NCWM

Form 15: Proposal to Amend NIST Handbooks, NCWM Guidance Documents, Bylaws, or Publication 14.

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General Information

- **Proposal to:** NCWM S&T Committee
- Submitter's Name: Prentiss Searles - API, et. al.

Proposal Information

- **Purpose:** Concise statement as to the intent or purpose of this proposal, such as a problem being fixed. (Do not include justification here.)
    - Clarify the acceptable use of specific density correction methods that allow for the accurate determination of volume growth that occurs when gasoline is blended with ethanol to make a finished motor fuel.
- **Document to be Amended:** HB 44
- **Cite Portion to be Amended (include the section and paragraph):** **Section 3.30 Liquid Measuring Devices**

S.2. Measuring Elements

S.2.9. Wholesale Devices Equipped with Electronic Automatic Density Correction Systems.

S.2.9.1. Automatic Density Correction.

S.2.9.2. Provision for Deactivating

S.2.9.3. Provision for Sealing Automatic Density Correction System.

S.4 Marking Requirements

S.4.3. Wholesale Devices.

S.4.3.3. Automatic Density Correction for Changes in Product Composition.

N.4. Testing Procedures

N.4.1.2. Wholesale Devices Equipped with Automatic Density Correction.

UR.3.6. ~~Temperature~~ Volume Compensation and Correction, Wholesale

UR.3.6.1.2. Invoices.

UR.3.6.2. Nonautomatic.

UR.3.6.2.2. Density Determination.

UR.3.6.2.3. Invoices.

T.5. Density Correction Systems.

Submit a separate Form 15 for each code, model law, or regulation to be amended.

- **Proposal:** Proposal Upload (Please upload a Microsoft Word document of your proposal below):

  Modify Handbook 44 to codify that density correction may be used to account for the volume growth that occurs when gasoline is blended with ethanol to make a finished motor fuel.

Clarify the acceptable use of specific density correction methods that allow for the accurate determination of volume growth that occurs when gasoline is blended with ethanol to make a finished motor fuel.

- **For Handbook 44 proposals, indicate one of the following:**

  1) **Retroactive** (Enforceable with respect to all devices)
  2) **Nonretroactive** (Enforceable on or after the effective date for devices (a) manufactured within a state after the effective date, (b) both new and used equipment brought into a state after the effective date, (c) used in non-commercial applications which are placed into commercial use after the effective date, and (d) undergoing type evaluation including devices that have been modified to be extent that a new Certificate of Conformance is required.

- **Justification:** Include national importance, background on the issue, and reference to supporting data or documents.

The volume of gasoline and ethanol when blended is more than the volume of the two liquids measured separately. Due to the way terminal load racks are configured, some measure the blended product using the custody meter and therefore capture the volume gain at the custody transfer meter (side stream blending), while others use multiple custody transfer meters to measure the gasoline and ethanol components separately (ratio blending) and do not capture the volume gain. The proposed changes will codify that a calculation can be applied at the Ratio-Blend terminal such that the two terminals have a comparable PTD.

The difference in terminal operations can cause inequity between the two types of terminals. The solution is for terminals that don't directly measure the volume growth in the final blended product to apply an industry standard (API Chapter 11.3.4) that calculates that volume expansion. Correcting the volume for this growth is known as Density Correction. The calculation used for density correction would use the same API gravities used by the automatic temperature compensation system to calculate the net volume of the gasoline-ethanol blend at 60^{O}F.

Table 1. Density Correction Uses Same Variables as Temperature Compensation Except for Ideal Fraction Ethanol

Variable	**Temperature Compensation (GST)**	**Density Correction (Net Volume)**
Reference Density of Gasoline (BOB) in API gravity units	✓ (API MPMS 11.1)	✓ (API MPMS 11.1)
Reference Density of Ethanol in API gravity units	✓ (API MPMS 11.3.3)	✓ (API MPMS 11.3.3)
Gross Meter Readings	✓ (API MPMS 12.2)	✓ (API MPMS 12.2)
Product Temperature (load average)	✓ (API MPMS 7.4)	✓ (API MPMS 7.4)
Net Meter Readings for ethanol and BOB	*(output from Temp Comp)*	

Ideal Fraction Ethanol (i.e., ethanol blend percentage)		✓ (API MPMS 11.3.4)

The proposed changes to Handbook 44 identify the sections that should be updated to codify the use of the API standard without replumbing the terminal. [Note there is also a separate but related proposal to change Handbook 130, Method of Sale.]

