5	-
ΔMMF	NA	0.002	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-

Prior vs Current

ΔQ_{av}	0.1	%
ΔT_P	0.120	°C

Roundtrip Measurements							Base Density	
ρ_{obs} kg/m³	T_{dm} °C	P_{dm} kPag	T_{FP_INLET} °C	T_{FP_OUTLET} °C	T_{MM} °C	T_{FD} °C	ρ_B kg/m³	Run
			22.817	22.889	22.994	23.956	848.809	1
			22.806	22.844	22.994	23.900	848.809	2
			22.822	22.856	23.000	23.967	848.809	3
								4
								5
								6
			22.815	22.863	22.996	23.941	848.809	Avg

Ch 11.1 Iteration Results	Roundtrip Measurements					T_{FP} and P_{FP} Values		
	N or N_i Pulses	Q_{MM} MPH	P_{FP_INLET} kPag	P_{FP_OUTLET} kPag	P_{MM} kPag	T_{FP} °C	P_{FP} kPag	Run
Crude Oil, JP-4	411.407	140.247	1,214.0	1,198.0	1,278.0	22.853 0	1,206.00	1
Crude Oil, JP-4	411.413	140.248	1,218.0	1,200.0	1,282.0	22.825 0	1,209.00	2
Crude Oil, JP-4	411.408	140.247	1,215.0	1,200.0	1,285.0	22.839 0	1,207.50	3
								4
								5
								6
	411.409 3	140.247	1,216.0	1,199.0	1,282.0	22.839 0	1,208.00	Avg

Example A.2 - Calibration Set III - 1 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set III

API Chapter 12.4.2
SI_15 Measurement Units
Sampling Method - Spot
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Crude Oil - Tables 5A/6A

ΔMMF_{SET}	**Pass**	-
(r) $ICPV_{SET}$	**Pass**	-
(r) CPV_{SET}	**Pass**	-

Report Summary

	Prior	*Current*
Report No.	Start	Stop
Date	Start 3	Stop 3
Time	00:00:00	00:00:00
Fluid, Batch No.	2342501.02	2343601.02

N or N_i Pulses	**NKF** P / M3	**IV_{MM}**	**CTL_{MM}**	**CPL_{MM}**	**$CTPL_{MM}$**	**GSV_{MM}** M3	**Run**
411.407	4,382.111 0	0.093 883 3	0.993 170 895	1.000 973 761	0.994 138 006	0.093 319 461	**1**
411.413	4,382.111 0	0.093 884 7	0.993 170 895	1.000 976 812	0.994 141 036	0.093 321 137	**2**
411.408	4,382.111 0	0.093 883 5	0.993 165 759	1.000 979 136	0.994 138 203	0.093 319 678	**3**
							4
							5
							6
411.409 3	4,382.111 0	0.093 883 8	0.993 169 183	1.000 976 570	0.994 139 082	0.093 320 092	**Avg**

Iteraton Results	**CTS_{FP}**	**CPS_{FP}**	**CTL_{FP}**	**CPL_{FP}**	**$CTPL_{FP}$**	**CPV_run** M3	**Run**
Crude Oil, JP-4	1.000 395 137	1.000 059 560	0.993 291 584	1.000 918 066	0.994 203 491	0.093 820 879	**1**
Crude Oil, JP-4	1.000 393 342	1.000 059 708	0.993 315 550	1.000 920 195	0.994 229 594	0.093 820 256	**2**
Crude Oil, JP-4	1.000 394 865	1.000 059 634	0.993 303 567	1.000 919 130	0.994 216 543	0.093 819 885	**3**
							4
							5
							6
	1.000 394 448	1.000 059 634	0.993 303 567	1.000 919 130	0.994 216 543	0.093 820 340	**Avg**

	1 means ΔCPV Passed	**$\Delta\rho_{B\_SET}$** kg/m³	**ΔT_{P_SET}** °C	**ΔP_{P_SET}** kPag	**ΔQ_{MM_SET}** %	**r% ICPV_run**	**CPV_set**	**CPV_set** M3	
Runs 1-3	1	0.000	0.028	3.00	0.0	0.001	**Pass**	0.093 820 340	**Runs 1-3**
Runs 2-4		NA	NA	NA	NA		-		**Runs 2-4**
Runs 3-5		NA	NA	NA	NA		-		**Runs 3-5**
Runs 4-6		NA	NA	NA	NA		-		**Runs 4-6**

Signature	**Date**	**Company**
		API Midstream Representative

Example A.2 - Calibration Set III - 2 of 2

Annex B
(informative)
USC Unit Examples[3]

Example B.1 – Standard Method

USC Units, Continuous Sampling, Master Prover - Bidirectional Free Displacer, Master Meter - PD, MF r% - Fixed Range, MF Method - IMF, Field Prover - Bidirectional Free Displacer

[3] The following examples are for illustration purposes only. Each company should develop its own approach. They are not to be considered exclusive or exhaustive in nature. API makes no warranties, express or implied, for reliance on or any omissions from the information contained in this document.

	Master Prover	
BPV Units	0	(0-USC_{60}, 1-SI_{15}, 2-SI_{20})
Detector Design	0	(0-Internal, 1-External)
Wall Material	1	(1-CS, 2-304SS, 3-316SS, 4-17-4PH)
Rod Material	0	(0-NA, 1-CS, 2-304SS, 3-316SS, 4-17-4PH, 5-Invar)
Certificate BPV	30,030.795 3	cubic inches at 60.0 °F, 0.0 psig

	Base Prover Volume (BPV)		
	BPV_{60} Barrels	**BPV_{15} Cubic Meters**	**BPV_{20} Cubic Meters**
	3. 095 320 068 027	0. 492 107 411 000	0. 492 189 795 000
Decimals	9	10	10
Conversion	in^3 / Bbl 9.702E+03	mL / M^3 1.00E+06	mL / M^3 1.00E+06
Rnd'd BPV	3.095 320 068 000	0.492 107 411 000	0.492 189 795 000

in^3 = mL / 16.387 064
U.S. Gallons = in^3 / 2.31E+02
Bbl = in^3 / 9.702E+03
Cubic Feet = in^3 / 1.728E+03

mL = M^3 x 1E+06
mL = in^3 x 16.387 064

M^3 = mL x 1E-06
L = mL x 1E-03

Note: This Worksheet produces a BPV_{60} or BPV_{SI} to **10 digits** (the appropriate decimal place) to increase the precision of the Master Prover's BPV, not the uncertainty of the Master Prover's BPV.

T_B	60.0	°F
Decimal Base CTS	9	-
Decimal BPV_{60}	4	cubic inches at 60.0 °F, 0.0 psig
Decimal BPV_{SI}	3	mL at 15.0 °C and 0.0 kPag
Decimal BPV	9	Barrels

Detector Design,

$CTS_P = [1 + (T_P - T_B) \times GL_P]^3$, for detectors mounted in calibrated section

$CTS_P = [1 + (T_P - T_B) \times GL_P]^2 \times [1 + (T_D - T_B) \times GL_d]$, for detectors mounted on external shaft

If Measurement Units = 0, then BPV in cubic inches, T_B is 60.0 °F

BPV_{60} = cubic inches at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 1, then BPV in mL, T_B is 15.0 °C

BPV_{60} = ROUND(BPV_{15} / 16.387 064 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(BPV_{15} x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 2, then BPV in mL, T_B is 20.0 °C

BPV_{60} = ROUND(BPV_{20} / 16.387 064 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(CPV_{20} x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = mL at 20.0 °C, 0.0 kPag

T_B	60.0 °F	15.0 °C	20.0 °C
GL_P	0.000 006 20	0.000 011 16	0.000 011 16
GL_D	NA	NA	NA
Base CTS_{60}	1.000 000 000	1.000 018 600	0.999 851 207
Base CTS_{15}	0.999 981 400	1.000 000 000	0.999 832 609
Base CTS_{20}	1.000 148 807	1.000 167 409	1.000 000 000

API Properties

Linear Coefficient of Thermal Expansion, GL

	SI Unit[2,4] (per °C)	**USC Unit[2,3,5]** (per °F)
Mild Carbon	0.000 011 16	**0.000 006 20**
304 SS	**0.000 017 28**	0.000 009 60
316 SS	**0.000 016 02**	0.000 008 90
17-4PH	0.000 010 80	**0.000 006 00**
Invar™	0.000 001 44	**0.000 000 80**

Notes:

(1) The User/Owner should obtain GL values from the prover manufacturer.

(2) The GL values shown above are a function of the materials, operating temperature range, calibration temperature range. Values in **bold face** were obtained from American Society of Metals (ASM) International, 2020 edition.

(3) GL values shown above are applicable from 0 °C to 100 °C (32 °F to 212 °F). If operating outside this range, the GL values depicted are not appropriate.

(4) The SI values of GL per °C **not in bold face**, was obtained by multiplying the USC values, GL per °F, times 1.8.

(5) The USC values per °F **not in bold face**, was obtained by dividing the SI values, GL per °C, by 1.8.

Base Unit Volume

BPV_{60}	30,030.795 3	cubic inches at 60.0 °F, 0.0 psig
BPV_{15}	492,107.411	mL at 15.0 °C and 0.0 kPag
BPV_{20}	492,189.795	mL at 20.0 °C and 0.0 kPag

Example B.1 - Expanded Discrimination of Master Prover's BPV

Washington, D.C., USA

Master Meter Proving Report

General Data

Operator	API Midstream	-
Station Name	MPMS	-
Ch 11.1	Tables 5B/6B	-
T_B	60.0	°F
P_B	0.0	psig

Master Meter

Flowmeter ID	200	-
Manufacturer	API	-
Model	PD	-
Nominal Size	4	inch
Type	PD	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	8,400.000 0	P / Bbl
Cartridge No.	API-0011	-

Density Method

Sample Method	Continuous	-
ρ_{obs} Device	Densitometer	-
DMF	0.999 8	-
HYC Factor	NA	-

API MPMS Chapter 12.4.2
Measurement Units - USC
Sampling Method - Continuous (or Online)
Meter Factor Method - Intermediate (or IMF)
Repeatability Method (r%) - Fixed, 5 out of 5 Runs
API MPMS Chapter 11.1 - Tables 5B/6B

Displacement Prover

Manufacturer	API	-
Prover Type	Displacement	-
Flow Design	Bidirectional	-
Wall Design	Single	-
Detector	Internal	-
Displacer	Free Sphere	-
Wall Material	Carbon Steel	-
Rod Material	NA	-
GL_P	0.000 006 20	per °F
GL_D	NA	per °F
E_P	030 000 000	per psig
ID_P	7.981 0	inch
WT_P	0.322 0	inch
Calibration Date	2021-09-04	-
Serial No.	8904-01	-
Certificate No.	10101010	-
Switches	9201 to 9202	-
BPV	3.095 320 068 0	Bbl

Spot Sample

API_{ind}		°API
ρ_{ind}		kg/m³
T_{obs}		°F
P_{obs}	NA	psig

Report Summary

	Start	Stop	
Report No.	Start I	Stop I	-
Date	14-Feb-24	14-Feb-24	-
Time	8:21:18	11:21:18	-
Totalizer	2,342,501.020	2,343,601.020	Bbl
Fluid, Batch No.	Products	Products	-
API_{60}	60.8	60.6	°API
ρ_{60}	735.210	735.710	kg/m³
API_{15}	60.7	60.5	°API
ρ_{15}	735.715	736.216	kg/m³
API_{20}	61.7	61.5	°API
ρ_{20}	731.158	731.660	kg/m³
Flowrate, Q	700.350	700.350	BPH
T_{P_AVG}	73.090	73.093	°F
P_{P_AVG}	170.6	175.4	psig
Trips per Run	1	1	-
Roundtrips	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.018	0.017	%
Allowable (r)	0.020	0.020	%
(r) Pass/Fail	Pass	Pass	-
MMF	0.999 900 0	0.999 904 1	-
ΔMMF	NA	0.000	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-

Prior vs Current

ΔQ	0.0	%
ΔT_P	0.003	°F

Base Density	Roundtrip Measurements							Base Density	
API_B °API	ρ_{ind} kg/m³	T_{dm} °F	P_{dm} psig	T_{P_INLET} °F	T_{P_OUTLET} °F	T_M °F	T_D °F	ρ_B kg/m³	Run
60.7	729.543	73.840	184.6	73.070	73.200	73.390		735.311	1
60.6	729.745	74.730	184.9	73.050	73.120	73.370		735.959	2
60.6	729.543	74.770	186.2	73.080	73.140	73.400		735.770	3
60.6	729.545	74.750	185.8	73.060	73.070	73.350		735.764	4
60.6	729.512	74.780	185.8	73.050	73.090	73.260		735.747	5
NA									6
NA									7
NA									8
NA									9
NA									10
60.6	729.578	74.574	185.5	NA	NA	73.354	NA	735.710	Runs 1-5

Commodity Type	Roundtrip Measurements					T_P and P_P Values		
	N or N_i Pulses	Q_M BPH	P_{P_INLET} psig	P_{P_OUTLET} psig	P_M psig	T_{P_RUN} °F	P_{P_RUN} psig	Run
Gasoline, Napthene	26,020.000	700.110 0	177.9	173.2	173.5	73.135 0	175.55	1
Gasoline, Napthene	26,016.000	700.120 0	178.2	172.9	173.4	73.085 0	175.55	2
Gasoline, Napthene	26,018.000	700.250 0	177.2	173.4	173.0	73.110 0	175.30	3
Gasoline, Napthene	26,020.000	701.020 0	177.6	173.7	173.5	73.065 0	175.65	4
Gasoline, Napthene	26,018.000	700.240 0	177.2	173.0	173.8	73.070 0	175.10	5
NA								6
NA								7
NA								8
NA								9
NA								10
Runs 1-5	26,018.400 0	700.350 0	NA	NA	173.4	73.093 0	175.40	Runs 1-5

Example B.1 - Calibration Set I - Stop Proving Report - 1 of 2

Washington, D.C., USA

Master Meter Proving Report

API MPMS Chapter 12.4.2
Measurement Units - USC
Sampling Method - Continuous (or Online)
Meter Factor Method - Intermediate (or IMF)
Repeatability Method (r%) - Fixed, 5 out of 5 Runs
API MPMS Chapter 11.1 - Tables 5B/6B

Report Summary

	Prior	*Current*
Report No.	Start I	Stop I
Date	14-Feb-24	14-Feb-24
Time	08:21:18	11:21:18
Fluid, Batch No.	Products	Products

Run	BPV Bbl	CTS_P	CPS_P	Rnd CTL_P	Rnd CPL_P	Rnd $CTPL_P$	GSV_P Bbl	Run
1	3.095 320 068 0	1.000 244 331	1.000 145 038	0.990 943 192	1.001 436 670	0.992 366 851	3.072 889 158 0	1
2	3.095 320 068 0	1.000 243 401	1.000 145 038	0.990 989 845	1.001 431 843	0.992 408 787	3.073 016 158 0	2
3	3.095 320 068 0	1.000 243 866	1.000 144 831	0.990 969 051	1.001 431 272	0.992 387 398	3.072 950 717 0	3
4	3.095 320 068 0	1.000 243 029	1.000 145 120	0.991 000 024	1.001 433 887	0.992 421 006	3.073 053 104 0	4
5	3.095 320 068 0	1.000 243 122	1.000 144 666	0.990 996 239	1.001 429 546	0.992 412 914	3.073 026 937 0	5
6								6
7								7
8								8
9								9
10								10
Runs 1-5	3.095 320 068 0	1.000 243 550	1.000 144 939	0.990 979 670	1.001 432 644	0.992 399 391	3.072 987 215 0	Runs 1-5

