From:	Cadence Matijevich
To:	Cadence Matijevich
Subject:	FW: NET-22.2 –Section 3.1.1 Test Methods and 3.X. Gravimetric Test Procedure for Viscous and Non-Viscous Liquids by Portable Digital Density Meter.
Date:	Wednesday, September 14, 2022 11:54:39 AM
Attachments:	DS RH 8-22-22 NET 22-2 OWM Density Meter Proposal WITHOUT Comments.docx

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From: **Ron Hayes** <hydrocarbonmixture@hotmail.com>
Date: Tue, Sep 13, 2022 at 4:04 PM
Subject: NET-22.2 –Section 3.1.1 Test Methods and 3.X. Gravimetric Test Procedure for Viscous and Non-Viscous Liquids by Portable Digital Density Meter.
To: mbrooks@azda.gov <mbrooks@azda.gov>
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Chairman Brooks and WWMA L&R Committee members,

NET-22.2 –Section 3.1.1 Test Methods and 3.X. Gravimetric Test Procedure for Viscous and Non-Viscous Liquids by Portable Digital Density Meter.

I would like to update the WWMA on Item NET-22.2 and offer a new version which addresses many of NIST comments and questions about the proposed test procedures.

Since the July NCWM Annual meeting, David Sefcik and I have had 4 Webex meetings. We covered the entire procedures and I responded to each of NIST's comments. As result, I offered some changes to the proposal, i.e. some sections were moved, some sections were reworded and some sections were expanded. But basically, it is the same procedure

This new version was accepted at the last 2022 CWMA Interim meeting (Aug 29-Sep 1) as a voting item.

Table X.2. Density Coefficient Factor (Alpha) was added back into the test procedures. Although it is not necessary for the test procedure, it is essential for speed and accuracy for the common products W&M inspectors are inspecting. I will send you an updated table by Monday September 19, 2022, with products verified alpha corrections.

This proposal does not represent NIST OWM endorsement.

Thank you for your consideration for moving this forward as a voting item.

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NIST OWM Item NET 22.2.

NET-22.2 –Section 3.1.1 Test Methods and 3.X. Gravimetric Test Procedure for Viscous and Non-Viscous Liquids by Portable Digital Density Meter.

Preamble under the Item Under Consideration:

Amend NIST Handbook 133, Checking the Net Contents of Packaged Goods, to modify Note 2 in Section 3.1.1. Test Methods and Section 3.X. Gravimetric Test Procedure for Viscous and Non-Viscous Liquids by Portable Digital Density Meter. Add acompliance test procedure for 3.X. Gravimetric Test Procedure for Viscous and Non-Viscous Liquids by Portable Density Meter as follows:

3.1. Scope

3.1.1. Test Methods

Notes:

(2) When checking liquid products using a volumetric or gravimetric procedure for **density determination**, the temperature of the samples must be maintained at the reference temperature ± 2 °C (± 5 °F), **except when using Section 3.X. Gravimetric Test Procedure for Viscous and Non-Viscous Liquids by Portable Digital Density Meter, where a correction factor is used to correct the density to the reference temperature.**

3.X. Gravimetric Test Procedure for Viscous and Non-Viscous Liquids by Portable Digital Density Meter

Use the following procedure for packages labeled in fluid volume.

Most portable digital density meters are suitable for measuring the density of homogenous liquids free of suspended gas, air, sediment, and suspended matter. Portable digital dentity meters should not be used for products such as orange juice with pulp, buttermilk, liquids requiring "shake before use", paint, carbonated products such as soda and beer, or substances not approved by the digital density meter manufacturer.

The suitability of a given meter for use with specific product types is determined based upon the specifications of the manufacturer, the intended application, and verification by a recognized laboratory.

A portable digital density meter must meet the following criteria:

- **Influence of viscosity on density result is automatically corrected for highly viscous samples.**
- **Bar Code reading technology (RFID) for inputting test methods.**
- **Built in data storage for storing test results.**
- **Printing capabilities to print test results.**
- **Resolution of 4 decimal places with an accuracy to 0.001 g/cm^3. Instrument has a measurement mode setting set to the most "accurate" mode (e.g., precise mode) as defined by the manufacturer.**

Note: Typically, portable digital density meters manufactured after 2??? meet this criteria, but user of the instruments should verify with the manufacturer.