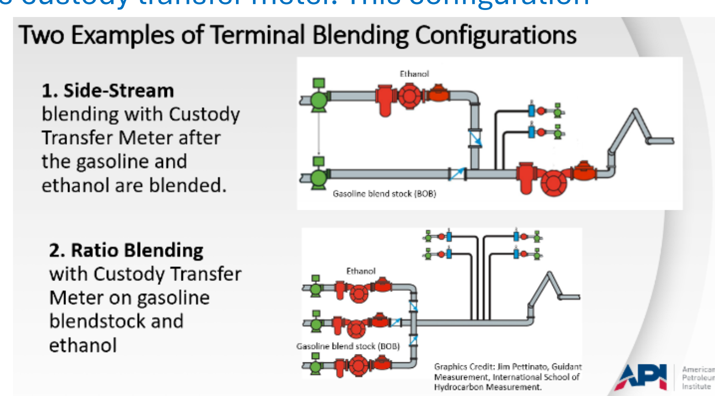
The proposed changes to HB 44 are the result of nine task force meetings where the group reviewed the science of the expanded volume, raised and discussed concerns, and discussed the proposed language incorporated in this proposal. The task force was led by API with participation from five states, NIST staff, retailer representatives, meter manufacturers, terminal operators, ethanol representatives, and consultants.

Background:

When gasoline and ethanol are blended the volume of the finished fuel increases by about 0.2% (range 0.08% to 0.4%) that is dependent on the density of the gasoline blend stock and the percentage of ethanol blended into the finished gasoline-ethanol fuel.

Some terminal configurations capture the volume expansion in the overall net calculation, while others do not, resulting in an inequity between the two configurations. To understand the inequity at the terminals, it is helpful to consider two of the terminal configurations that blend gasoline and ethanol (e.g., 10% ethanol, 15% ethanol, 85% ethanol). For simplicity, when we refer to a fuel it will be E10 as that fuel is more than 95% of the consumed gasoline in the U.S.

The first configuration is a **Side-Stream terminal.** It measures the ethanol which is then added to the gasoline blend stock ahead of the custody transfer meter. This configuration captures the volume growth that takes place when the net volume of the blended product is calculated.



The second is a **Ratio-Blending terminal.** The ethanol is measured through a custody transfer meter and the gasoline blend stock is measured through a separate custody transfer meter. The two components are blended in the terminal piping or in the tank truck where the volume growth takes place.

Since the component net volumes are calculated separately, the volume growth of the blended product is not captured.

In a Ratio-Blending terminal a calculation can be applied using the process identified in API MPMS Ch. 11.3.4. that corrects for the change in the density of the combined products and the additional volume gain that will occur.

Additional questions and answers:

Q1. If the API standard is used at a Ratio-Blending Terminal, how does an inspector prove that the density correction has been appropriately applied?

A1. An inspector would use a process similar to proving a terminal with an automatic temperature compensation system. The EPO No. 25, Loading Rack Meters, would be updated.

Q2. What are the Density Correction System requirements?

A2. API believes that HB 44 allows for a system to correct for a density shift in a gasoline-ethanol blend and recognizes that some NTEP devices are currently approved for that use. However, to ensure that the use of this correction is clearly permissible, we identify language in Handbook 44 that would be clarifying for devices that provide density correction algorithms per API standards.

A metering system uses the same data to determine the excess volume as it uses for the correction for temperature (the reference density, the meter gross volume reading and the live temperature measurement). The device then will apply the density of the finished product or of the base components (e.g., gasoline or ethanol) to determine the correction for excess volume. The BOB reference density is typically quite stable. Only the observed (live) density varies from batch to batch, depending on temperature. As such a density correction system can accept, calculate, or measure the density of the finished product or of each base component (i.e., gasoline or ethanol) using these inputs. This would apply to HB 44 Section 3.30 Liquid Measuring Devices paragraphs S.2.9., S.4., N.4., UR.3.6.1., and T.5.

Q3. How is the density of the gasoline blend stock measured?

A3. Terminals measure the density (as an API Gravity) of gasoline in the aboveground storage tank by using a handheld density meter, an in-tank densitometer, or sending it to the lab. The sample that is tested using the handheld device or the lab uses the procedures identified in API MPMS Ch. 8 which details how to grab a sample from the bottom, middle, and top of tank. The API Gravity of the gasoline blend stock must be brought to a reference temperature of 60ºF or 15ºC. The API gravity is entered into the terminal automation system either manually or through a connected system. The API Gravity, corrected to 60ºF of the individual products (i.e., BOB) does not change between the tank and the meter.

Q4. How is the API Gravity of ethanol determined?

A4. Ethanol is a single-molecule fuel that is denatured with 2-5% petroleum fuel. The small percentage of denaturant does not meaningfully affect the API Gravity of the ethanol between batches. Thus when calculating denatured ethanol net volumes, for any ethanol with 1 to 5% denaturant (regardless of whether the denaturant is natural gasoline or gasoline), the calculation should use API Table 6C with an alpha coefficient of 0.000603 ºF or use API Table 6B with 50.61 ºAPI.