Run	N or N_i	NKF P / Bbl	IV_M	Rnd CTL_M	Rnd CPL_M	Rnd $CTPL_M$	ISV_M Bbl	Run
1	26,020.000	8,400.000 0	3.097 619 048 0	0.990 766 899	1.001 421 479	0.992 175 254	3.073 380 964 0	1
2	26,016.000	8,400.000 0	3.097 142 857 0	0.990 793 079	1.001 416 072	0.992 196 113	3.072 973 105 0	2
3	26,018.000	8,400.000 0	3.097 380 952 0	0.990 768 752	1.001 414 286	0.992 169 983	3.073 128 405 0	3
4	26,020.000	8,400.000 0	3.097 619 048 0	0.990 803 180	1.001 418 104	0.992 208 242	3.073 483 150 0	4
5	26,018.000	8,400.000 0	3.097 380 952 0	0.990 865 007	1.001 420 115	0.992 272 149	3.073 444 854 0	5
6								6
7								7
8								8
9								9
10								10
Runs 1-5	26,018.400 0	8,400.000 0	3.097 428 571 0	0.990 799 383	1.001 418 011	0.992 204 348	3.073 282 096 0	Runs 1-5

Run	'1' indicates Repeatability (r%) criteria satisifed	Repeatability (r%) Actual	Repeatability (r%) Allowable	Meter Factor Method - Intermediate (or IMF)	IMF	Run
NA		NA	NA		0.999 839 98	1
NA		NA	NA		1.000 014 01	2
NA	NA	NA	NA	Repeatability Method (r%) - Fixed, 5 out of 5 Runs	0.999 942 18	3
NA	NA	NA	NA		0.999 860 08	4
Runs 1-5	1	0.017	0.020		0.999 864 02	5
Runs 2-6			0.020			6
Runs 3-7			0.020			7
Runs 4-8			0.020			8
Runs 5-9			0.020			9
Runs 6-10			0.020			10
	Pass	0.017			0.999 904 10	MMF

MMF Rounded to 7 decimal places

		API Midstream Representative

Example B.1 - Calibration Set I - Stop Proving Report - 2 of 2

	Field Prover	
Measurement Units	0	(0-USC_{60}, 1-SI_{15}, 2-SI_{20})
Detector Design	0	(0-Internal, 1-External)
Wall Material	1	(1-CS, 2-304SS, 3-316SS, 4-17-4PH)
Rod Material	0	(0-NA, 1-CS, 2-304SS, 3-316SS, 4-17-4PH, 5-Invar)
Source for GL_{MP}, GL_{md}, E_{MP}	1	(0-Prover Manufacturer, 1-API Table)
BPV_P	115,481.685 8	cubic inches at 60.0 °F, 0.0 psig

	Base Prover Volume (BPV)		
	BPV_{60} Barrels	**BPV_{15} Cubic Meters**	**BPV_{20} Cubic Meters**
	11. 902 874 232 117	1. 892 370 577 000	1. 892 687 379 000
Decimals	4	5	5
Conversion	in^3 / Bbl 9.702E+03	mL / M^3 1.00E+06	mL / M^3 1.00E+06
Rnd'd BPV	11.902 900 000 000	1.892 370 000 000	1.892 690 000 000

in^3 = mL / 16.387 064
U.S. Gallons = in^3 / 2.31E+02
Bbl = in^3 / 9.702E+03
Cubic Feet = in^3 / 1.728E+03

mL = M^3 x 1E+06
mL = in^3 x 16.387 064

M^3 = mL x 1E-06
L = mL x 1E-03

Note: This Worksheet produces a BPV_{60} or BPV_{SI} to **6 digits** (the appropriate decimal place).

T_B	60.0	°F
Decimal Base CTS	9	-
Decimal BPV_{60}	4	cubic inches at 60.0 °F, 0.0 psig
Decimal BPV_{SI}	3	mL at 15.0 °C and 0.0 kPag
Decimal BPV	4	Barrels
Decimal BPV	5	Cubic Meters

API Properties

Linear Coefficient of Thermal Expansion, GL

	SI Unit[2,4] (per °C)	**USC Unit[2,3,5]** (per °F)
Mild Carbon	0.000 011 16	0.000 006 20
304 SS	**0.000 017 28**	0.000 009 60
316 SS	**0.000 016 02**	0.000 008 90
17-4PH	0.000 010 80	**0.000 006 00**
Invar™	0.000 001 44	**0.000 000 80**

Detector Design,

$CTS_P = [1 + (T_P - T_B) \times GL_P]^3$, for detectors mounted in calibrated section

$CTS_P = [1 + (T_P - T_B) \times GL_P]^2 \times [1 + (T_D - T_B) \times GL_d]$, for detectors mounted on external shaft

If Measurement Units = 0, then BPV in cubic inches, T_B is 60.0 °F

BPV_{60} = cubic inches at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 1, then BPV in mL, T_B is 15.0 °C

BPV_{60} = ROUND(BPV_{15} / 16.387 064 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(BPV_{15} x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 2, then BPV in mL, T_B is 20.0 °C

BPV_{60} = ROUND(BPV_{20} / 16.387 064 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(CPV_{20} x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = mL at 20.0 °C, 0.0 kPag

Notes:

(1) The User/Owner should obtain GL values from the prover manufacturer.

(2) The GL values shown above are a function of the materials, operating temperature range, calibration temperature range. Values in **bold face** were obtained from American Society of Metals (ASM) International, 2020 edition.

(3) GL values shown above are applicable from 0 °C to 100 °C (32 °F to 212 °F). If operating outside this range, the GL values depicted are not appropriate.

(4) The SI values of GL per °C **not in bold face**, was obtained by multiplying the USC values, GL per °F, times 1.8.

(5) The USC values per °F **not in bold face**, was obtained by dividing the SI values, GL per °C, by 1.8.

GL_P	0.000 006 20	0.000 011 16	0.000 011 16
GL_D	NA	NA	NA
T_B	60.0	15.0	20.0
Base CTS_{60}	1.000 000 000	1.000 018 600	0.999 851 207
Base CTS_{15}	0.999 981 400	1.000 000 000	0.999 832 609
Base CTS_{20}	1.000 148 807	1.000 167 409	1.000 000 000

Base Unit Volume

BPV_{60}	115,481.685 8	cubic inches at 60.0 °F, 0.0 psig
BPV_{15}	1,892,370.577 0	mL at 15.0 °C and 0.0 kPag
BPV_{20}	1,892,687.379 0	mL at 20.0 °C and 0.0 kPag

Example B.1 - Field Prover's BPV Conversion

Washington, D.C., USA

BPV Determination using a Master Meter - Standard Method

General Data		Master Meter			Field Prover		
API Midstream	Operator	Flowmeter ID	200	-	Manufacturer	API	-
Headquarters	Station Name	Manufacturer	API	-	Prover Design	Displacement	-
Washington	City, Town	Model	API-PD	-	Flow Design	Bidirectional	-
D.C.	State, Province	Nominal Size	4	inch	Wall Design	Single	-
USA	Country	Type	PD	-	Detector	Internal	-
RBOB	Fluid, Batch No.	Proving Result	MMF	-	Displacer	Free Sphere	-
Products	Ch 11.1	T_F Comp	No	-	Wall Material	Carbon Steel	-
60.0	T_B	P_F Comp	No	-	Rod Material	NA	-
0.0	P_B	NKF	8,400.000 0	P / Bbl	GL_P	0.000 006 20	per °F
14-Feb-2024	Start Calibration	Cartridge No.	API-0011	-	GL_D	NA	per °F
14-Feb-2024	Stop Calibration	**Density Method**			E_P	030 000 000	per psig
API Chapter 12.4.2		ρ_{obs} Method	Continuous	-	ID_P	21.562 0	inch
USC_60 Measurement Units		ρ_{obs} Device	Online Density	-	WT_P	1.219 0	inch
Sampling Method - Continuous		DMF	0.999 8	-	Trips per Run	1	-
BPV - Standard Method		HYC Factor	No	-	Serial No.	Bidi-SI-001	-
Fixed Range Method, r ≤ 0.02%, for 3 consecutive Calibration Sets					Switches	9206 to 9236	-
Refined Product - Tables 5B/6B							

	Calibration Set I		Calibration Set II		Calibration Set III		
	Start	**Stop**	**Start**	**Stop**	**Start**	**Stop**	
Report No.	Start 1	Stop 1	Start 2	Stop 2	1	Stop 1	-
Date	14-Feb-24	14-Feb-24	14-Feb-24	14-Feb-24	14-Feb-24	14-Feb-24	-
Products	Products	Products	84RBOB	84RBOB	Products	Products	-
API_B	60.8	60.6	61.0	61.0	60.8	60.6	°API
ρ_B	735.210	735.710	734.457	734.419	735.210	735.710	kg/m^3
Q_{MM}	700.350	700.350	524.145	524.785	882.146	881.970	BPH
T_{MP_AVG}	73.090	70.093	70.710	70.730	73.100	73.240	°F
P_{MP_AVG}	170.6	175.4	189.1	189.5	187.7	188.3	psig
Roundtrips	Runs 1-5	Runs 1-5	Runs 1-5	Runs 1-5	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.018	0.017	0.011	0.008	0.018	0.017	%
MMF	0.999 900 0	0.999 904 1	0.999 974 0	0.999 999 0	1.000 099 0	1.000 154 0	-
MMF_{SET}	NA	0.999 902 1	NA	0.999 986 5	NA	1.000 126 5	-
ΔMMF	NA	0.000	NA	0.003	NA	0.006	%
	ΔMMF_{SET}	**Pass**		**Pass**		**Pass**	
	(r) CPV_{RUN}	**Pass**	-	**Pass**	-	**Pass**	-
	(R) CPV_{SET}	NA	-	**Pass**	-	**Pass**	-
	ΔQ_{SET}	NA	-	**Pass**	-	**Pass**	-
	Selected Set	**Runs 4-6**	-	**Runs 1-3**	-	**Runs 1-3**	-
	CPV_{SET}	**11.903 715 5**	Bbls	**11.902 465 7**	Bbls	**11.903 036 5**	Bbls
	API_{B_SET}	60.7	°API	61.1	°API	60.7	°API
	ρ_{B_SET}	735.456	kg/m^3	734.016	kg/m^3	735.383	kg/m^3
	T_{FP_SET}	73.080	°F	70.600	°F	73.110	°F
	P_{FP_SET}	175.7	psig	185.7	psig	175.1	psig
	Q_{MM_SET}	701.040	BPH	524.142	BPH	882.128	BPH
CPV_{SET} Stability Parameters	ΔMMF_{SET}	0.000	%	0.003	%	0.006	%
	$\Delta\rho_{B\_SET}$	0.072	kg/m^3	0.292	kg/m^3	0.278	kg/m^3
	ΔT_{P_SET}	0.010	°F	0.050	°F	0.050	°F
	ΔP_{P_SET}	0.3	psig	1.1	psig	0.4	psig
	ΔQ_{MM_SET}	0.0	%	0.0	%	0.0	%
	$\Delta Q_{between\ SETS}$	NA	%	(25.2)	%	40.6	%
	(r) CPV_{RUN}	0.004	%	0.015	%	0.006	%
	(R) CPV_{SET}	NA	%	0.011	%	0.005	%

Example B.1 - Calibration Report Summary - 1 of 2

Washington, D.C., USA

BPV Determination using a Master Meter - Standard Method

General Data

API Midstream	Operator
Headquarters	Station Name
Washington	City, Town
D.C.	State, Province
USA	Country
RBOB	Fluid, Batch No.
Products	Ch 11.1
60.0	T_B
0.0	P_B
14-Feb-2024	Start Calibration
14-Feb-2024	Stop Calibration

API Chapter 12.4.2
USC_60 Measurement Units
Sampling Method - Continuous
BPV - Standard Method
Fixed Range Method, r ≤ 0.02 %, for 3 consecutive Calibration Sets
Refined Product - Tables 5B/6B

BPV_{NEW}	11.903 100 0	Bbls
BPV_{OLD}	11.902 900 0	Bbls
ΔBPV	0.000 200 0	Bbls
ΔBPV	0.001 7	% BPV_{NEW} Bigger / (Smaller)
Average CPV_{SET}	11.903 072 600	Bbls
BPV_{60}	115,483.610 4	in^3 at 60.0 °F and 0.0 psig
BPV_{15}	1,892,402.115	mL at 15.0 °C and 0.0 kPag
BPV_{20}	1,892,718.922	mL at 20.0 °C and 0.0 kPag

Field Prover

Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Bidirectional	-
Wall Design	Single	-
Detector	Internal	-
Displacer	Free Sphere	-
Wall Material	Carbon Steel	-
Rod Material	NA	-
GL_P	0.000 006 20	per °F
GL_D	NA	per °F
E_P	030 000 000	per psig
ID_P	21.562 0	inch
WT_P	1.219 0	inch
Serial No.	Bidi-SI-001	-
Switches	9206 to 9236	-

Base Prover Volume (BPV_{NEW})

BPV_{60}			BPV_{15}		BPV_{20}	
Barrels	**U.S. Gallons**	**Cubic Feet**	**Cubic Meters**	**Liters**	**Cubic Meters**	**Liters**
-	-	-	-	-	-	-
-	-	-	-	1,892.40	-	1,892.72
-	499.929	-	-	-	-	-
11.903 1	-	66.830 8	-	-	-	-
-	-	-	1.892 40	-	1.892 72	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

Note: The BPV_{NEW} values (BPV_{60}, BPV_{15}, BPV_{20}) shown are reported to 6 significant digits (10 ppm, or, 0.001%).

Signature	Date	Company
		API Midstream Representative

Example B.1 - Calibration Report Summary - 2 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set I

General Data		
Operator	API Midstream	
Station Name	Headquarters	
Fluid or Batch	RBOB	-
Ch 11.1	Products	-
T_B	60.0	°F
P_B	0.0	psig

Master Meter		
Flowmeter ID	200	-
Manufacturer	API	-
Model	API-PD	-
Nominal Size	4	inch
Type	PD	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	8,400.000 0	P / Bbl
Cartridge No.	API-0011	-

Density Method		
ρ_{obs} Method	Continuous	-
ρ_{obs} Device	Online Density	-
DMF	0.999 8	-
HYC Factor	No	-

API Chapter 12.4.2
USC_60 Measurement Units
Sampling Method - Continuous
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Refined Product - Tables 5B/6B

Field Prover		
Prover Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Bidirectional	-
Wall Design	Single	-
Detector	Internal	-
Displacer	Free Sphere	-
Wall Material	300 SS	-
Rod Material	NA	-
GL_P	0.000 006 20	per °F
GL_D	NA	per °F
E_P	030 000 000	per psig
ID_P	21.562 0	inch
WT_P	1.219 0	inch
Serial No.	Bidi-SI-001	-
Switches	9206 to 9236	-

Calibration Set Criteria		
ΔMMF_{SET}	≤ 0.02	%
(r) $ICPV_{RUN}$	≤ 0.02	%
(r) CPV_{RUN}	≤ 0.02	%

Spot Sample		
ρ_{60_START}	NA	kg/m³
ρ_{60_STOP}	NA	kg/m³
ρ_{60_SET}	NA	kg/m³
MMF_{SET}	0.999 902 1	-

Report Summary	Start	Stop	
Report No.	Start 1	Stop 1	-
Date	14-Feb-24	14-Feb-24	-
Time	8:21:18 AM	11:21:18 AM	-
Totalizer	2,342,501.020	2,343,601.020	Bbl
Fluid, Batch No.	Products	Products	-
API_{60}	60.8	60.6	°API
ρ_{60}	735.210	735.710	kg/m3
API_{15}	60.7	60.5	°API
ρ_{15}	735.715	736.216	kg/m3
API_{20}	61.7	61.5	°API
ρ_{20}	731.158	731.660	kg/m3
Flowrate, Q_{av}	700.350	700.350	BPH
T_{MP_AVG}	73.090	70.093	°F
P_{MP_AVG}	170.6	175.4	psig
Trips per Run	1	1	-
Roundtrips	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.018	0.017	%
Allowable (r)	0.020	0.020	%
(r) Pass/Fail	Pass	Pass	-
MMF	0.999 900 0	0.999 904 1	-
ΔMMF	NA	0.000	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	**Pass**	-