The portable digital density meter shall be verified and approved in accordance with the manufacturers and other recognized calibration procedures before being put into service. The portable digital density meter must only be used in a manner for which it was designed and calibrated. This device must be routinely recertified according to your agency's measurement assurance policies. Refer to NIST HB 130 Section 11 (h) of Weights and Measures Law and NIST HB 133 Chapter 1, Section 1.7. Good Measurement Practices for additional guidance.

Verify the accuracy (calibration) of the PDDM before each initial daily use, before each use at new location, or when there is any indication of abnormal equipment performance (e.g., erratic indications). Recheck the PDDM accuracy (calibration) if it is found that the sample does not pass, to confirm that the test equipment is not at fault".

Users must consult with the manufacturers to ensure the brand and model automatically correct for viscosity for viscosities greater than 100 mPa·s. Viscosities less than 100 mPa·s do not require a viscosity correction.

This test procedure may be used as an alternative test procedure for the following Sections:

- **Section 3.2. Gravimetric Test Procedure for Non-Viscous Liquids.**
- **Section 3.3. Volumetric Test Procedure for Non-Viscous Liquids.**
- **Section 3.4. Volumetric Test Procedures for Viscous Fluids – Headspace.**

Note: Portable Digital Density Meters can also be used as a timesaver for screening products for product quality and product identification .

3.X.1. Test Equipment

- **A scale that meets the requirements in Chapter 2, Section 2.2. "Measurement Standards and Test Equipment."**

  To verify the scale has adequate resolution, use the following steps.

  - **Determine the density of the liquid.**
  - **Using the density, convert the labeled volume to weight.**
  - **Based on the labeled volume, determine the MAV using Table 2-6 "Maximum Allowable Variations for Packages Labeled by Liquid and Dry Volume" found in Appendix A.**
  - **Using the density, convert the MAV from volume to weight.**
  - **Next verify that the scale division is no larger than MAV/6 for the package size under test.**
  - **The smallest graduation on the scale must not exceed the weight value for MAV/6.**

Example:

Assume the inspector is using a scale with 1 g (0.002 lb) increments to test packages labeled 1 L (33.8 fl oz) that have an MAV of 29 mL (1 fl oz). Also, assume the inspector finds that the weight of 1 L of the liquid is 943 g (2.078 lb).

Density: ***1 L = 943 g (2.078 lb)***

MAV: ***29 mL (1 fl oz)***

- ***Convert the Density into mL and Fl oz:***

  943 g ÷ 1000 mL= 0.943 g/mL
  (2.07 8 lb ÷ 33.8 Fl oz = 0.061 4 lb/fl oz)

- ***Convert MAV from Volume (mL/fl oz) to Weight:***

  29 mL × 0.943 g/mL = 27.347 g
  (1 Fl oz × 0.061 4 lb/fl oz = 0.064 lb)

MAV in Weight/6: ***27.347 g ÷ 6 = 4.557 g*** ***0.064 lb ÷ 6 = 0.010 lb***

In this example, the 1 g (0.002 lb) scale division is smaller than the MAV/6 value of 4.557 g (0.010 lb) so the scale is suitable for making a density determination.

- **Low pressure air pump (small) – (e.g., an aquarium air pump)**
- **Syringe (glass or plastic with a Luer fitting 5 mL or larger). The syringe should be free of any lubricating substances)**
- **Distilled or deionized water**
- **Cleaning agents (See Table 3.4. Cleaning Agents)**
- **Waste container**
- **Barometer for obtaining the prevailing barometric pressure, with an accuracy of ± 3.0 mmHg**
- **Thermometer for measuring air temperature with a tolerance of ± 1 °C (2 °F)**
- **Portable digital density meter meeting a minimum requirement of:**

Measuring Range	
Density	**0 – 3 g/cm^3**
Temperature	**0 – 40 °C (32 – 104 °F)[a]**
Viscosity	**0 – 1000 mPa·s**
Accuracy[b]	

Density	**0.001 g/cm^3**
Temperature	**0.2 °C (0.4 °F)**
Repeatability s.d.	
Density	**0.0005 g/cm^3**
Temperature	**0.1 °C (0.1 °F)**
Resolution	
Density	**0.0001 g/cm^3**
Temperature	**0.1 °C (0.1 °F)**
Sample Volume	**2 mL**
Sample Temperature	**max. 100 °C (212 °F)**
Footnotes **[a.] Filling at higher temperatures possible.** **[b.] Viscosity < 100 mPa·s, density < g/cm^3**	

3.X.2. Test Procedure

1. **Follow Section 2.3.1. "Define the Inspection Lot." Use a "Category A" sampling plan in the inspection. Select a random sample**

2. **Bring the packages and their contents to a temperature, between the reference and ambient temperatures**

   Note: Some packages (e.g., flavored milk) may need to be gently rolled to mix the contents. Avoid shaking liquids, since shaking some products to mix them will entrap air that will affect density measurements.