API MPMS Chapter 11.3.3, paragraph 4.2 Denatured 95 % to 99 % Fuel Ethanol

> For volume or density correction from observed temperature to 60 °F, the implementation procedure given in API MPMS Ch. 11.1-2004 shall be used for ethanol denatured with 1 % to 5 % by volume of either natural gasoline or gasoline (Annex B). Such denatured ethanol is classified a "special application" (formerly known as Table 6C or Table 54C) with an alpha coefficient of 0.000603 °F or 0.001085 °C (Annex C). For more information on denaturant choice, see Annex B. For more information on the applicability of these alpha coefficients to other denaturants, see Annex C and Annex D.

Q5: With the possibility of the density of the BOB changing each time the terminal receives a batch from the pipeline, and given that the density impacts the calculated net temperature correction and the density correction, is the density traceable within the terminal metering system? If not when new density values are entered, should they be traceable and verifiable?

A5: The answer to both questions is, yes. Some, if not all systems have an audit log, and if it is properly configured, it will log the changes to the reference density. Each system will be different, but as an example, an inspector could look at the log to see the old densities that were entered. To determine if the system is properly configured, an inspector could perhaps change the reference density value temporarily to determine if it is properly logged in the system.

Q6. What is the relationship between specific gravity and API gravity of a fuel?
A6. According to Pennsylvania State University, "Density is defined as mass per unit volume of a fluid. The density of crude oil and liquid hydrocarbons is usually reported in terms of specific gravity (SG) or relative density, defined as the density of the liquid material at 60°F (15.6°C) divided by the density of liquid water at 60°F. At a reference temperature of 15.6°C, the density of liquid water is 0.999 g/cm^3 (999 kg/m^3), which is equivalent to 8.337 lb/gal (U.S.). Therefore, for a hydrocarbon or a petroleum fraction, the SG is defined as:

SG (60^{O}F/60^{O}F) = (Density of liquid at 60^{O}F in g/cm3)/(0.999g/cm3)"

In the early years of the petroleum industry, the American Petroleum Institute (API) adopted the API gravity (°API) as a measure of the crude oil density. The API gravity is calculated from the following equation:

$$API = 141.5/(SG15.6\ °C/15.6°C) - 131.5$$

Source: https://www.e-education.psu.edu/fsc432/content/api-gravity

Q7. At what temperature should API gravity be observed?

A. API gravity and specific gravity must always be observed at 60^{O}F or 15^{O}C.

Q8. How will an invoice or product transfer document (PTD) be affected?

A8. The major requirement would be that the invoice/PTD reflects either the metered components or the finished product. All the appropriate information to provide a transparent invoice would be included on the invoice/PTD for an Automatic Density Correction system and Nonautomatic system. Specifically, it would include API gravity, temperature, gross readings, excess volume, and the net volume including the calculated growth. A statement would be required stating, "Volume delivered has been adjusted to the volume at 15 °C (60 °F) and for changes in density".

Q9. What API standards are used in a terminal to ensure an accurate measurement?

A9. There are at least 12 different API Manual of Petroleum Measurement Standards (MPMS) that form the basis of an accurate measurement at a terminal.[1]

- Ch. 8.1 Manual Sampling of Petroleum Products (ASTM D4057)
- Ch. 5.x Metering (5.1 General Considerations for Measurement by Meters, with specific chapters that address for displacement meters, turbine meters, Coriolis meters, ultrasonic flow meters, Fidelity and Security of Flow Measurement Pulsed-Data Transmissions Systems)
- Ch. 6.x – Metering Systems (6.1 Metering Assemblies- General Considerations, with specific chapters for - Truck and Rail Loading and Unloading Measurement Systems; - Pipeline and Marine Loading/Unloading Measurement Systems; and Lease Automatic Custody Transfer Systems)
- Ch. 4.x Proving Systems (Displacement Provers, Master-Meter Provers, Field Standard Test Measures, Methods of Calibration for Displacement and Volumetric Tank Provers, Part 1—Introduction to the Determination of the Volume of Displacement and Tank Provers)
- Ch. 7.4 Dynamic Temperature Measurement
- Ch. 11 Physical Properties Data (ASTM D1250, Adjunct)
    - Chapter 11.1 - Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils
    - Ch. 11.3.3 Miscellaneous Hydrocarbon Product Properties—Denatured Ethanol Density and Volume Correction Factors
    - Ch. 11.3.4 Miscellaneous Hydrocarbon Properties - Denatured Ethanol and Gasoline Component Blend Densities and Volume Correction Factors
    - Ch. 11.4.1 Density of Water and Water Volumetric Correction Factors for Water Calibration of Volumetric Provers
- Ch. 12.2 Calculation of Petroleum Quantities using Dynamic Measurement Methods and Volumetric Correction Factors
- Ch. 21.2 Electronic Liquid Measurement Using Positive Displacement and Turbine Meters

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[1] https://www.api.org/-/media/files/publications/2024-catalog/2024-publication-catalog.pdf.