Prior vs Current		
ΔQ_{av}	0.02	%
ΔT_P	0.065	°C

Roundtrip Measurements							Base Density	
ρ_{obs} kg/m³	T_{dm} °F	P_{dm} psig	T_{P_INLET} °F	T_{P_OUTLET} °F	T_M °F	T_D °F	ρ_B kg/m³	Run
729.748	73.230	174.5	73.070	73.200	73.390		735.415	1
729.843	73.230	175.2	73.050	73.120	73.390		735.506	2
729.545	73.270	175.2	73.080	73.140	73.400		735.228	3
729.748	73.240	175.5	73.070	73.070	73.400		735.414	4
729.799	73.240	174.8	73.060	73.090	73.500		735.469	5
729.823	73.230	175.1	73.060	73.100	73.420		735.486	6
729.751	73.240	175.1	73.070	73.120	73.420		735.420	Avg

Ch 11.1 Iteration Results	Roundtrip Measurements							
	N or N_i Pulses	Q_M BPH	P_{P_INLET} psig	P_{P_OUTLET} psig	P_M psig	T_{P_RUN} °F	P_{P_RUN} psig	Run
Gasoline, Napthene	100,015.000	701.110	176.1	173.8	185.4	73.135 0	174.95	1
Gasoline, Napthene	100,001.000	700.982	176.7	174.0	185.9	73.085 0	175.35	2
Gasoline, Napthene	100,022.000	700.995	176.2	174.0	186.4	73.110 0	175.10	3
Gasoline, Napthene	100,051.000	701.014	176.8	174.3	186.4	73.070 0	175.55	4
Gasoline, Napthene	100,054.000	701.002	176.9	174.6	186.7	73.075 0	175.75	5
Gasoline, Napthene	100,052.000	701.103	176.9	174.8	185.5	73.080 0	175.85	6
	100,032.500 0	701.034	176.6	174.3	186.1	73.090 0	175.40	Avg

Example B.1 - Calibration Set I - 1 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set I

API Chapter 12.4.2
USC_60 Measurement Units
Sampling Method - Continuous
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Refined Product - Tables 5B/6B

ΔMMF_{SET}	Pass	-
(r) $ICPV_{RUN}$	Pass	-
(r) CPV_{RUN}	Pass	-

Report Summary

	Prior	*Current*
Report No.	Start	Stop
Date	14-Feb-24	14-Feb-24
Time	08:21:18	11:21:18
Fluid, Batch No.	Products	Products

N or N_i Pulses	NKF P / Bbl	IV_M	CTL_M	CPL_M	$CTPL_M$	GSV_M Bbls	Run
100,015.000	8,400.000 0	11.906 547 6	0.990 768 877	1.001 518 360	0.992 273 221	11.813 391 700	1
100,001.000	8,400.000 0	11.904 881 0	0.990 770 609	1.001 521 790	0.992 278 354	11.811 799 200	2
100,022.000	8,400.000 0	11.907 381 0	0.990 758 393	1.001 528 016	0.992 272 288	11.814 207 500	3
100,051.000	8,400.000 0	11.910 833 3	0.990 761 947	1.001 526 637	0.992 274 480	11.817 658 900	4
100,054.000	8,400.000 0	11.911 190 5	0.990 693 883	1.001 529 367	0.992 209 018	11.817 233 600	5
100,052.000	8,400.000 0	11.910 952 4	0.990 749 505	1.001 518 856	0.992 254 311	11.817 536 800	6
100,032.500 0	8,400.000 0	11.908 631 0	0.990 750 536	1.001 523 838	0.992 260 279	11.815 304 600	Avg

Iteraton Results	CTS_P	CPS_P	CTL_P	CPL_P	$CTPL_P$	CPV_run Bbls	Run
Gasoline, Napthene	1.000 244 331	1.000 103 152	0.990 945 132	1.001 431 033	0.992 363 208	11.900 167 000	1
Gasoline, Napthene	1.000 243 401	1.000 103 388	0.990 981 383	1.001 433 360	0.992 401 816	11.898 108 100	2
Gasoline, Napthene	1.000 243 866	1.000 103 241	0.990 958 917	1.001 433 403	0.992 379 360	11.900 799 500	3
Gasoline, Napthene	1.000 243 122	1.000 103 506	0.990 990 040	1.001 435 540	0.992 412 646	11.903 882 700	4
Gasoline, Napthene	1.000 243 215	1.000 103 624	0.990 987 612	1.001 436 825	0.992 411 488	11.903 465 600	5
Gasoline, Napthene	1.000 243 308	1.000 103 683	0.990 984 476	1.001 437 557	0.992 409 073	11.903 798 200	6
	1.000 243 541	1.000 103 432	0.990 974 593	1.001 434 620	0.992 396 265	11.901 703 500	Avg

1 means ΔCPV Passed	$\Delta\rho_{B\_SET}$ kg/m³	ΔT_{P_SET} °F	ΔP_{P_SET} psig	ΔQ_{M_SET} %	r% CPV	CPV_set	CPV_set Bbls	
	0.278	0.050	0.40	0.0	0.023	-	11.899 691 500	Runs 1-3
	0.278	0.040	0.45	0.0	0.049	-	11.900 930 100	Runs 2-4
	0.241	0.040	0.65	0.0	0.026	-	11.902 715 900	Runs 3-5
1	0.072	0.010	0.30	0.0	0.004	Pass	11.903 715 500	Runs 4-6

Signature	Date	Company
		API Midstream Representative

Example B.1 - Calibration Set I - 2 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set II

General Data

Operator	API Midstream	
Station Name	Headquarters	
Fluid or Batch	RBOB	-
Ch 11.1	Products	-
T_B	60.0	°F
P_B	0.0	psig

Master Meter

Flowmeter ID	200	-
Manufacturer	API	-
Model	API-PD	-
Nominal Size	4	inch
Type	PD	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	8,400.000 0	P / Bbl
Cartridge No.	API-0011	-

Density Method

ρ_{obs} Method	Continuous	-
ρ_{obs} Device	Online Density	-
DMF	0.999 8	-
HYC Factor	No	-

API Chapter 12.4.2
USC_60 Measurement Units
Sampling Method - Continuous
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Refined Product - Tables 5B/6B

Field Prover

Prover Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Bidirectional	-
Wall Design	Single	-
Detector	Internal	-
Displacer	Free Sphere	-
Wall Material	300 SS	-
Rod Material	NA	-
GL_P	0.000 006 20	per °F
GL_D	NA	per °F
E_P	030 000 000	per psig
ID_P	21.562 0	inch
WT_P	1.219 0	inch
Serial No.	Bidi-SI-001	-
Switches	9206 to 9236	-

Calibration Set Criteria

ΔMMF_{SET}	≤ 0.02	%
(r) $ICPV_{RUN}$	≤ 0.02	%
(r) CPV_{RUN}	≤ 0.02	%

Spot Sample

ρ_{60_START}	NA	kg/m³
ρ_{60_STOP}	NA	kg/m³
ρ_{60_SET}	NA	kg/m³
MMF_{SET}	0.999 986 5	-

Report Summary

	Start	Stop	
Report No.	Start 2	Stop 2	-
Date	14-Feb-24	14-Feb-24	-
Time	10:53:11 AM	12:40:18 PM	-
Totalizer	2,342,521.020	2,343,841.020	Bbl
Fluid, Batch No.	84RBOB	84RBOB	-
API_{60}	61.0	61.0	°API
ρ_{60}	734.457	734.419	kg/m3
API_{15}	60.9	60.9	°API
ρ_{15}	734.963	734.924	kg/m3
API_{20}	61.9	61.9	°API
ρ_{20}	730.402	730.364	kg/m3
Flowrate, Q_{av}	524.145	524.785	BPH
T_{MP_AVG}	70.710	70.730	°F
P_{MP_AVG}	189.1	189.5	psig
Trips per Run	1	1	-
Roundtrips	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.011	0.008	%
Allowable (r)	0.020	0.020	%
(r) Pass/Fail	Pass	Pass	-
MMF	0.999 974 0	0.999 999 0	-
ΔMMF	NA	0.003	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-

Prior vs Current

ΔQ_{av}	0.1	%
ΔT_P	0.120	°C

Roundtrip Measurements							Base Density	
ρ_{obs} kg/m³	T_{dm} °F	P_{dm} psig	T_{FP_INLET} °F	T_{FP_OUTLET} °F	T_{MM} °F	T_{FD} °F	ρ_B kg/m³	Run
729.748	70.710	188.6	70.690	70.510	70.520		734.061	1
729.843	70.690	189.7	70.700	70.540	70.560		734.139	2
729.545	70.690	188.7	70.690	70.450	70.630		733.847	3
								4
								5
								6
729.712	70.700	189.0	70.690	70.500	70.570		734.016	Avg

Ch 11.1 Iteration Results	Roundtrip Measurements					T_{FP} and P_{FP} Values		
	N or N_i Pulses	Q_{MM} BPH	P_{FP_INLET} psig	P_{FP_OUTLET} psig	P_{MM} psig	T_{FP} °F	P_{FP} psig	Run
Gasoline, Napthene	100,015.000	524.145	186.2	185.5	183.9	70.600 0	185.85	1
Gasoline, Napthene	100,001.000	524.139	186.8	185.4	184.2	70.620 0	186.10	2
Gasoline, Napthene	100,022.000	524.141	186.2	183.9	182.3	70.570 0	185.05	3
								4
								5
								6
	100,012.700 0	524.142	186.4	184.9	183.5	70.600 0	185.70	Avg

Example B.1 - Calibration Set II - 1 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set II

API Chapter 12.4.2
USC_60 Measurement Units
Sampling Method - Continuous
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Refined Product - Tables 5B/6B

ΔMMF_{SET}	**Pass**	-
(r) $ICPV_{SET}$	**Pass**	-
(r) CPV_{SET}	**Pass**	-

Report Summary

	Prior	*Current*
Report No.	Start	Stop
Date	Start 2	Stop 2
Time	00:00:00	00:00:00
Fluid, Batch No.	2342521.02	2343841.02

N or N_i Pulses	**NKF** P / Bbl	**IV_{MM}**	**CTL_{MM}**	**CPL_{MM}**	**$CTPL_{MM}$**	**GSV_{MM}** Bbls	**Run**
100,015.000	8,400.000 0	11.906 547 6	0.992 731 258	1.001 496 747	0.994 217 126	11.837 533 700	**1**
100,001.000	8,400.000 0	11.904 881 0	0.992 704 747	1.001 498 890	0.994 192 702	11.835 586 000	**2**
100,022.000	8,400.000 0	11.907 381 0	0.992 651 838	1.001 485 974	0.994 126 893	11.837 287 900	**3**
							4
							5
							6
100,012.700 0	8,400.000 0	11.906 269 9	0.992 695 948	1.001 493 870	0.994 178 907	11.836 802 500	**Avg**

Iteraton Results	**CTS_{FP}**	**CPS_{FP}**	**CTL_{FP}**	**CPL_{FP}**	**$CTPL_{FP}$**	**CPV_run** Bbls	**Run**
Gasoline, Napthene	1.000 197 173	1.000 109 579	0.992 675 865	1.001 513 182	0.994 177 964	11.903 204 300	**1**
Gasoline, Napthene	1.000 197 545	1.000 109 726	0.992 663 209	1.001 514 779	0.994 166 874	11.901 372 300	**2**
Gasoline, Napthene	1.000 196 615	1.000 109 107	0.992 693 402	1.001 508 020	0.994 190 403	11.902 820 400	**3**
							4
							5
							6
	1.000 197 111	1.000 109 471	0.992 677 492	1.001 511 994	0.994 178 414	11.902 465 700	**Avg**

	1 means ΔCPV Passed	**$\Delta\rho_{B\_SET}$** kg/m^3	**ΔT_{P_SET}** °F	**ΔP_{P_SET}** psig	**ΔQ_{MM_SET}** %	**r% CPV**	**CPV_set**	**CPV_set** Bbls	
Runs 1-3	1	0.292	0.050	1.05	0.0	0.015	**Pass**	11.902 465 700	**Runs 1-3**
Runs 2-4		NA	NA	NA	NA		**-**		**Runs 2-4**
Runs 3-5		NA	NA	NA	NA		**-**		**Runs 3-5**
Runs 4-6		NA	NA	NA	NA		**-**		**Runs 4-6**

Signature	**Date**	**Company**
		API Midstream Representative

Example B.1 - Calibration Set II - 2 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set III

General Data

Operator	API Midstream	
Station Name	Headquarters	
Fluid or Batch	RBOB	-
Ch 11.1	Products	-
T_B	60.0	°F
P_B	0.0	psig

Master Meter

Flowmeter ID	200	-
Manufacturer	API	-
Model	API-PD	-
Nominal Size	4	inch
Type	PD	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	8,400.000 0	P / Bbl
Cartridge No.	API-0011	-

Density Method

ρ_{obs} Method	Continuous	-
ρ_{obs} Device	Online Density	-
DMF	0.999 8	-
HYC Factor	No	-

API Chapter 12.4.2
USC_60 Measurement Units
Sampling Method - Continuous
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Refined Product - Tables 5B/6B

Field Prover

Prover Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Bidirectional	-
Wall Design	Single	-
Detector	Internal	-
Displacer	Free Sphere	-
Wall Material	300 SS	-
Rod Material	NA	-
GL_P	0.000 006 20	per °F
GL_D	NA	per °F
E_P	030 000 000	per psig
ID_P	21.562 0	inch
WT_P	1.219 0	inch
Serial No.	Bidi-SI-001	-
Switches	9206 to 9236	-

Calibration Set Criteria

ΔMMF_{SET}	≤ 0.02	%
(r) $ICPV_{RUN}$	≤ 0.02	%
(r) CPV_{RUN}	≤ 0.02	%

Spot Sample

ρ_{60_START}	NA	kg/m³
ρ_{60_STOP}	NA	kg/m³
ρ_{60_SET}	NA	kg/m³
MMF_{SET}	1.000 126 5	-

Report Summary

	Start	Stop	
Report No.	1	Stop 1	-
Date	14-Feb-24	14-Feb-24	-
Time	8:21:18 AM	11:21:18 AM	-
Totalizer	2,342,501.020	2,343,601.020	Bbl
Fluid, Batch No.	Products	Products	-
API_{60}	60.8	60.6	°API
ρ_{60}	735.210	735.710	kg/m3
API_{15}	60.7	60.5	°API
ρ_{15}	735.715	736.216	kg/m3
API_{20}	61.7	61.5	°API
ρ_{20}	731.158	731.660	kg/m3
Flowrate, Q_{av}	882.146	881.970	BPH
T_{MP_AVG}	73.100	73.240	°F
P_{MP_AVG}	187.7	188.3	psig
Trips per Run	1	1	-
Roundtrips	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.018	0.017	%
Allowable (r)	0.020	0.020	%
(r) Pass/Fail	Pass	Pass	-
MMF	1.000 099 0	1.000 154 0	-
ΔMMF	NA	0.006	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-

Prior vs Current

ΔQ_{av}	0.1	%
ΔT_P	0.120	°C

Roundtrip Measurements							Base Density	
ρ_{obs} kg/m³	T_{dm} °F	P_{dm} psig	T_{FP_INLET} °F	T_{FP_OUTLET} °F	T_{MM} °F	T_{FD} °F	ρ_B kg/m³	Run
729.748	73.230	174.5	73.070	73.200	73.390		735.415	1
729.843	73.230	175.2	73.050	73.120	73.390		735.506	2
729.545	73.270	175.2	73.080	73.140	73.400		735.228	3
								4
								5
								6
729.712	73.240	175.0	73.070	73.150	73.390		735.383	Avg