3. **The portable digital density meter must be near ambient temperature and above the dew point of the ambient air to avoid causing condensation within the unit. Condensation must be avoided and could cause the digital density meter to malfunction and cause potential damage.**

4. **Using distilled or deionized water or other reference standard(s), validate the digital density meter per the manufacturer's calibration instructions. The portable digital density meter shall be validated to verify the accuracy (calibration) of the portable density meter before each initial daily use, before each use at new location, or when there is any indication of abnormal equipment performance (e.g., erratic indications). Recheck the portable density meter accuracy (calibration) if it is found that the sample does not pass, to confirm that the test equipment is not at fault. The digital density meter shall be calibrated using a standard sample, within an allowable density range of ± 0.0005 g/cm^3.**

5. **Select the first 2 random sample packages selected from the lot for density determination.**

6. **Ensure the portable digital density meter is clean prior to testing. Any residual liquid should be drained, and the unit should be flushed with a small amount of the sample to be tested. Flush and discard the sample two times before taking a measurement.**

7. **To test the first package of the sample, follow the manufacturer's instructions to select the correct method, when using a meter with built in correction factors, and measure the density of the sample using a syringe or the built-in pump. Fill the specimen of the sample slowly and gently. If gas or air bubbles are present drain sample and refill. If the correction factor is not known, refer to step 9.**

   Note: Use of a syringe may be desirable to allow sample specimen to achieve ambient temperature prior to introduction of specimen into testing cell and for viscous specimens.

8. **Once the temperature reading on the portable digital density meter has stabilized (maintained reading ± 0.2 °C (± 0.5 °F) for 10 seconds), record density and temperature as indicated on instrument. Instruments have a measurement mode setting that shall be set in the most "accurate" mode (e.g., precise mode) as defined by the manufacturer.**

9. **Apply the density coefficient of expansion (Alpha) also known as the density correction factor, to correct to the reference temperature. See Table X.2. Density Coefficient Factor (Alpha) If the Alpha correction is not known, then the factor can be calculated using the below formula.**

   After this correction, this value is the density of the substance in the vacuum at the prescribed reference temperature.Calculating the Temperature Coefficient Alpha

   Temperature coefficient Alpha = $\left|\frac{\rho^1-\rho_2}{T^1-T_2}\right|$

   ρ_1 …. density at temperature T_1

   ρ_2 …. density at temperature T_2

   T_1 …. temperature at initial measurement

   T_2 …. temperature at second measurement

   Notes:

   - **If the density correction factor is not known but the volume correction factor is known, the density correction factor can be calculated from the volume correction factor using the following formula.**
   - **Density Temperature Factor Alpha = Absolute Value of Beta × Density.**

   Note: Influence of viscosity on density result will be automatically corrected by the portable digital density meter for highly viscous samples.

10. **Apply the apparent density correction by applying one of the following steps:**

(1) multiplying the density by 0.999; or

(2) multiplying the density by the Apparent Mass Factor from Table X.4.; or

(3) calculate apparent density by using the following:

Converting True Density into Apparent Density

The apparent density is defined as:

$$Paap = \frac{Ptrue,sample - Pair}{1 - \frac{Pair}{8.0\ g/cm3}}$$

Where:

Paap = apparent density of the sample

Psteel = 8.0 g/cm3

Pair = true density of air

Ptrue,sample = true density of the sample

The apparent density is smaller than the true density and can be calculated from the true density considering the buoyancy of the sample in air and the weight and density of a reference weight in steel.

*** Pair = true density of air as calculated from equation in Table X.1. Density Measurement.**

After application of this factor or calculation, the new value is density of the substance in air.

11. Drain the instrument and repeat Steps 7–10 on a second specimen of the same package for verification of first measurement.

12. Note: It is not necessary to fully clean the cell between measurements for the second specimen of the same sample. Simply flush the cell using the same sample at least two times before taking your second measurement. Compare the two specimen readings, they must agree within 0.0003 g/cm^3. Calculate the average density of the two specimens from the sample. If the difference of two readings is greater than 0.0003 g/cm^3, discard results and repeat testing of sample. Air or undissolved gas will cause erroneous measurement errors. The user of the shall always visually inspect for undissolved gas in the measurement tube for a valid test.