Q10. How are API standards used in terminals today?

A10. Terminals require the implementation of multiple API standards including all the standards identified in A9 above to ensure there is an accurate and transparent measurement for the customer receiving the product into the tank and the customer receiving the product from the terminal into a tank truck for delivery to a retail gasoline station. Further, sales agreements may state that where temperature compensation is used, those calculations incorporate the methods and procedures specified in API MPMS Chapter 11.

Q11. How is an automatic temperature compensation system proven today?

A11. Regulators may use spreadsheets, lookup tables or commercial software to compare the calculated temperature compensated volume to the net volume that is printed on the Bill of Lading, Invoice or on the ticket from the terminal system.

Q12. How would an inspector prove the calculated volume expansion at a terminal?

A12. The volume expansion that occurs due to physical chemistry can be proven in the same manner as an automatic temperature compensation system that calculates the net volume of gasoline. The volume expansion that occurs when the components are blended can be demonstrated using a spreadsheet, look-up table or commercial software. Additionally, the Examination Procedure Outline (EPO) No. 25 for Loading Rack Meters would be updated to incorporate the appropriate procedures.

Q13. Is there a specific API standard that should be used to calculate the volume expansion?

A13. Yes. API MPMS Ch. 11.3.4 which is a subchapter of Ch. 11.1 should be used. The volume change calculated using Ch. 11.3.4 is needed to reconcile the fact that the volume of gasoline and ethanol when blended is slightly greater than the volume of the two liquids measured separately. In equation form,

$$\text{Gasoline BOB}_{\text{(net volume)}} + \text{Ethanol}_{\text{(net volume)}} \neq \text{Gasoline-Ethanol Blend}_{\text{(net volume)}}$$

Q14. In the context of NCWM, why should the API standards be accepted?

A.14. Handbook 130, Uniform Weights and Measures Law, Section 16, recognizes "firmly established trade custom and practice" that dictate how liquid fuels are sold. Specifically, it states,

> **Section 16. Method of Sale**
>
> Except as otherwise provided by the Director or by firmly established trade custom and practice,
>
> > (a) commodities in liquid form shall be sold by liquid measure or by weight; and
> >
> > (b) commodities not in liquid form shall be sold by weight, by measure, or by count.
>
> The method of sale shall provide accurate and adequate quantity information that permits the buyer to make price and quantity comparisons.
>
> (Amended 1989)

In 2024, the U.S. customers consumed 137 billion gallons of gasoline (most of which was 10% ethanol) and 63 billion gallons of diesel fuel. Another 24 billion gallons of jet fuel were consumed in the U.S. At each stage of the process from producing the crude oil to selling the finished fuel to a retail gasoline station the product is measured. So, while there is over 224 billion gallons of finished product consumed in the U.S., those molecules have likely been measured many times over. These measurements are so important that the API Committee on Petroleum Measurement (COPM) meets twice a year, with over 700 people in attendance, at each meeting to review the standards that are used in the U.S. and around the world. By definition, the petroleum industry uses the API standards which are firmly established trade custom and practice.

- **Possible Opposing Arguments:** Demonstrate that you are aware and have considered possible opposition.

Some have suggested that the terminal should be replumbed to allow the finished fuel to flow through a custody meter. However, this is often not possible due to the footprint and design of the terminal. Regardless, it should not be required as there is accurate technology available and approved NTEP equipment already available.

Some have raised concerns that metering systems should not modify the volume of the product after it has gone through the custody meter. This concern appears to be premised on the belief that the gross volume **and** the net volume are measured. In practice, the only measured volume is the gross volume and that is measured by counting pulses from the meter in accordance with an API standard. The gross volume is then used by the custody transfer system or the automatic terminal management system to calculate the net volume using another set of API standards including Chapters 5.x, 6x, 7.4, 11.1, 11.3.3, 11.3.4, 12.2, and 21.2. Please see above for the names of these standards.

Some have shared concerns that only standards approved by NCWM or by NIST and referenced in the Handbooks or in Publications can be used to determine volumes. As stated in the previous paragraph, this is simply not possible. None of the API standards that are needed to calculate the temperature corrected volume of fuels is listed in the NIST/NCWM publications or Handbooks. With this logic, it would be impossible to determine the net volume of fuels and other chemicals.

- **Requested Action if Considered for NCWM Agenda:** If you chose other in the previous question please describe:
    - Voting Item
    - Developing Item
    - Informational Item
    - Other
- **List of attachments:**