Ch 11.1 Iteration Results	Roundtrip Measurements					T_{FP} and P_{FP} Values		
	N or N_i Pulses	Q_{MM} BPH	P_{FP_INLET} psig	P_{FP_OUTLET} psig	P_{MM} psig	T_{FP} °F	P_{FP} psig	Run
Gasoline, Napthene	100,015.000	882.125	176.1	173.8	185.4	73.135 0	174.95	1
Gasoline, Napthene	100,018.000	882.131	176.7	174.0	185.9	73.085 0	175.35	2
Gasoline, Napthene	100,022.000	882.129	176.2	174.0	186.4	73.110 0	175.10	3
								4
								5
								6
	100,018.300 0	882.128	176.3	173.9	185.9	73.110 0	175.10	Avg

Example B.1 - Calibration Set III - 1 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set III

API Chapter 12.4.2
USC_60 Measurement Units
Sampling Method - Continuous
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Refined Product - Tables 5B/6B

ΔMMF_{SET}	**Pass**	-
(r) $ICPV_{SET}$	**Pass**	-
(r) CPV_{SET}	**Pass**	-

Report Summary

	Prior	*Current*
Report No.	Start	Stop
Date	1-Jan-00	Stop 1
Time	00:00:00	00:00:00
Fluid, Batch No.	2342501.02	2343601.02

N or N_i Pulses	**NKF** P / Bbl	**IV_{MM}**	**CTL_{MM}**	**CPL_{MM}**	**$CTPL_{MM}$**	**GSV_{MM}** Bbls	**Run**
100,015.000	8,400.000 0	11.906 547 6	0.990 768 877	1.001 518 360	0.992 273 221	11.816 042 900	**1**
100,018.000	8,400.000 0	11.906 904 8	0.990 770 609	1.001 521 790	0.992 278 354	11.816 458 500	**2**
100,022.000	8,400.000 0	11.907 381 0	0.990 758 393	1.001 528 016	0.992 272 288	11.816 858 800	**3**
							4
							5
							6
100,018.300 0	8,400.000 0	11.906 944 5	0.990 765 960	1.001 522 722	0.992 274 621	11.816 453 400	**Avg**

Iteraton Results	**CTS_{FP}**	**CPS_{FP}**	**CTL_{FP}**	**CPL_{FP}**	**$CTPL_{FP}$**	**CPV_run** Bbls	**Run**
Gasoline, Napthene	1.000 244 331	1.000 103 152	0.990 945 132	1.001 431 033	0.992 363 208	11.902 837 700	**1**
Gasoline, Napthene	1.000 243 401	1.000 103 388	0.990 981 383	1.001 433 360	0.992 401 816	11.902 801 500	**2**
Gasoline, Napthene	1.000 243 866	1.000 103 241	0.990 958 917	1.001 433 403	0.992 379 360	11.903 470 300	**3**
							4
							5
							6
	1.000 243 866	1.000 103 260	0.990 961 811	1.001 432 599	0.992 381 461	11.903 036 500	**Avg**

	1 means ΔCPV Passed	**$\Delta\rho_{B\_SET}$** kg/m³	**ΔT_{P_SET}** °F	**ΔP_{P_SET}** psig	**ΔQ_{MM_SET}** %	**r% CPV**	**CPV_set**	**CPV_set** Bbls	
Runs 1-3	1	0.278	0.050	0.40	0.0	0.006	**Pass**	11.903 036 500	**Runs 1-3**
Runs 2-4		NA	NA	NA	NA		**-**		**Runs 2-4**
Runs 3-5		NA	NA	NA	NA		**-**		**Runs 3-5**
Runs 4-6		NA	NA	NA	NA		**-**		**Runs 4-6**

Signature	**Date**	**Company**
		API Midstream Representative

Example B.1 - Calibration Set III - 2 of 2

Example B.2 – Standard Method

USC Units, Spot Sampling, Master Prover - Unidirectional Captive Displacer, Master Meter - Turbine, MF r% - Moving Range, MF Method - IMF, Field Prover - Unidirectional Captive Displacer

	Master Prover	
BPV Units	0	(0-USC_{60}, 1-SI_{15}, 2-SI_{20})
Detector Design	1	(0-Internal, 1-External)
Wall Material	3	(1-CS, 2-304SS, 3-316SS, 4-17-4PH)
Rod Material	3	(0-NA, 1-CS, 2-304SS, 3-316SS, 4-17-4PH, 5-Invar)
Certificate BPV	5,725.326 1	cubic inches at 60.0 °F, 0.0 psig

	Base Prover Volume (BPV)		
	BPV_{60} Barrels	**BPV_{15} Cubic Meters**	**BPV_{20} Cubic Meters**
	0. 590 118 130 282	0. 093 818 780 000	0. 093 841 327 000
Decimals	10	11	11
Conversion	in^3 / Bbl 9.702E+03	mL / M^3 1.00E+06	mL / M^3 1.00E+06
Rnd'd BPV	0.590 118 130 300	0.093 818 780 000	0.093 841 327 000

in^3 = mL / 16.387 064
U.S. Gallons = in^3 / 2.31E+02
Bbl = in^3 / 9.702E+03
Cubic Feet = in^3 / 1.728E+03

mL = M^3 x 1E+06
mL = in^3 x 16.387 064

M^3 = mL x 1E-06
L = mL x 1E-03

Note: This Worksheet produces a BPV_{60} or BPV_{SI} to **10 digits** (the appropriate decimal place) to increase the precision of the Master Prover's BPV, not the uncertainty of the Master Prover's BPV.

T_B	60.0	°F
Decimal Base CTS	9	-
Decimal BPV_{60}	4	cubic inches at 60.0 °F, 0.0 psig
Decimal BPV_{SI}	3	mL at 15.0 °C and 0.0 kPag
Decimal BPV	10	Barrels

API Properties

Linear Coefficient of Thermal Expansion, GL

	SI Unit[2,4] (per °C)	USC Unit[2,3,5] (per °F)
Mild Carbon	0.000 011 16	**0.000 006 20**
304 SS	**0.000 017 28**	0.000 009 60
316 SS	**0.000 016 02**	0.000 008 90
17-4PH	0.000 010 80	**0.000 006 00**
Invar™	0.000 001 44	**0.000 000 80**

Detector Design,

$CTS_P = [1 + (T_P - T_B) \times GL_P]^3$, for detectors mounted in calibrated section

$CTS_P = [1 + (T_P - T_B) \times GL_P]^2 \times [1 + (T_D - T_B) \times GL_d]$, for detectors mounted on external shaft

If Measurement Units = 0, then BPV in cubic inches, T_B is 60.0 °F

BPV_{60} = cubic inches at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 1, then BPV in mL, T_B is 15.0 °C

BPV_{60} = ROUND(BPV_{15} / 16.387 064 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(BPV_{15} x Base CTS_{20}, 3) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 2, then BPV in mL, T_B is 20.0 °C

BPV_{60} = ROUND(BPV_{20} / 16.387 064 x Base CTS_{60}, 4) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(CPV_{20} x Base CTS_{15}, 3) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = mL at 20.0 °C, 0.0 kPag

Notes:

(1) The User/Owner should obtain GL values from the prover manufacturer.

(2) The GL values shown above are a function of the materials, operating temperature range, calibration temperature range. Values in **bold face** were obtained from American Society of Metals (ASM) International, 2020 edition.

(3) GL values shown above are applicable from 0 °C to 100 °C (32 °F to 212 °F). If operating outside this range, the GL values depicted are not appropriate.

(4) The SI values of GL per °C **not in bold face**, was obtained by multiplying the USC values, GL per °F, times 1.8.

(5) The USC values per °F **not in bold face**, was obtained by dividing the SI values, GL per °C, by 1.8.

T_B	60.0 °F	15.0 °C	20.0 °C
GL_P	0.000 008 90	0.000 016 02	0.000 016 02
GL_D	0.000 008 90	0.000 016 02	0.000 016 02
Base CTS_{60}	1.000 000 000	1.000 026 700	0.999 786 415
Base CTS_{15}	0.999 973 300	1.000 000 000	0.999 759 719
Base CTS_{20}	1.000 213 615	1.000 240 319	1.000 000 000

Base Unit Volume

BPV_{60}	5,725.326 1	cubic inches at 60.0 °F, 0.0 psig
BPV_{15}	93,818.780	mL at 15.0 °C and 0.0 kPag
BPV_{20}	93,841.327	mL at 20.0 °C and 0.0 kPag

Example B.2 - Expanded Discrimination of Master Prover's BPV

Washington, D.C., USA

Master Meter Proving Report

General Data		
Operator	API Midstream	-
Station Name	MPMS	-
Ch 11.1	Tables 5A/6A	-
T_B	60.0	°F
P_B	0.0	psig
Master Meter		
Flowmeter ID	400	-
Manufacturer	API	-
Model	Turbine	-
Nominal Size	3	inch
Type	Turbine	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	696.700 0	P / Bbl
Cartridge No.	API-0011	-
Density Method		
Sample Method	Spot Sample	-
ρ_{obs} Device	Hydrometer	-
DMF	NA	-
HYC Factor	Yes	-

Displacement Prover		
Manufacturer	API	-
Prover Type	Displacement	-
Flow Design	Unidirectional	-
Wall Design	Single	-
Detector	External	-
Displacer	Captive Displacer	-
Wall Material	316SS	-
Rod Material	316SS	-
GL_P	0.000 008 90	per °F
GL_D	0.000 008 90	per °F
E_P	028 000 000	per psig
ID_P	17.400 0	inch
WT_P	1.825 0	inch
Calibration Date	2021-09-04	-
Serial No.	8904-04	-
Certificate No.	10101010	-
Switches	9201 to 9202	-
BPV	0.590 118 130 3	Bbl
Spot Sample		
API_{ind}		°API
ρ_{ind}	848.217	kg/m³
T_{obs}	60.000	°F
P_{obs}	0.0	psig

Report Summary	Start	Stop	
Report No.	Start I	Stop I	-
Date	14-Feb-24	14-Feb-24	-
Time	8:21:18	11:21:18	-
Totalizer	2,342,501.020	2,343,601.020	Bbl
Fluid, Batch No.	Crude	Crude	-
API_{60}	35.1	35.2	°API
ρ_{60}	848.597	848.217	kg/m³
API_{15}	35.0	35.1	°API
ρ_{15}	848.999	848.619	kg/m³
API_{20}	35.6	35.7	°API
ρ_{20}	845.377	844.995	kg/m³
Flowrate, Q	364.966	365.440	BPH
T_{P_AVG}	73.090	73.428	°F
P_{P_AVG}	170.6	176.1	psig
Trips per Run	1	1	-
Roundtrips	Runs 1-3	Runs 1-3	-
Repeatability (r)	0.004	0.002	%
Allowable (r)	0.007	0.007	%
(r) Pass/Fail	Pass	Pass	-
MMF	0.999 997 8	0.999 986 5	-
ΔMMF	NA	(0.001)	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-
Prior vs Current			
ΔQ	0.1		%
ΔT_P	0.338		°F

API MPMS Chapter 12.4.2
Measurement Units - USC
Sampling Method - Spot
Meter Factor Method - Intermediate (or IMF)
Repeatability Method (r%) - Moving Range
API MPMS Chapter 11.1 - Tables 5A/6A

Base Density	Roundtrip Measurements							Base Density	
API_B °API	ρ_{ind} kg/m³	T_{dm} °F	P_{dm} psig	T_{P_INLET} °F	T_{P_OUTLET} °F	T_M °F	T_D °F	ρ_B kg/m³	Run
35.2				73.480	73.360	73.210	75.020	848.217	1
35.2				73.510	73.430	73.280	75.140	848.217	2
35.2				73.470	73.320	73.230	75.120	848.217	3
NA									4
NA									5
NA									6
NA									7
NA									8
NA									9
NA									10
35.2	NA	NA	NA	NA	NA	73.240	75.090	848.217	Runs 1-3

Commodity Type	Roundtrip Measurements					T_P and P_P Values		
	N or N_i Pulses	Q_M BPH	P_{P_INLET} psig	P_{P_OUTLET} psig	P_M psig	T_{P_RUN} °F	P_{P_RUN} psig	Run
Crude Oil, JP-4	411.278	365.408 0	177.9	174.2	173.5	73.420 0	176.05	1
Crude Oil, JP-4	411.291	365.287 0	178.0	174.3	173.6	73.470 0	176.15	2
Crude Oil, JP-4	411.294	365.618 0	177.9	174.2	173.5	73.395 0	176.05	3
NA								4
NA								5
NA								6
NA								7
NA								8
NA								9
NA								10
Runs 1-3	411.287 7	365.440 0	NA	NA	173.5	73.428 3	176.08	Runs 1-3

Example B.2 - Calibration Set I - Stop Proving Report - 1 of 2

Washington, D.C., USA

Master Meter Proving Report

API MPMS Chapter 12.4.2
Measurement Units - USC
Sampling Method - Spot
Meter Factor Method - Intermediate (or IMF)
Repeatability Method (r%) - Moving Range
API MPMS Chapter 11.1 - Tables 5A/6A

Report Summary

	Prior	*Current*
Report No.	Start I	Stop I
Date	14-Feb-24	14-Feb-24
Time	08:21:18	11:21:18
Fluid, Batch No.	Crude	Crude

Run	BPV Bbl	CTS_P	CPS_P	Rnd CTL_P	Rnd CPL_P	Rnd $CTPL_P$	GSV_P Bbl	Run
1	0.590 118 130 3	1.000 372 600	1.000 059 947	0.993 624 077	1.000 925 468	0.994 543 644	0.587 152 110 0	1
2	0.590 118 130 3	1.000 374 559	1.000 059 981	0.993 600 277	1.000 926 150	0.994 520 500	0.587 139 616 0	2
3	0.590 118 130 3	1.000 373 045	1.000 059 947	0.993 635 976	1.000 925 390	0.994 555 477	0.587 159 356 8	3
4								4
5								5
6								6
7								7
8								8
9								9
10								10
Runs 1-3	0.590 118 130 3	1.000 373 401	1.000 059 958	0.993 620 110	1.000 925 669	0.994 539 874	0.587 150 360 9	Runs 1-3

Run	N or N_i	NKF P / Bbl	IV_M	Rnd CTL_M	Rnd CPL_M	Rnd $CTPL_M$	ISV_M Bbl	Run
1	411.278	696.700 0	0.590 322 951 1	0.993 724 032	1.000 911 405	0.994 629 717	0.587 152 749 8	1
2	411.291	696.700 0	0.590 341 610 4	0.993 690 714	1.000 912 146	0.994 597 105	0.587 152 056 7	2
3	411.294	696.700 0	0.590 345 916 5	0.993 714 512	1.000 911 467	0.994 620 250	0.587 170 003 0	3
4								4
5								5
6								6
7								7
8								8
9								9
10								10
Runs 1-3	411.287 7	696.700 0	0.590 336 826 0	0.993 709 753	1.000 911 673	0.994 615 691	0.587 158 269 8	Runs 1-3

Run	'1' indicates Repeatability (r%) criteria satisifed	Repeatability (r%) Actual	Repeatability (r%) Allowable	Meter Factor Method - Intermediate (or IMF)	IMF	Run
1		NA	NA		0.999 998 91	1
2		NA	NA		0.999 978 81	2
3	1	0.002	0.007	Repeatability Method (r%) - Moving Range	0.999 981 87	3
4			0.014			4
5			0.020			5
6			0.025			6
7			0.031			7
8			0.036			8
9			0.041			9
10			0.045			10
	Pass	0.002			0.999 986 50	MMF

MMF Rounded to 7 decimal places

		API Midstream Representative

Example B.2 - Calibration Set I - Stop Proving Report - 2 of 2

	Field Prover	
Measurement Units	0	(0-USC_{60}, 1-SI_{15}, 2-SI_{20})
Detector Design	1	(0-Internal, 1-External)
Wall Material	3	(1-CS, 2-304SS, 3-316SS, 4-17-4PH)
Rod Material	3	(0-NA, 1-CS, 2-304SS, 3-316SS, 4-17-4PH, 5-Invar)
Source for GL_{MP}, GL_{md}, E_{MP}	1	(0-Prover Manufacturer, 1-API Table)
BPV_P	5,725.326 1	cubic inches at 60.0 °F, 0.0 psig

	Base Prover Volume (BPV)		
	BPV_{60} Barrels	**BPV_{15} Cubic Meters**	**BPV_{20} Cubic Meters**
	0. 590 118 130 282	0. 093 818 780 000	0. 093 841 327 000
Decimals	6	7	7
Conversion	in^3 / Bbl 9.702E+03	mL / M^3 1.00E+06	mL / M^3 1.00E+06
Rnd'd BPV	0.590 118 000 000	0.093 818 800 000	0.093 841 300 000

in^3 = mL / 16.387 064
U.S. Gallons = in^3 / 2.31E+02
Bbl = in^3 / 9.702E+03
Cubic Feet = in^3 / 1.728E+03

mL = M^3 x 1E+06
mL = in^3 x 16.387 064

M^3 = mL x 1E-06
L = mL x 1E-03

Note: This Worksheet produces a BPV_{60} or BPV_{SI} to **6 digits** (the appropriate decimal place).