13. Drain the instrument and repeat testing for the second (or subsequent) package of the sample, repeating Steps 6–12.

14. Calculate the Average Product Density of sample 1 and 2. The two results must agree within 0.0005 g/cm^3. If the difference between the densities of the two packages exceeds 0.0005 g/cm^3, use the volumetric procedure in Section 3.3. "Volumetric Test Procedure for Non-Viscous Liquids", or you may continue the testing of all the subsequent sample packages selected from the lot using Steps 6-13.

15. Determine the Average Used Dry Tare Weight of the sample according to provisions of Section 2.3.5. "Procedures for Determining Tare."

16. Calculate the "nominal gross weight" using the following formula:

Nominal Gross Weight = (Average Product Density [in weight units]) × (Labeled Volume) + (Average Used Dry Tare Weight)

17. Weigh the remaining packages in the sample.

18. Subtract the nominal gross weight from the gross weight of each package to obtain package errors in terms of weight. All sample packages are compared to the nominal gross weight.

19. To convert the average error or package error from weight to volume, use the following formula:

Package Error in Volume = Package Error in Weight ÷ Average Product Density Per Volume Unit of Measure

20. 3.X.3. Evaluation of Results
Follow the procedures in Chapter 2, Section 2.3.7. "Evaluate for Compliance" to determine lot conformance.

3.X.4. Cleaning and Storage of Digital Density Meter

Anytime the portable digital density meter is used to test a different commodity, or if the digital density meter use is done for the day and going to be stored after final use, the instrument shall be drained and cleaned following the manufacturer's recommended cleaning procedures and using two cleaning agents. The first cleaning agent removes sample residue, and the second cleaning agent removes the first cleaning agent. See Table X.5. Cleaning Agents for examples of cleaning agents recommended by a digital density meter manufacturer.

NOTE: If the unit will be immediately used to measure another sample of similar composition (e.g., milk with different fat contents, different viscosity oils), the unit may be drained and flushed with the new sample three times before the next analysis.

If the density meter is not going to be used within 2 days, it is recommended that the measuring cell be dried using an external low-pressure air source. Bypassing the internal pump may be necessary to dry the measuring cell. After a thorough cleaning, connect the portable digital density meter to a low-pressure air source, (e.g., aquarium air pump) to dry the unit's measurement cell. This will ensure no buildup of deposits in the measuring cell and no long-term drift of the instrument calibration. To determine if the measuring cell is "dry", the density will display an air value of 0.0012 g/cm$^{3.}$ See Table X.1. Air Density Calculation. If this value is not achieved, additional cleaning may be necessary.

Note: The digital density meter must be properly stored to avoid the possibility of any water residue within the measuring cell from freezing.

Table X.1. Air Density Calculation		
Calculate the density of air at the temperature of test using the following equation		
ρ_{air}, g/mL = 0.001293[273.15/T][P/760]		
Where:		
T = temperature, K, and		
P = barometric pressure, torr.		
°C	mmHg	d_{air}, g/mL
15.56	760	0.001223314

Table X.2. Density Coefficient Factor (Alpha)			
Notice: This Table is currently under review. Do not use without validation. **Ron to add a new columns indicating the source of alpha values verified at a specific temperature range.** **Note: Do not use these alpha values if they are outside the accepted temperature range as shown.**			
Product	**alpha/°C**	**Typical Density at 20°C, g/cm^3**	**Reference Temperature, °C**
Petroleum Products			
Benzene	0.00125	0.989	15.56
n-Heptane	0.00124	0.684	15.56
Gasoline	0.00095	0.74	15.56
Kerosene, jet fuel	0.00099	0.81	15.56
Oil (unused engine oil)	0.0007	-	15.56
Paint Thinner	-	-	15.56