T_B	60.0	°F
Decimal Base CTS	9	-
Decimal BPV_{60}	4	cubic inches at 60.0 °F, 0.0 psig
Decimal BPV_{SI}	3	mL at 15.0 °C and 0.0 kPag
Decimal BPV	6	Barrels, 6 digits
Decimal BPV	7	Cubic Meters, 6 digits

API Properties

Linear Coefficient of Thermal Expansion, GL

	SI Unit[2,4] (per °C)	**USC Unit[2,3,5]** (per °F)
Mild Carbon	0.000 011 16	**0.000 006 20**
304 SS	**0.000 017 28**	0.000 009 60
316 SS	**0.000 016 02**	0.000 008 90
17-4PH	0.000 010 80	**0.000 006 00**
Invar™	0.000 001 44	**0.000 000 80**

Detector Design,

$CTS_P = [1 + (T_P - T_B) \times GL_P]^3$, for detectors mounted in calibrated section

$CTS_P = [1 + (T_P - T_B) \times GL_P]^2 \times [1 + (T_D - T_B) \times GL_d]$, for detectors mounted on external shaft

If Measurement Units = 0, then BPV in cubic inches, T_B is 60.0 °F

BPV_{60} = cubic inches at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{15}, 12) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(BPV_{60} x 16.387 064 x Base CTS_{20}, 12) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 1, then BPV in mL, T_B is 15.0 °C

BPV_{60} = ROUND(BPV_{15} / 16.387 064 x Base CTS_{60}, 12) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = mL at 15.0 °C, 0.0 kPag
BPV_{20} = ROUND(BPV_{15} x Base CTS_{20}, 12) = mL at 20.0 °C, 0.0 kPag

If Measurement Units = 2, then BPV in mL, T_B is 20.0 °C

BPV_{60} = ROUND(BPV_{20} / 16.387 064 x Base CTS_{60}, 12) = in^3 at 60.0 °F, 0.0 psig
BPV_{15} = ROUND(CPV_{20} x Base CTS_{15}, 12) = mL at 15.0 °C, 0.0 kPag
BPV_{20} = mL at 20.0 °C, 0.0 kPag

Notes:

(1) The User/Owner should obtain GL values from the prover manufacturer.

(2) The GL values shown above are a function of the materials, operating temperature range, calibration temperature range. Values in **bold face** were obtained from American Society of Metals (ASM) International, 2020 edition.

(3) GL values shown above are applicable from 0 °C to 100 °C (32 °F to 212 °F). If operating outside this range, the GL values depicted are not appropriate.

(4) The SI values of GL per °C **not in bold face**, was obtained by multiplying the USC values, GL per °F, times 1.8.

(5) The USC values per °F **not in bold face**, was obtained by dividing the SI values, GL per °C, by 1.8.

GL_P	0.000 008 90	0.000 016 02	0.000 016 02
GL_D	0.000 008 90	0.000 016 020	0.000 016 020
T_B	60.0	15.0	20.0
Base CTS_{60}	1.000 000 000	1.000 026 700	0.999 786 415
Base CTS_{15}	0.999 973 300	1.000 000 000	0.999 759 719
Base CTS_{20}	1.000 213 615	1.000 240 319	1.000 000 000

Base Unit Volume

BPV_{60}	5,725.326 1	cubic inches at 60.0 °F, 0.0 psig
BPV_{15}	93,818.780	mL at 15.0 °C and 0.0 kPag
BPV_{20}	93,841.327	mL at 20.0 °C and 0.0 kPag

Example B.2 - Field Prover's BPV Conversion

Washington, D.C., USA

BPV Determination using a Master Meter - Standard Method

General Data		Master Meter			Field Prover		
API Midstream	Operator	Flowmeter ID	400	-	Manufacturer	API	-
Headquarters	Station Name	Manufacturer	API	-	Prover Design	Displacement	-
Washington	City, Town	Model	Turbine	-	Flow Design	Unidirectional	-
D.C.	State, Province	Nominal Size	3	inch	Wall Design	Single	-
USA	Country	Type	PD	-	Detector	External	-
Crude	Fluid, Batch No.	Proving Result	MMF	-	Displacer	Captive Displacer	-
Crude	Ch 11.1	T_F Comp	No	-	Wall Material	316SS	-
60.0	T_B	P_F Comp	No	-	Rod Material	316SS	-
0.0	P_B	NKF	696.700 0	P / Bbl	GL_P	0.000 008 90	per °F
14-Feb-2024	Start Calibration	Cartridge No.	API-0011	-	GL_D	0.000 008 90	per °F
14-Feb-2024	Stop Calibration		**Density Method**		E_P	028 000 000	per psig
API Chapter 12.4.2		ρ_{obs} Method	Spot Sample	-	ID_P	17.400 0	inch
USC_60 Measurement Units		ρ_{obs} Device	Online Density	-	WT_P	1.825 0	inch
Sampling Method - Spot		DMF	0.000 0	-	Trips per Run	1	-
BPV - Standard Method		HYC Factor	No	-	Serial No.	Uni-USC-004	-
Fixed Range Method, r ≤ 0.02%, for 3 consecutive Calibration Sets					Switches	9204 to 9234	-
Crude Oil - Tables 5A/6A							

	Calibration Set I		Calibration Set II		Calibration Set III		
	Start	**Stop**	**Start**	**Stop**	**Start**	**Stop**	
Report No.	Start I	Stop I	Start 2	Stop 2	Start 3	Stop 3	-
Date	14-Feb-24	14-Feb-24	14-Feb-24	14-Feb-24	14-Feb-24	14-Feb-24	-
Crude	Crude	Crude	Crude	Crude	Crude	Crude	-
API_B	35.1	35.2	35.2	35.1	35.1	35.1	°API
ρ_B	848.597	848.217	848.217	848.587	848.427	848.387	kg/m^3
Q_{MM}	354.990	365.438	524.145	524.785	882.146	881.970	BPH
T_{MP_AVG}	73.090	70.093	70.710	70.730	73.100	73.240	°F
P_{MP_AVG}	170.6	175.4	189.1	189.5	187.7	188.3	psig
Roundtrips	Runs 1-3	Runs 1-3	Runs 1-5	Runs 1-5	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.004	0.002	0.011	0.008	0.008	0.014	%
MMF	0.999 997 8	0.999 986 5	1.000 055 2	1.000 058 6	0.999 845 2	0.999 865 5	-
MMF_{SET}	NA	0.999 992 2	NA	1.000 056 9	NA	0.999 855 4	-
ΔMMF	NA	(0.001)	NA	0.000	NA	0.002	%
ΔMMF_{SET}	**Pass**			**Pass**		**Pass**	
(r) CPV_{RUN}	**Pass**	-		**Pass**	-	**Pass**	-
(R) CPV_{SET}	NA	-		**Pass**	-	**Pass**	-
ΔQ_{SET}	NA	-		**Pass**	-	**Pass**	-
Selected Set	**Runs 4-6**	-		**Runs 1-3**	-	**Runs 1-3**	-
CPV_{SET}	**0.590 108 4**	Bbls		**0.590 126 5**	Bbls	**0.590 127 7**	Bbls
API_{B_SET}	35.1	°API		35.1	°API	35.1	°API
ρ_{B_SET}	848.407	kg/m^3		848.402	kg/m^3	848.407	kg/m^3
T_{FP_SET}	73.080	°F		70.600	°F	73.110	°F
P_{FP_SET}	175.7	psig		185.7	psig	175.1	psig
Q_{MM_SET}	701.040	BPH		524.142	BPH	882.128	BPH
CPV_{SET} Stability Parameters	ΔMMF_{SET}	(0.001)	%	0.000	%	0.002	%
	$\Delta\rho_{B\_SET}$	0.075	kg/m^3	(0.073)	kg/m^3	0.008	kg/m^3
	ΔT_{P_SET}	0.010	°F	0.050	°F	0.050	°F
	ΔP_{P_SET}	0.3	psig	1.1	psig	0.4	psig
	ΔQ_{MM_SET}	0.0	%	0.0	%	0.0	%
	$\Delta Q_{between\ SETS}$	NA	%	(25.2)	%	40.6	%
	(r) CPV_{RUN}	0.006	%	0.007	%	0.001	%
	(R) CPV_{SET}	NA	%	0.003	%	0.000	%

Example B.2 - Calibration Report Summary - 1 of 2

Washington, D.C., USA

BPV Determination using a Master Meter - Standard Method

General Data

API Midstream	Operator
Headquarters	Station Name
Washington	City, Town
D.C.	State, Province
USA	Country
Crude	Fluid, Batch No.
Crude	Ch 11.1
60.0	T_B
0.0	P_B
14-Feb-2024	Start Calibration
14-Feb-2024	Stop Calibration

API Chapter 12.4.2
USC_60 Measurement Units
Sampling Method - Spot
BPV - Standard Method
Fixed Range Method, r ≤ 0.02 %, for 3 consecutive Calibration Sets
Crude Oil - Tables 5A/6A

BPV_{NEW}	0.590 121 0	Bbls
BPV_{OLD}	0.590 118 0	Bbls
ΔBPV	0.000 003 0	Bbls
ΔBPV	0.000 5	% BPV_{NEW} Bigger / (Smaller)
Average CPV_{SET}	0.590 120 829	Bbls
BPV_{60}	5,725.352 3	in^3 at 60.0 °F and 0.0 psig
BPV_{15}	93,819.209	mL at 15.0 °C and 0.0 kPag
BPV_{20}	93,841.756	mL at 20.0 °C and 0.0 kPag

Field Prover

Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Unidirectional	-
Wall Design	Single	-
Detector	External	-
Displacer	Captive Displacer	-
Wall Material	316SS	-
Rod Material	316SS	-
GL_P	0.000 008 90	per °F
GL_D	0.000 008 90	per °F
E_P	028 000 000	per psig
ID_P	17.400 0	inch
WT_P	1.825 0	inch
Serial No.	Uni-USC-004	-
Switches	9204 to 9234	-

Base Prover Volume (BPV_{NEW})

BPV_{60}			BPV_{15}		BPV_{20}	
Barrels	**U.S. Gallons**	**Cubic Feet**	**Cubic Meters**	**Liters**	**Cubic Meters**	**Liters**
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	24.785 1	-	-	93.819 2	-	93.841 8
-	-	3.313 28	-	-	-	-
0.590 121	-	-	-	-	-	-
-	-	-	0.093 819 2	-	0.093 841 8	-

Note: The BPV_{NEW} values (BPV_{60}, BPV_{15}, BPV_{20}) shown are reported to 6 significant digits (10 ppm, or, 0.001%).

Signature	Date	Company
		API Midstream Representative

Example B.2 - Calibration Report Summary - 2 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set I

General Data

Operator	API Midstream	
Station Name	Headquarters	
Fluid or Batch	Crude	-
Ch 11.1	Crude	-
T_B	60.0	°F
P_B	0.0	psig

Master Meter

Flowmeter ID	400	-
Manufacturer	API	-
Model	Turbine	-
Nominal Size	3	inch
Type	PD	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	696.700 0	P / Bbl
Cartridge No.	API-0011	-

Density Method

ρ_{obs} Method	Spot Sample	-
ρ_{obs} Device	Online Density	-
DMF	0.000 0	-
HYC Factor	No	-

API Chapter 12.4.2
USC_60 Measurement Units
Sampling Method - Spot
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Crude Oil - Tables 5A/6A

Field Prover

Prover Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Unidirectional	-
Wall Design	Single	-
Detector	External	-
Displacer	Captive Displacer	-
Wall Material	316SS	-
Rod Material	Invar	-
GL_P	0.000 008 90	per °F
GL_D	0.000 008 90	per °F
E_P	028 000 000	per psig
ID_P	17.400 0	inch
WT_P	1.825 0	inch
Serial No.	Uni-USC-004	-
Switches	9204 to 9234	-

Calibration Set Criteria

ΔMMF_{SET}	≤ 0.02	%
(r) $ICPV_{RUN}$	≤ 0.02	%
(r) CPV_{RUN}	≤ 0.02	%

Spot Sample

ρ_{60_START}	848.597 000 000 000	kg/m^3
ρ_{60_STOP}	848.216 823 342 456	kg/m^3
ρ_{60_SET}	848.406 911 671 228	kg/m^3
MMF_{SET}	0.999 992 2	-

Report Summary

	Start	Stop	
Report No.	Start I	Stop I	-
Date	14-Feb-24	14-Feb-24	-
Time	8:21:18 AM	11:21:18 AM	-
Totalizer	2,342,501.020	2,343,601.020	Bbl
Fluid, Batch No.	Crude	Crude	-
API_{60}	35.1	35.2	°API
ρ_{60}	848.597	848.217	kg/m3
API_{15}	35.0	35.1	°API
ρ_{15}	848.999	848.619	kg/m3
API_{20}	35.6	35.7	°API
ρ_{20}	845.377	844.995	kg/m3
Flowrate, Q_{av}	354.990	365.438	BPH
T_{MP_AVG}	73.090	70.093	°F
P_{MP_AVG}	170.6	175.4	psig
Trips per Run	1	1	-
Roundtrips	Runs 1-3	Runs 1-3	-
Repeatability (r)	0.004	0.002	%
Allowable (r)	0.007	0.007	%
(r) Pass/Fail	Pass	Pass	-
MMF	0.999 997 8	0.999 986 5	-
ΔMMF	NA	(0.001)	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-

Prior vs Current

ΔQ_{av}	0.02	%
ΔT_P	0.400	°C

Roundtrip Measurements							Base Density	
ρ_{obs} kg/m^3	T_{dm} °F	P_{dm} psig	T_{P_INLET} °F	T_{P_OUTLET} °F	T_M °F	T_D °F	ρ_B kg/m^3	Run
			73.480	73.360	73.210	75.020	848.407	1
			73.510	73.430	73.280	75.140	848.407	2
			73.470	73.320	73.230	75.120	848.407	3
			73.070	73.070	73.400	75.020	848.407	4
			73.060	73.090	73.500	75.140	848.407	5
			73.060	73.100	73.420	75.120	848.407	6
			73.280	73.230	73.340	75.090	848.407	Avg

Ch 11.1 Iteration Results	Roundtrip Measurements							
	N or N_i Pulses	Q_M BPH	P_{P_INLET} psig	P_{P_OUTLET} psig	P_M psig	T_{P_RUN} °F	P_{P_RUN} psig	Run
Crude Oil, JP-4	411.103	701.110	176.1	173.8	185.4	73.420 0	174.95	1
Crude Oil, JP-4	411.174	700.982	176.7	174.0	185.9	73.470 0	175.35	2
Crude Oil, JP-4	411.383	700.995	176.2	174.0	186.4	73.395 0	175.10	3
Crude Oil, JP-4	411.357	701.014	176.8	174.3	186.4	73.070 0	175.55	4
Crude Oil, JP-4	411.353	701.002	176.9	174.6	186.7	73.075 0	175.75	5
Crude Oil, JP-4	411.358	701.103	176.9	174.8	185.5	73.080 0	175.85	6
	411.288 0	701.034	176.6	174.3	186.1	73.250 0	175.40	Avg

Example B.2 - Calibration Set I - 1 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set I

API Chapter 12.4.2
USC_60 Measurement Units
Sampling Method - Spot
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Crude Oil - Tables 5A/6A

ΔMMF_{SET}	**Pass**	-
(r) $ICPV_{RUN}$	**Pass**	-
(r) CPV_{RUN}	**Pass**	-

Report Summary

	Prior	*Current*
Report No.	Start	Stop
Date	14-Feb-24	14-Feb-24
Time	08:21:18	11:21:18
Fluid, Batch No.	Crude	Crude

N or N_i Pulses	**NKF** P / Bbl	**IV_M**	**CTL_M**	**CPL_M**	**$CTPL_M$**	**GSV_M** Bbls	**Run**
411.103	696.700 0	0.590 071 8	0.993 726 846	1.000 973 393	0.994 694 133	0.586 936 379	**1**
411.174	696.700 0	0.590 173 7	0.993 693 543	1.000 976 251	0.994 663 638	0.587 019 740	**2**
411.383	696.700 0	0.590 473 7	0.993 717 331	1.000 978 714	0.994 689 896	0.587 333 642	**3**
411.357	696.700 0	0.590 436 3	0.993 636 452	1.000 979 275	0.994 609 495	0.587 248 970	**4**
411.353	696.700 0	0.590 430 6	0.993 588 874	1.000 981 183	0.994 563 767	0.587 216 301	**5**
411.358	696.700 0	0.590 437 8	0.993 626 936	1.000 974 608	0.994 595 333	0.587 242 100	**6**
411.288 0	696.700 0	0.590 337 3	0.993 664 997	1.000 977 237	0.994 636 044	0.587 166 189	**Avg**

Iteraton Results	**CTS_P**	**CPS_P**	**CTL_P**	**CPL_P**	**$CTPL_P$**	**CPV_run** Bbls	**Run**
Crude Oil, JP-4	1.000 372 600	1.000 059 572	0.993 626 936	1.000 919 128	0.994 540 206	0.589 903 570	**1**
Crude Oil, JP-4	1.000 374 559	1.000 059 708	0.993 603 147	1.000 921 386	0.994 518 640	0.589 998 911	**2**
Crude Oil, JP-4	1.000 373 045	1.000 059 623	0.993 638 831	1.000 919 839	0.994 552 818	0.590 295 063	**3**
Crude Oil, JP-4	1.000 366 369	1.000 059 776	0.993 793 449	1.000 921 196	0.994 708 928	0.590 121 184	**4**
Crude Oil, JP-4	1.000 367 526	1.000 059 844	0.993 791 071	1.000 922 262	0.994 707 606	0.590 088 417	**5**
Crude Oil, JP-4	1.000 367 437	1.000 059 878	0.993 788 692	1.000 922 803	0.994 705 763	0.590 115 468	**6**
	1.000 370 256	1.000 059 734	0.993 707 021	1.000 921 102	0.994 622 327	0.590 087 102	**Avg**

1 means ΔCPV Passed	**$\Delta\rho_{B\_SET}$** kg/m³	**ΔT_{P_SET}** °F	**ΔP_{P_SET}** psig	**ΔQ_{M_SET}** %	**r% ICPV_run**	**CPV_set**	**CPV_set** Bbls	
	0.000	0.075	0.40	0.0	0.066	-	0.590 065 848	**Runs 1-3**
	0.000	0.400	0.45	0.0	0.050	-	0.590 138 386	**Runs 2-4**
	0.000	0.325	0.65	0.0	0.035	-	0.590 168 221	**Runs 3-5**
1	0.000	0.010	0.30	0.0	0.006	**Pass**	0.590 108 356	**Runs 4-6**

Signature	**Date**	**Company**
		API Midstream Representative

Example B.2 - Calibration Set I - 2 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set II

General Data

Operator	API Midstream	
Station Name	Headquarters	
Fluid or Batch	Crude	-
Ch 11.1	Crude	-
T_B	60.0	°F
P_B	0.0	psig

Master Meter

Flowmeter ID	400	-
Manufacturer	API	-
Model	Turbine	-
Nominal Size	3	inch
Type	PD	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	696.700 0	P / Bbl
Cartridge No.	API-0011	-

Density Method

ρ_{obs} Method	Spot Sample	-
ρ_{obs} Device	Online Density	-
DMF	0.000 0	-
HYC Factor	No	-

API Chapter 12.4.2
USC_60 Measurement Units
Sampling Method - Spot
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Crude Oil - Tables 5A/6A

Field Prover

Prover Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Unidirectional	-
Wall Design	Single	-
Detector	External	-
Displacer	Captive Displacer	-
Wall Material	316SS	-
Rod Material	Invar	-
GL_P	0.000 008 90	per °F
GL_D	0.000 008 90	per °F
E_P	028 000 000	per psig
ID_P	17.400 0	inch
WT_P	1.825 0	inch
Serial No.	Uni-USC-004	-
Switches	9204 to 9234	-

Calibration Set Criteria

ΔMMF_{SET}	≤ 0.02	%
(r) $ICPV_{RUN}$	≤ 0.02	%
(r) CPV_{RUN}	≤ 0.02	%

Spot Sample

ρ_{60_START}	848.216 823 342 456	kg/m³
ρ_{60_STOP}	848.586 998 731 528	kg/m³
ρ_{60_SET}	848.401 911 036 992	kg/m³
MMF_{SET}	1.000 056 9	-

Report Summary

	Start	Stop	
Report No.	Start 2	Stop 2	-
Date	14-Feb-24	14-Feb-24	-
Time	10:53:11 AM	12:40:18 PM	-
Totalizer	2,342,521.020	2,343,841.020	Bbl
Fluid, Batch No.	Crude	Crude	-
API_{60}	35.2	35.1	°API
ρ_{60}	848.217	848.587	kg/m3
API_{15}	35.1	35.0	°API
ρ_{15}	848.619	848.989	kg/m3
API_{20}	35.7	35.6	°API
ρ_{20}	844.995	845.367	kg/m3
Flowrate, Q_{av}	524.145	524.785	BPH
T_{MP_AVG}	70.710	70.730	°F
P_{MP_AVG}	189.1	189.5	psig
Trips per Run	1	1	-
Roundtrips	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.011	0.008	%
Allowable (r)	0.020	0.020	%
(r) Pass/Fail	Pass	Pass	-
MMF	1.000 055 2	1.000 058 6	-
ΔMMF	NA	0.000	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-

Prior vs Current

ΔQ_{av}	0.1	%
ΔT_P	0.120	°C

Roundtrip Measurements							Base Density	
ρ_{obs} kg/m³	T_{dm} °F	P_{dm} psig	T_{FP_INLET} °F	T_{FP_OUTLET} °F	T_{MM} °F	T_{FD} °F	ρ_B kg/m³	Run
			70.690	70.510	70.520	75.120	848.402	1
			70.700	70.540	70.560	75.020	848.402	2
			70.690	70.450	70.630	75.140	848.402	3
								4
								5
								6
			70.690	70.500	70.570	75.090	848.402	Avg

Ch 11.1 Iteration Results	Roundtrip Measurements					T_{FP} and P_{FP} Values		
	N or N_i Pulses	Q_{MM} BPH	P_{FP_INLET} psig	P_{FP_OUTLET} psig	P_{MM} psig	T_{FP} °F	P_{FP} psig	Run
Crude Oil, JP-4	411.277	524.145	186.2	185.5	183.9	70.600 0	185.85	1
Crude Oil, JP-4	411.273	524.139	186.8	185.4	184.2	70.620 0	186.10	2
Crude Oil, JP-4	411.278	524.141	186.2	183.9	182.3	70.570 0	185.05	3
								4
								5
								6
	411.276 0	524.142	186.4	184.9	183.5	70.600 0	185.70	Avg

Example B.2 - Calibration Set II - 1 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set II

API Chapter 12.4.2
USC_60 Measurement Units
Sampling Method - Spot
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Crude Oil - Tables 5A/6A

ΔMMF_{SET}	**Pass**	-
(r) $ICPV_{SET}$	**Pass**	-
(r) CPV_{SET}	**Pass**	-

Report Summary

	Prior	*Current*
Report No.	Start	Stop
Date	Start 2	Stop 2
Time	00:00:00	00:00:00
Fluid, Batch No.	2342521.02	2343841.02

N or N_i Pulses	**NKF** P / Bbl	**IV_{MM}**	**CTL_{MM}**	**CPL_{MM}**	**$CTPL_{MM}$**	**GSV_{MM}** Bbls	**Run**
411.277	696.700 0	0.590 321 5	0.995 006 077	1.000 956 812	0.995 958 111	0.587 968 940	**1**
411.273	696.700 0	0.590 315 8	0.994 987 061	1.000 958 504	0.995 940 760	0.587 953 019	**2**
411.278	696.700 0	0.590 323 0	0.994 953 782	1.000 948 831	0.995 897 825	0.587 934 844	**3**
							4
							5
							6
411.276 0	696.700 0	0.590 320 1	0.994 982 307	1.000 954 716	0.995 932 232	0.587 952 268	**Avg**

Iteraton Results	**CTS_{FP}**	**CPS_{FP}**	**CTL_{FP}**	**CPL_{FP}**	**$CTPL_{FP}$**	**CPV_run** Bbls	**Run**
Crude Oil, JP-4	1.000 323 282	1.000 063 284	0.994 968 045	1.000 967 228	0.995 930 406	0.590 143 371	**1**
Crude Oil, JP-4	1.000 322 748	1.000 063 369	0.994 958 536	1.000 968 596	0.995 922 249	0.590 132 489	**2**
Crude Oil, JP-4	1.000 322 926	1.000 063 011	0.994 982 307	1.000 962 964	0.995 940 439	0.590 103 575	**3**
							4
							5
							6
	1.000 322 985	1.000 063 221	0.994 969 629	1.000 966 263	0.995 931 031	0.590 126 478	**Avg**

	1 means ΔCPV Passed	**$\Delta\rho_{B\_SET}$** kg/m³	**ΔT_{P_SET}** °F	**ΔP_{P_SET}** psig	**ΔQ_{MM_SET}** %	**r% ICPV_run**	**CPV_set**	**CPV_set** Bbls	
Runs 1-3	1	0.000	0.050	1.05	0.0	0.007	**Pass**	0.590 126 478	**Runs 1-3**
Runs 2-4		NA	NA	NA	NA		-		**Runs 2-4**
Runs 3-5		NA	NA	NA	NA		-		**Runs 3-5**
Runs 4-6		NA	NA	NA	NA		-		**Runs 4-6**

Signature	**Date**	**Company**
		API Midstream Representative

Example B.2 - Calibration Set II - 2 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set III

General Data

Operator	API Midstream	
Station Name	Headquarters	
Fluid or Batch	Crude	-
Ch 11.1	Crude	-
T_B	60.0	°F
P_B	0.0	psig

Master Meter

Flowmeter ID	400	-
Manufacturer	API	-
Model	Turbine	-
Nominal Size	3	inch
Type	PD	-
Proving Result	MMF	-
T_F Comp	No	-
P_F Comp	No	-
NKF	696.700 0	P / Bbl
Cartridge No.	API-0011	-

Density Method

ρ_{obs} Method	Spot Sample	-
ρ_{obs} Device	Online Density	-
DMF	0.000 0	-
HYC Factor	No	-

API Chapter 12.4.2
USC_60 Measurement Units
Sampling Method - Spot
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Crude Oil - Tables 5A/6A

Field Prover

Prover Manufacturer	API	-
Prover Design	Displacement	-
Flow Design	Unidirectional	-
Wall Design	Single	-
Detector	External	-
Displacer	Captive Displacer	-
Wall Material	316SS	-
Rod Material	Invar	-
GL_P	0.000 008 90	per °F
GL_D	0.000 008 90	per °F
E_P	028 000 000	per psig
ID_P	17.400 0	inch
WT_P	1.825 0	inch
Serial No.	Uni-USC-004	-
Switches	9204 to 9234	-

Calibration Set Criteria

ΔMMF_{SET}	≤ 0.02	%
(r) $ICPV_{RUN}$	≤ 0.02	%
(r) CPV_{RUN}	≤ 0.02	%

Spot Sample

ρ_{60_START}	848.426 922 906 387	kg/m³
ρ_{60_STOP}	848.386 903 945 631	kg/m³
ρ_{60_SET}	848.406 913 426 009	kg/m³
MMF_{SET}	0.999 855 4	-

Report Summary

	Start	Stop	
Report No.	Start 3	Stop 3	-
Date	14-Feb-24	14-Feb-24	-
Time	8:21:18 AM	11:21:18 AM	-
Totalizer	2,342,501.020	2,343,601.020	Bbl
Fluid, Batch No.	Crude	Crude	-
API_{60}	35.1	35.1	°API
ρ_{60}	848.427	848.387	kg/m3
API_{15}	35.1	35.1	°API
ρ_{15}	848.829	848.789	kg/m3
API_{20}	35.6	35.6	°API
ρ_{20}	845.206	845.166	kg/m3
Flowrate, Q_{av}	882.146	881.970	BPH
T_{MP_AVG}	73.100	73.240	°F
P_{MP_AVG}	187.7	188.3	psig
Trips per Run	1	1	-
Roundtrips	Runs 1-5	Runs 1-5	-
Repeatability (r)	0.008	0.014	%
Allowable (r)	0.020	0.020	%
(r) Pass/Fail	Pass	Pass	-
MMF	0.999 845 2	0.999 865 5	-
ΔMMF	NA	0.002	%
Allowable ± ΔMMF	NA	0.020	%
ΔMMF Pass/Fail	NA	Pass	-

Prior vs Current

ΔQ_{av}	0.1	%
ΔT_P	0.120	°C

Roundtrip Measurements							Base Density	
ρ_{obs} kg/m³	T_{dm} °F	P_{dm} psig	T_{FP_INLET} °F	T_{FP_OUTLET} °F	T_{MM} °F	T_{FD} °F	ρ_B kg/m³	Run
			73.070	73.200	73.390	75.120	848.407	1
			73.050	73.120	73.390	75.020	848.407	2
			73.080	73.140	73.400	75.140	848.407	3
								4
								5
								6
			73.070	73.150	73.390	75.090	848.407	Avg

Ch 11.1 Iteration Results	Roundtrip Measurements					T_{FP} and P_{FP} Values		
	N or N_i Pulses	Q_{MM} BPH	P_{FP_INLET} psig	P_{FP_OUTLET} psig	P_{MM} psig	T_{FP} °F	P_{FP} psig	Run
Crude Oil, JP-4	411.407	882.125	176.1	173.8	185.4	73.135 0	174.95	1
Crude Oil, JP-4	411.413	882.131	176.7	174.0	185.9	73.085 0	175.35	2
Crude Oil, JP-4	411.408	882.129	176.2	174.0	186.4	73.110 0	175.10	3
								4
								5
								6
	411.409 3	882.128	176.3	173.9	185.9	73.110 0	175.10	Avg

Example B.2 - Calibration Set III - 1 of 2

Washington, D.C., USA

BPV Determination using Master Meter - Calibration Set III

API Chapter 12.4.2
USC_60 Measurement Units
Sampling Method - Spot
BPV - Standard Method
Fixed Range Method, r% ≤ 0.02, for 3 Consecutive CPVs
Crude Oil - Tables 5A/6A