Paraffin oil	**0.000764**		**15.56**
n-Pentane	**0.00158**		**15.56**
Toluene	**0.00108**		**15.56**
Generalized Petroleum Products (ASTM D1250 Table 54B)			
Distilled Spirits			**15.56**
Other Liquids and Wine			
Acetic acid	**0.0011**		**20**
Acetone	**0.00143**	**0.799**	**20**
Alcohol, ethyl (ethanol)	**0.00109**	**0.789**	**20**
Alcohol, methyl	**0.00149**	**0.792**	**20**
Ammonia	**0.00245**		**20**
Aniline	**0.00085**	**1.022**	**20**
Ether	**0.0016**		**20**
Ethyl acetate	**0.00138**		**20**
Ethylene glycol	**0.00057**	**1.115**	**20**
Isobutyl alcohol	**0.00094**		**20**
Glycerin (glycerol)	**0.0005**	**1.261**	**20**
Olive oil	**0.0007**		**20**
Sulfuric acid, concentrated	**0.00055**		**20**
Turpentine	**0.001**		**20**
Water	**0.00018**	**0.9982**	**20**
Diesel Exhaust Fluid	**0.00022**	**1.08805**	**20**
Dairy Products	**alpha/°C**	**Typical Density at 4°C, kg/L**	**Reference Temperature, °C**
Homogenized milk	**0.00025**	**1.033**	**4**
Skim milk, pkg	**0.00019**	**1.036**	**4**

Fortified skim	**0.00019**	**1.041**	**4**
Half and half	**0.00044**	**1.027**	**4**
Half and half, fort.	**0.00044**	**1.031**	**4**
Light cream	**0.00056**	**1.021**	**4**
Heavy cream	**0.00088**	**1.008**	**4**

Table X.3. Viscosity Corrections of Common Materials

Note: Values for Viscosity and Corrections are published in XXXX.

Material	Viscosity in Centipoise (at 20° C)	Correction g/cc
Water	**1 cP**	
Milk	**3 cP**	
SAE 10 Motor Oil	**85–140 cP**	**0.0003**
SAE 20 Motor Oil	**140–420 cP**	**0.0006**
SAE 30 Motor Oil	**420–650 cP**	**0.0007**
SAE 40 Motor Oil	**650–900 cP**	**0.0007**
Castrol Oil	**1,000 cP**	**0.0008**
Karo Syrup	**5,000 cP**	**0.0008**
Honey	**10,000 cP**	**0.00085**

Table X.4. Apparent Mass Factor

Elevation, ft	sea level	1500	3000	4500	6000
Barometer, mmHg	**760**	**720**	**680**	**640**	**600**
density, g/cc	**Apparent Mass Factor**				
0.500	**0.9977**	**0.9979**	**0.9980**	**0.9981**	**0.9982**
0.600	**0.9981**	**0.9982**	**0.9983**	**0.9984**	**0.9985**
0.700	**0.9984**	**0.9985**	**0.9986**	**0.9987**	**0.9988**
0.800	**0.9986**	**0.9987**	**0.9988**	**0.9989**	**0.9989**
0.900	**0.9988**	**0.9989**	**0.9989**	**0.9990**	**0.9991**
1.000	**0.9989**	**0.9990**	**0.9991**	**0.9991**	**0.9992**

1.100	**0.9991**	**0.9991**	**0.9992**	**0.9992**	**0.9993**
1.200	**0.9991**	**0.9992**	**0.9992**	**0.9993**	**0.9993**
1.300	**0.9992**	**0.9993**	**0.9993**	**0.9993**	**0.9994**
1.400	**0.9993**	**0.9993**	**0.9994**	**0.9994**	**0.9994**
1.500	**0.9993**	**0.9994**	**0.9994**	**0.9994**	**0.9995**
Elevation or prevailing barometric pressure at the location of measurement.					

Table X.5. Cleaning Agents

(Examples of cleaning agents recommended by digital density meter manufacturers. Verify the proper cleaning agent for the digital density meter used based on manufacturers recommendation.)

Commodity	Cleaning Liquid 1	Cleaning Liquid 2
Petroleum products	**Toluene, petroleum naphtha, petroleum ether, n-nonane, cyclohexane**	**Ethanol**
Battery acid	**Tap water**	**Ultra-pure (bi-distilled or deionized) water**
Liquid soap and detergent, shampoo	**Tap water**	**Ultra-pure (bi-distilled or deionized) water**
Salad dressing, mayonnaise	**Petroleum naphtha, dish washing agent in water**	**Ethanol**
Suntan lotion	**Tap water**	**Ethanol**
Spirits	**Tap water**	**Ultra-pure (bi-distilled or deionized) water**
Grape juice, syrup	**Warm tap water**	**Ultra-pure (bi-distilled or deionized) water**
Milk*	**Tap water, enzymatic lab cleaner**	**Ultra-pure (bi-distilled or deionized) water**
***NOTE: Do not introduce ethanol or other alcohols into instrument without first flushing all milk products from instruments.**		