ΔMMF_{SET}	**Pass**	-
(r) $ICPV_{SET}$	**Pass**	-
(r) CPV_{SET}	**Pass**	-

Report Summary

	Prior	*Current*
Report No.	Start	Stop
Date	Start 3	Stop 3
Time	00:00:00	00:00:00
Fluid, Batch No.	2342501.02	2343601.02

N or N_i Pulses	**NKF** P / Bbl	**IV_{MM}**	**CTL_{MM}**	**CPL_{MM}**	**$CTPL_{MM}$**	**GSV_{MM}** Bbls	**Run**
411.407	696.700 0	0.590 508 1	0.993 641 209	1.000 973 983	0.994 609 000	0.587 239 743	**1**
411.413	696.700 0	0.590 516 7	0.993 641 209	1.000 976 613	0.994 611 612	0.587 249 838	**2**
411.408	696.700 0	0.590 509 5	0.993 636 452	1.000 979 275	0.994 609 495	0.587 241 428	**3**
							4
							5
							6
411.409 3	696.700 0	0.590 511 4	0.993 639 624	1.000 976 624	0.994 610 036	0.587 243 670	**Avg**

Iteraton Results	**CTS_{FP}**	**CPS_{FP}**	**CTL_{FP}**	**CPL_{FP}**	**$CTPL_{FP}$**	**CPV_run** Bbls	**Run**
Crude Oil, JP-4	1.000 368 416	1.000 059 572	0.993 762 527	1.000 918 245	0.994 675 045	0.590 130 927	**1**
Crude Oil, JP-4	1.000 366 636	1.000 059 708	0.993 786 313	1.000 920 192	0.994 700 787	0.590 126 769	**2**
Crude Oil, JP-4	1.000 368 149	1.000 059 623	0.993 774 420	1.000 918 956	0.994 687 655	0.590 125 266	**3**
							4
							5
							6
	1.000 367 734	1.000 059 634	0.993 774 420	1.000 919 131	0.994 687 829	0.590 127 654	**Avg**

	1 means ΔCPV Passed	**$\Delta\rho_{B\_SET}$** kg/m^3	**ΔT_{P_SET}** °F	**ΔP_{P_SET}** psig	**ΔQ_{MM_SET}** %	**r% ICPV_run**	**CPV_set**	**CPV_set** Bbls	
Runs 1-3	1	0.000	0.050	0.40	0.0	0.001	**Pass**	0.590 127 654	**Runs 1-3**
Runs 2-4		NA	NA	NA	NA		-		**Runs 2-4**
Runs 3-5		NA	NA	NA	NA		-		**Runs 3-5**
Runs 4-6		NA	NA	NA	NA		-		**Runs 4-6**

Signature	**Date**	**Company**
		API Midstream Representative

Example B.2 - Calibration Set III - 2 of 2

Annex C
(informative)
Equations for the Master Meter Volumetric Method

Figure C.1 - Standard Method Using Continuous Sampling

Figure C.2 - Standard Method Equations Using Spot Sampling

Figure C.3 - Alternate Method 'A' Using Continuous Sampling

Figure C.4 - Alternate Method 'A' Using Spot Sampling

Figure C.5 - Alternate Method 'B' Using Continuous Sampling

Figure C.6 - Alternate Method 'B' Using Spot Sampling

Density Correlations using API MPM Chapter 11.1

The density correlations in accordance with API MPMS Chapter 11.1 for atmospherically stable fluids ($P_{E\_at\_Tfluid}$ = 0.0 psig, 0.0 kPag):

$CTPL = CTL \times CPL = \rho_{TP} / \rho_B$

$\rho_{TP} = CTPL \times \rho_B = CTL \times CPL \times \rho_B$

And,

$CTL \sim f (\rho_B, T_{Fluid})$

$CPL \sim f (\rho_B, T_{Fluid}, P_{Fluid}, F_{FLuid})$

$F_{Fluid} \sim f (\rho_B, T_{Fluid})$

For Continuous Sampling,

ρ_B and $\rho_{B\_RUN} \sim (\rho_{obs} , T_{dm, Pdm})$

And,

$\rho_{B\_SET} = \sum^3 (\rho_{B\_RUN}) / 3$

ICPV Equations

Master Meter

$CTL_{MM} \sim f (\rho_{B\_START}, T_{MM})$

$F_{MM} \sim f (\rho_{B\_START}, T_{MM})$

$CPL_{MM} = 1 / [1 - (P_{MM} \times F_{MM})]$

$GSV_{MM} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM}] \times MMF_{START}$

Field Displacement Prover

CTS_{FP}

$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP}] \}^3$ free displacer design

$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP})] \}^2 \times \{ 1 + [(T_{fd} - T_B) \times GL_{fd}] \}$ captive displacer design

$CPS_{FP} = \{ 1 + [(P_{FP} \times ID_{FP}) / (E_{FP} \times WT_{FP})] \}$ single wall design

$CTL_{FP} \sim f (\rho_{B\_START}, T_{FP})$

$F_{FP} \sim f (\rho_{B\_START}, T_{FP})$

$CPL_{FP} = 1 / [1 - (P_{FP} \times F_{FP})]$

$ICPV_{RUN} = GSV_{MM} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$

Field Open Tank Prover

$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP}] \}^3$

$CPS_{FP} = 1.000\ 000$

$CPS_{MP} = \{ 1 + [(P_{MP} \times ID_{MP}) / (E_{MP} \times WT_{MP})] \}$

$CTL_{FP} \sim f (\rho_{B\_START}, T_{FP})$

$CPL_{FP} = 1.000\ 000$

$ICPV_{RUN} = GSV_{MM} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$

CPV Equations

Master Meter

$CTL_{MM} \sim f (\rho_{B\_RUN}, T_{MM})$

$F_{MM} \sim f (\rho_{B\_RUN}, T_{MM})$

$CPL_{MM} = 1 / [1 - (P_{MM} \times F_{MM})]$

$MMF_{SET} = [MMF_{START} + MMF_{STOP}] / 2$

$GSV_{MM\_RUN} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM}] \times MMF_{SET}$

Field Displacement Prover

CTS_{FP}

$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP}] \}^3$ free displacer design

$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP})] \}^2 \times \{ 1 + [(T_{fd} - T_B) \times GL_{fd}] \}$ captive displacer design

$CPS_{FP} = \{ 1 + [(P_{FP} \times ID_{FP}) / (E_{FP} \times WT_{FP})] \}$ single wall design

$CTL_{FP} \sim f (\rho_{B\_RUN}, T_{FP})$

$F_{FP} \sim f (\rho_{B\_RUN}, T_{FP})$

$CPL_{FP} = 1 / [1 - (P_{FP} \times F_{FP})]$

$CPV_{RUN} = GSV_{MM\_RUN} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$

$CPV_{SET} = (\sum^3 CPV_{RUN}) / 3$

Field Open Tank Prover

$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP}] \}^3$

$CPS_{FP} = 1.000\ 000$

$CPS_{MP} = \{ 1 + [(P_{MP} \times ID_{MP}) / (E_{MP} \times WT_{MP})] \}$

$CTL_{FP} \sim f (\rho_{B\_RUN}, T_{FP})$

$CPL_{FP} = 1.000\ 000$

$CPV_{RUN} = GSV_{MM\_RUN} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$

$CPV_{SET} = (\sum^3 CPV_{RUN}) / 3$

Figure C.1 - Standard Method Using Continuous Sampling

Conservation of Mass Principle

The Conservation of Mass Principle is the basis for calibrating provers and flowmeters. Assuming no leaks, a constant line pack between the Master Meter and Field Prover, and a homopgeneous fluid, then the Conservation of Mass Principle allows us to apply the following equations -

The Mass measured by the Master Meter (M_{MM}) is calculated as follows -

$$M_{MM} = [(\sum N \ / \ NKF) \times \rho_{TmmPmm}] \times MMF = IM_{MM} \times MMF$$

or,

$$M_{MM} = [(\sum N \ / \ NKF) \times CTL_{MM} \times CPL_{MM} \times \rho_B] \times MMF$$

The Gross Standard Volume of the Master Meter (GSV_{MM}) is calculated as follows -

$$GSV_{MM} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM}] \times MMF = M_{MM} / \rho_B$$

The Mass in the Field Prover (M_{FP}) is calculated as follows -

$$M_{FP} = M_{MM}$$

or,

$$M_{FP} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM} \times \rho_B] \times MMF$$

The Calibrated Prover Volume for a Run (CPV_{RUN}) is calculated as follows -

$$CPV_{RUN} = GSV_{MM} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP}) = [M_{MM} / \rho_B] / [(\rho_{FP\_TP} / \rho_B) \times CTS_{FP} \times CPS_{FP}]$$

Figure C.1 - Standard Method Using Continuous Sampling (continued)

Density Correlations using API MPM Chapter 11.1

The density correlations in accordance with API MPMS Chapter 11.1 for atmospherically stable fluids ($P_{E\_at\_Tfluid}$ = 0.0 psig, 0.0 kPag):

$CTPL = CTL \times CPL = \rho_{TP} / \rho_B$

$\rho_{TP} = CTPL \times \rho_B = CTL \times CPL \times \rho_B$

And,

$CTL \sim f(\rho_B, T_{Fluid})$

$CPL \sim f(\rho_B, T_{Fluid}, P_{Fluid}, F_{FLuid})$

$F_{Fluid} \sim f(\rho_B, T_{Fluid})$

And,

$\rho_{B\_SET} = (\rho_{B\_START} + \rho_{B\_STOP}) / 2$

For Spot Sampling,

ρ_B and $\rho_{B\_RUN} \sim (\rho_{obs}, T_{obs, Pobs})$

ICPV Equations

Master Meter

$CTL_{MM} \sim f(\rho_{B\_START}, T_{MM})$

$F_{MM} \sim f(\rho_{B\_START}, T_{MM})$

$CPL_{MM} = 1 / [1 - (P_{MM} \times F_{MM})]$

$GSV_{MM} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM}] \times MMF_{START}$

Field Displacement Prover

CTS_{FP}

$CTS_{FP} = \{1 + [(T_{FP} - T_B) \times GL_{FP}]\}^3$ free displacer design

$CTS_{FP} = \{1 + [(T_{FP} - T_B) \times GL_{FP})]\}^2 \times \{1 + [(T_{fd} - T_B) \times GL_{fd}]\}$ captive displacer design

$CPS_{FP} = \{1 + [(P_{FP} \times ID_{FP}) / (E_{FP} \times WT_{FP})]\}$ single wall design

$CTL_{FP} \sim f(\rho_{B\_START}, T_{FP})$

$F_{FP} \sim f(\rho_{B\_START}, T_{FP})$

$CPL_{FP} = 1 / [1 - (P_{FP} \times F_{FP})]$

$ICPV_{RUN} = GSV_{MM} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$

Field Open Tank Prover

$CTS_{FP} = \{1 + [(T_{FP} - T_B) \times GL_{FP}]\}^3$

$CPS_{FP} = 1.000\,000$

$CPS_{MP} = \{1 + [(P_{MP} \times ID_{MP}) / (E_{MP} \times WT_{MP})]\}$

$CTL_{FP} \sim f(\rho_{B\_START}, T_{FP})$

$CPL_{FP} = 1.000\,000$

$ICPV_{RUN} = GSV_{MM} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$

CPV Equations

Master Meter

$CTL_{MM} \sim f(\rho_{B\_SET}, T_{MM})$

$F_{MM} \sim f(\rho_{B\_SET}, T_{MM})$

$CPL_{MM} = 1 / [1 - (P_{MM} \times F_{MM})]$

$MMF_{SET} = [MMF_{START} + MMF_{STOP}] / 2$

$GSV_{MM\_RUN} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM}] \times MMF_{SET}$

Field Displacement Prover

CTS_{FP}

$CTS_{FP} = \{1 + [(T_{FP} - T_B) \times GL_{FP}]\}^3$ free displacer design

$CTS_{FP} = \{1 + [(T_{FP} - T_B) \times GL_{FP})]\}^2 \times \{1 + [(T_{fd} - T_B) \times GL_{fd}]\}$ captive displacer design

$CPS_{FP} = \{1 + [(P_{FP} \times ID_{FP}) / (E_{FP} \times WT_{FP})]\}$ single wall design

$CTL_{FP} \sim f(\rho_{B\_SET}, T_{FP})$

$F_{FP} \sim f(\rho_{B\_SET}, T_{FP})$

$CPL_{FP} = 1 / [1 - (P_{FP} \times F_{FP})]$

$CPV_{RUN} = GSV_{MM\_RUN} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$

$CPV_{SET} = (\sum^3 CPV_{RUN}) / 3$

Field Open Tank Prover

$CTS_{FP} = \{1 + [(T_{FP} - T_B) \times GL_{FP}]\}^3$

$CPS_{FP} = 1.000\,000$

$CPS_{MP} = \{1 + [(P_{MP} \times ID_{MP}) / (E_{MP} \times WT_{MP})]\}$

$CTL_{FP} \sim f(\rho_{B\_SET}, T_{FP})$

$CPL_{FP} = 1.000\,000$

$CPV_{RUN} = GSV_{MM\_RUN} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$

$CPV_{SET} = (\sum^3 CPV_{RUN}) / 3$

Figure C.2 - Standard Method Equations Using Spot Sampling

Conservation of Mass Principle

The Conservation of Mass Principle is the basis for calibrating provers and flowmeters. Assuming no leaks, a constant line pack between the Master Meter and Field Prover, and a homopgeneous fluid, then the Conservation of Mass Principle allows us to apply the following equations -

The Mass measured by the Master Meter (M_{MM}) is calculated as follows -

$$M_{MM} = [(\sum N \ / \ NKF) \times \rho_{TmmPmm}] \times MMF = IM_{MM} \times MMF$$

or,

$$M_{MM} = [(\sum N \ / \ NKF) \times CTL_{MM} \times CPL_{MM} \times \rho_B] \times MMF$$

The Gross Standard Volume of the Master Meter (GSV_{MM}) is calculated as follows -

$$GSV_{MM} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM}] \times MMF = M_{MM} / \rho_B$$

The Mass in the Field Prover (M_{FP}) is calculated as follows -

$$M_{FP} = M_{MM}$$

or,

$$M_{FP} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM} \times \rho_B] \times MMF$$

The Calibrated Prover Volume for a Run (CPV_{RUN}) is calculated as follows -

$$CPV_{RUN} = GSV_{MM} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP}) = [M_{MM} / \rho_B] / [(\rho_{FP\_TP} / \rho_B) \times CTS_{FP} \times CPS_{FP}]$$

Figure C.2 - Standard Method Equations Using Spot Sampling (continued)

Density Correlations using API MPM Chapter 11.1

The density correlations in accordance with API MPMS Chapter 11.1 for atmospherically stable fluids ($P_{E\_at\_Tfluid}$ = 0.0 psig, 0.0 kPag):

$$CTPL = CTL \times CPL = \rho_{TP} / \rho_B$$

$$\rho_{TP} = CTPL \times \rho_B = CTL \times CPL \times \rho_B$$

And,

$$CTL \sim f (\rho_B, T_{Fluid})$$

$$CPL \sim f (\rho_B, T_{Fluid}, P_{Fluid}, F_{FLuid})$$

$$F_{Fluid} \sim f (\rho_B, T_{Fluid})$$

For Continuous Sampling,

$$\rho_B \text{ and } \rho_{B\_RUN} \sim (\rho_{obs} , T_{dm,\ Pdm})$$

And,

$$\rho_{B\_SET} = \sum^3 (\rho_{B\_RUN}) / 3$$

CPV Equations

Master Meter

$$CTL_{MM} \sim f (\rho_{B\_RUN}, T_{MM})$$

$$F_{MM} \sim f (\rho_{B\_RUN}, T_{MM})$$

$$CPL_{MM} = 1 / [1 - (P_{MM} \times F_{MM})]$$

$$MMF_{RUN} = [MMF_{START} + MMF_{STOP}] / 2$$

$$GSV_{MM\_RUN} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM}] \times MMF_{RUN}$$

Field Displacement Prover

$$CTS_{FP}$$

$$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP}] \}^3 \quad \text{free displacer design}$$

$$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP})] \}^2 \times \{ 1 + [(T_{fd} - T_B) \times GL_{fd}] \} \quad \text{captive displacer design}$$

$$CPS_{FP} = \{ 1 + [(P_{FP} \times ID_{FP}) / (E_{FP} \times WT_{FP})] \} \quad \text{single wall design}$$

$$CTL_{FP} \sim f (\rho_{B\_RUN}, T_{FP})$$

$$F_{FP} \sim f (\rho_{B\_RUN}, T_{FP})$$

$$CPL_{FP} = 1 / [1 - (P_{FP} \times F_{FP})]$$

$$CPV_{RUN} = GSV_{MM\_RUN} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$$

$$CPV_{SET} = (\sum^3 CPV_{RUN}) / 3$$

Field Open Tank Prover

$$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP}] \}^3$$

$$CPS_{FP} = 1.000\ 000$$

$$CPS_{MP} = \{ 1 + [(P_{MP} \times ID_{MP}) / (E_{MP} \times WT_{MP})] \}$$

$$CTL_{FP} \sim f (\rho_{B\_SET}, T_{FP})$$

$$CPL_{FP} = 1.000\ 000$$

$$CPV_{RUN} = GSV_{MM\_RUN} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$$

$$CPV_{SET} = (\sum^3 CPV_{RUN}) / 3$$

Conservation of Mass Principle

The Conservation of Mass Principle is the basis for calibrating provers and flowmeters. Assuming no leaks, a constant line pack between the Master Meter and Field Prover, and a homopgeneous fluid, then the Conservation of Mass Principle allows us to apply the following equations -

The Mass measured by the Master Meter (M_{MM}) is calculated as follows -

$$M_{MM} = [(\sum N / NKF) \times \rho_{TmmPmm}] \times MMF = IM_{MM} \times MMF$$

or,

$$M_{MM} = [(\sum N / NKF) \times CTL_{MM} \times CPL_{MM} \times \rho_B] \times MMF$$

The Gross Standard Volume of the Master Meter (GSV_{MM}) is calculated as follows -

$$GSV_{MM} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM}] \times MMF = M_{MM} / \rho_B$$

The Mass in the Field Prover (M_{FP}) is calculated as follows -

$$M_{FP} = M_{MM}$$

or,

$$M_{FP} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM} \times \rho_B] \times MMF$$

The Calibrated Prover Volume for a Run (CPV_{RUN}) is calculated as follows -

$$CPV_{RUN} = GSV_{MM} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP}) = [M_{MM} / \rho_B] / [(\rho_{FP\_TP} / \rho_B) \times CTS_{FP} \times CPS_{FP}]$$

Figure C.3 - Alternate Method 'A' Using Continuous Sampling

Density Correlations using API MPM Chapter 11.1

The density correlations in accordance with API MPMS Chapter 11.1 for atmospherically stable fluids ($P_{E\_at\_Tfluid}$ = 0.0 psig, 0.0 kPag):

$$CTPL = CTL \times CPL = \rho_{TP} / \rho_B$$

$$\rho_{TP} = CTPL \times \rho_B = CTL \times CPL \times \rho_B$$

And,

$$CTL \sim f (\rho_B, T_{Fluid})$$

$$CPL \sim f (\rho_B, T_{Fluid}, P_{Fluid}, F_{FLuid})$$

$$F_{Fluid} \sim f (\rho_B, T_{Fluid})$$

And,

$$\rho_{B\_SET} = (\rho_{B\_START} + \rho_{B\_STOP}) / 2$$

For Spot Sampling,

$$\rho_B \text{ and } \rho_{B\_RUN} \sim (\rho_{obs} , T_{obs,\ Pobs})$$

CPV Equations

Master Meter

$$CTL_{MM} \sim f (\rho_{B\_SET}, T_{MM})$$

$$F_{MM} \sim f (\rho_{B\_SET}, T_{MM})$$

$$CPL_{MM} = 1 / [1 - (P_{MM} \times F_{MM})]$$

$$MMF_{RUN} = [MMF_{START} + MMF_{STOP}] / 2$$

$$GSV_{MM\_RUN} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM}] \times MMF_{RUN}$$

Field Displacement Prover

$$CTS_{FP}$$

$$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP}] \}^3 \quad \text{free displacer design}$$

$$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP})] \}^2 \times \{ 1 + [(T_{fd} - T_B) \times GL_{fd}] \} \quad \text{captive displacer design}$$

$$CPS_{FP} = \{ 1 + [(P_{FP} \times ID_{FP}) / (E_{FP} \times WT_{FP})] \} \quad \text{single wall design}$$

$$CTL_{FP} \sim f (\rho_{B\_SET}, T_{FP})$$

$$F_{FP} \sim f (\rho_{B\_SET}, T_{FP})$$

$$CPL_{FP} = 1 / [1 - (P_{FP} \times F_{FP})]$$

$$CPV_{RUN} = GSV_{MM\_RUN} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$$

$$CPV_{SET} = (\sum^3 CPV_{RUN}) / 3$$

Field Open Tank Prover

$$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP}] \}^3$$

$$CPS_{FP} = 1.000\ 000$$

$$CPS_{MP} = \{ 1 + [(P_{MP} \times ID_{MP}) / (E_{MP} \times WT_{MP})] \}$$

$$CTL_{FP} \sim f (\rho_{B\_SET}, T_{FP})$$

$$CPL_{FP} = 1.000\ 000$$

$$CPV_{RUN} = GSV_{MM\_RUN} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$$

$$CPV_{SET} = (\sum^3 CPV_{RUN}) / 3$$

Conservation of Mass Principle

The Conservation of Mass Principle is the basis for calibrating provers and flowmeters. Assuming no leaks, a constant line pack between the Master Meter and Field Prover, and a homopgeneous fluid, then the Conservation of Mass Principle allows us to apply the following equations -

The Mass measured by the Master Meter (M_{MM}) is calculated as follows -

$$M_{MM} = [(\sum N / NKF) \times \rho_{TmmPmm}] \times MMF = IM_{MM} \times MMF$$

or,

$$M_{MM} = [(\sum N / NKF) \times CTL_{MM} \times CPL_{MM} \times \rho_B] \times MMF$$

The Gross Standard Volume of the Master Meter (GSV_{MM}) is calculated as follows -

$$GSV_{MM} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM}] \times MMF = M_{MM} / \rho_B$$

The Mass in the Field Prover (M_{FP}) is calculated as follows -

$$M_{FP} = M_{MM}$$

or,

$$M_{FP} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM} \times \rho_B] \times MMF$$

The Calibrated Prover Volume for a Run (CPV_{RUN}) is calculated as follows -

$$CPV_{RUN} = GSV_{MM} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP}) = [M_{MM} / \rho_B] / [(\rho_{FP\_TP} / \rho_B) \times CTS_{FP} \times CPS_{FP}]$$

Figure C.4 - Alternate Method 'A' Using Spot Sampling

Density Correlations using API MPM Chapter 11.1

The density correlations in accordance with API MPMS Chapter 11.1 for atmospherically stable fluids ($P_{E\_at\_Tfluid}$ = 0.0 psig, 0.0 kPag):

$$CTPL = CTL \times CPL = \rho_{TP} / \rho_B$$

$$\rho_{TP} = CTPL \times \rho_B = CTL \times CPL \times \rho_B$$

And,

$$CTL \sim f (\rho_B, T_{Fluid})$$

$$CPL \sim f (\rho_B, T_{Fluid}, P_{Fluid}, F_{FLuid})$$

$$F_{Fluid} \sim f (\rho_B, T_{Fluid})$$

For Continuous Sampling,

$$\rho_B \text{ and } \rho_{B\_RUN} \sim (\rho_{obs} , T_{dm,\ Pdm})$$

And,

$$\rho_{B\_SET} = \sum^3 (\rho_{B\_RUN}) / 3$$

CPV Equations

Master Meter

$$CTL_{MM} \sim f (\rho_{B\_RUN}, T_{MM})$$

$$F_{MM} \sim f (\rho_{B\_RUN}, T_{MM})$$

$$CPL_{MM} = 1 / [1 - (P_{MM} \times F_{MM})]$$

$$MMF_{RUN} = MMF_{START}$$

$$GSV_{MM\_RUN} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM}] \times MMF_{RUN}$$

Field Displacement Prover

$$CTS_{FP}$$

$$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP}] \}^3 \quad \text{free displacer design}$$

$$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP})] \}^2 \times \{ 1 + [(T_{fd} - T_B) \times GL_{fd}] \} \quad \text{captive displacer design}$$

$$CPS_{FP} = \{ 1 + [(P_{FP} \times ID_{FP}) / (E_{FP} \times WT_{FP})] \} \quad \text{single wall design}$$

$$CTL_{FP} \sim f (\rho_{B\_RUN}, T_{FP})$$

$$F_{FP} \sim f (\rho_{B\_RUN}, T_{FP})$$

$$CPL_{FP} = 1 / [1 - (P_{FP} \times F_{FP})]$$

$$CPV_{RUN} = GSV_{MM\_RUN} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$$

$$CPV_{SET} = (\sum^3 CPV_{RUN}) / 3$$

Field Open Tank Prover

$$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP}] \}^3$$

$$CPS_{FP} = 1.000\ 000$$

$$CPS_{MP} = \{ 1 + [(P_{MP} \times ID_{MP}) / (E_{MP} \times WT_{MP})] \}$$

$$CTL_{FP} \sim f (\rho_{B\_SET}, T_{FP})$$

$$CPL_{FP} = 1.000\ 000$$

$$CPV_{RUN} = GSV_{MM\_RUN} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$$

$$CPV_{SET} = (\sum^3 CPV_{RUN}) / 3$$

Conservation of Mass Principle

The Conservation of Mass Principle is the basis for calibrating provers and flowmeters. Assuming no leaks, a constant line pack between the Master Meter and Field Prover, and a homopgeneous fluid, then the Conservation of Mass Principle allows us to apply the following equations -

The Mass measured by the Master Meter (M_{MM}) is calculated as follows -

$$M_{MM} = [(\sum N / NKF) \times \rho_{TmmPmm}] \times MMF = IM_{MM} \times MMF$$

or,

$$M_{MM} = [(\sum N / NKF) \times CTL_{MM} \times CPL_{MM} \times \rho_B] \times MMF$$

The Gross Standard Volume of the Master Meter (GSV_{MM}) is calculated as follows -

$$GSV_{MM} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM}] \times MMF = M_{MM} / \rho_B$$

The Mass in the Field Prover (M_{FP}) is calculated as follows -

$$M_{FP} = M_{MM}$$

or,

$$M_{FP} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM} \times \rho_B] \times MMF$$

The Calibrated Prover Volume for a Run (CPV_{RUN}) is calculated as follows -

$$CPV_{RUN} = GSV_{MM} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP}) = [M_{MM} / \rho_B] / [(\rho_{FP\_TP} / \rho_B) \times CTS_{FP} \times CPS_{FP}]$$

Figure C.5 - Alternate Method 'B' Using Continuous Sampling

Density Correlations using API MPM Chapter 11.1

The density correlations in accordance with API MPMS Chapter 11.1 for atmospherically stable fluids ($P_{E\_at\_Tfluid}$ = 0.0 psig, 0.0 kPag):

$$CTPL = CTL \times CPL = \rho_{TP} / \rho_B$$

$$\rho_{TP} = CTPL \times \rho_B = CTL \times CPL \times \rho_B$$

And,

$$CTL \sim f (\rho_B, T_{Fluid})$$

$$CPL \sim f (\rho_B, T_{Fluid}, P_{Fluid}, F_{FLuid})$$

$$F_{Fluid} \sim f (\rho_B, T_{Fluid})$$

And,

$$\rho_{B\_SET} = (\rho_{B\_START} + \rho_{B\_STOP}) / 2$$

For Spot Sampling,

$$\rho_B \text{ and } \rho_{B\_RUN} \sim (\rho_{obs} , T_{obs,\ Pobs})$$

CPV Equations

Master Meter

$$CTL_{MM} \sim f (\rho_{B\_SET}, T_{MM})$$

$$F_{MM} \sim f (\rho_{B\_SET}, T_{MM})$$

$$CPL_{MM} = 1 / [1 - (P_{MM} \times F_{MM})]$$

$$MMF_{RUN} = MMF_{START}$$

$$GSV_{MM\_RUN} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM}] \times MMF_{RUN}$$

Field Displacement Prover

$$CTS_{FP}$$

$$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP}] \}^3 \quad \text{free displacer design}$$

$$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP})] \}^2 \times \{ 1 + [(T_{fd} - T_B) \times GL_{fd}] \} \quad \text{captive displacer design}$$

$$CPS_{FP} = \{ 1 + [(P_{FP} \times ID_{FP}) / (E_{FP} \times WT_{FP})] \} \quad \text{single wall design}$$

$$CTL_{FP} \sim f (\rho_{B\_SET}, T_{FP})$$

$$F_{FP} \sim f (\rho_{B\_SET}, T_{FP})$$

$$CPL_{FP} = 1 / [1 - (P_{FP} \times F_{FP})]$$

$$CPV_{RUN} = GSV_{MM\_RUN} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$$

$$CPV_{SET} = (\sum^3 CPV_{RUN}) / 3$$

Field Open Tank Prover

$$CTS_{FP} = \{ 1 + [(T_{FP} - T_B) \times GL_{FP}] \}^3$$

$$CPS_{FP} = 1.000\ 000$$

$$CPS_{MP} = \{ 1 + [(P_{MP} \times ID_{MP}) / (E_{MP} \times WT_{MP})] \}$$

$$CTL_{FP} \sim f (\rho_{B\_SET}, T_{FP})$$

$$CPL_{FP} = 1.000\ 000$$

$$CPV_{RUN} = GSV_{MM\_RUN} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP})$$

$$CPV_{SET} = (\sum^3 CPV_{RUN}) / 3$$

Conservation of Mass Principle

The Conservation of Mass Principle is the basis for calibrating provers and flowmeters. Assuming no leaks, a constant line pack between the Master Meter and Field Prover, and a homopgeneous fluid, then the Conservation of Mass Principle allows us to apply the following equations -

The Mass measured by the Master Meter (M_{MM}) is calculated as follows -

$$M_{MM} = [(\sum N / NKF) \times \rho_{TmmPmm}] \times MMF = IM_{MM} \times MMF$$

or,

$$M_{MM} = [(\sum N / NKF) \times CTL_{MM} \times CPL_{MM} \times \rho_B] \times MMF$$

The Gross Standard Volume of the Master Meter (GSV_{MM}) is calculated as follows -

$$GSV_{MM} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM}] \times MMF = M_{MM} / \rho_B$$

The Mass in the Field Prover (M_{FP}) is calculated as follows -

$$M_{FP} = M_{MM}$$

or,

$$M_{FP} = [(\sum N) / NKF \times CTL_{MM} \times CPL_{MM} \times \rho_B] \times MMF$$

The Calibrated Prover Volume for a Run (CPV_{RUN}) is calculated as follows -

$$CPV_{RUN} = GSV_{MM} / (CTS_{FP} \times CPS_{FP} \times CTL_{FP} \times CPL_{FP}) = [M_{MM} / \rho_B] / [(\rho_{FP\_TP} / \rho_B) \times CTS_{FP} \times CPS_{FP}]$$

Figure C.6 - Alternate Method 'B' Using Spot Sampling

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