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

This test method is not recommended for high pulp or carbonated products (soda, beer, etc.) and all products tested should be free of suspended gas, air, sediment, or substances not approved by the instrument manufacturer.

3.X.1 Test Equipment

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

Note: To verify that the scale has adequate resolution for use, it is first necessary to determine the density of the liquid; 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). This will result in an MAV/6 value in weight of 4.715 g (0.010 lb):

29 mL ÷ 6 = 4.8 mL *(1 fl oz ÷ 6 = 0.166 6 fl oz)*

943 g ÷ 1000 mL= 0.943 g/mL *(2.07 8 lb ÷ 33.6 fl oz = 0.061 8 lb/fl oz)*

4.8 mL × 0.943 g/mL = 4.5264 g *(0.166 6 fl oz × 0.061 8 lb/fl oz = 0.010 lb)*

In this example, the 1 g (0.002 lb) scale division is smaller than the MAV/6 value of 4.5264 g (0.010 lb) so the scale is suitable for making a density determination.

- Air pump, low pressure– an aquarium air pump (to dry out measuring cell)
- Syringe, glass or plastic with Luer fitting (5mL or larger) - Note: Plastic syringe should be free of any lubricating substances
- Stopwatch (optional)
- Distilled water
- Cleaning agents (See Table X)
- Waste container
- Barometer, or other device for obtaining the prevailing barometric pressure, with an accuracy of ±3.0 mmHg – Note: smart phones with a barometer application that uses the phone's pressure sensor, have a typical accuracy of ±0.2 mmHg
- Thermometer for measuring air temperature with a tolerance of ±1°C (2°F)
- Portable digital density meter meeting a minimum requirement of: (page 63 of instruction manual)

Measuring range	
Density	0-3 g/cm³
Temperature	0-40 °C (32-104 °F)[a]
Viscosity	0-1000 mPa·s
Accuracy[b]	
Density	0.001 g/cm³
Temperature	0.2 °C (0.4 °F)
Repeatability s.d.	
Density	0.0005 g/cm³
Temperature	0.1 °C (0.2 °F)
Resolution	
Density	0.0001 g/cm³
Temperature	0.1 °C (0.1 °F)
Sample volume	2 mL
Sample temperature	max. 100 °C (212 °F)

a *Filling at higher temperatures possible*

b *Viscosity < 100 mPa·s, density < 2 g/cm³*

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 sample packages and their contents to ambient temperature +/-5°C (9°F). Note: For refrigerated samples such as milk and other dairy products, a specimen of the product may be taken and placed into a clean bottle or vial with a closure or a syringe to reach ambient temperature. If the product requires mixing for uniformity, mix it before opening in accordance with any instructions specified on the package label. Shaking liquids, such as flavored milk, often entraps air that will affect volume measurements, so use caution when testing these products. Often, less air is entrapped if the package is gently rolled to mix the contents.
3. The instrument should be at ambient temperature. Avoid causing condensation within the unit. Condensation could cause instrument malfunction and harm.
4. Validate the instrument per the manufacturer's calibration instructions. Instrument should calibrate within allowable density range (±0.0005)
5. Ensure the instrument 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.
6. Follow the manufacturer's instructions to select the correct method and measure the density of the sample using the built in pump or syringe. Fill sample gently. If gas or air bubbles are present drain sample and refill. Note: a syringe may be desirable to allow sample specimen to achieve ambient temperature prior to introduction of specimen into testing cell.
7. Once instrument has stabilized (maintained reading ±0.2°C for 10 seconds) record density and temperature as indicated on instrument.
8. Apply coefficient of expansion (Alpha) to correct to the reference temperature. See Table 3-1 for Reference Temperatures of Liquids. Note: some units may be programmed to automatically apply

Calculating the Temperature Coefficient Alpha

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

ρ_1 ….*density at temperature* T_1

ρ_2 ….*density at temperature* T_2

9. Apply viscosity correction if viscosity > 85 centipoise at 21°C (70°F). Note: some units may be programmed to automatically apply. See Table X for viscosity.
10. Multiply by 0.999 to correct density to apparent density of product at prevailing atmospheric pressure. See chart XX or calculate apparent density by using the following formula *"add formula here"*
11. Drain the instrument and repeat steps 6-10.

12. Compare the two readings, if they agree within 0.0003 g/cc report the average of the specimen of sample. If the difference of two readings is greater than 0.0003 g/cc, discard results and repeat testing of sample.
13. Repeat testing for the next sample in the lot.
14. Average the sample 1 and sample 2 if the two results agree within 0.0003 g/cc.
15. Convert the results to units as specified on the package label i.e. pounds/fluid ounce, etc.
16. After analysis has been completed the instrument should be drained and cleaned following the manufacturer's recommended cleaning procedures. Two cleaning agents should be used. The first cleaning liquid removes sample residue and the second cleaning liquid removes the first cleaning liquid. See Table X for examples of cleaning agents. If the unit will be immediately used to measure another sample of similar composition the unit may be drained and flushed with new sample three times before next analysis.
17. Connect instrument to a source of low pressure, such as an aquarium air pump, to dry the unit.

3.X.3. Evaluation of Results

Follow the procedures in Section 2.3.7. "Evaluate for Compliance" to determine lot confromance.

Calculate the density of air at the temperature of test

using the following equation:

dair, g/mL = 0.001293[273.15/T][P/760]

where:

T = temperature, K, and

P = barometric pressure, torr.

°C	mmHg	dair, g/mL
15.56	760	0.001223314

Approximate Viscosities of Common Materials

Material	Viscosity in Centipoise	Correction
Water	1 cps	
Milk	3 cps	
SAE 10 Motor Oil	85-140 cps	0.0003
SAE 20 Motor Oil	140-420 cps	0.0006
SAE 30 Motor Oil	420-650 cps	0.0007
SAE 40 Motor Oil	650-900 cps	0.0007
Castrol Oil	1,000 cps	0.0008
Karo Syrup	5,000 cps	0.0008
Honey	10,000 cps	0.00085
Chocolate	25,000 cps	0.0009
Ketchup	50,000 cps	0.0009
Mustard	70,000 cps	0.0009
Sour Cream	100,000 cps	0.0009
Peanut Butter	250,000 cps	

Sample	Cleaning liquid 1	Cleaning liquid 2
Petroleum products	Toluene, petroleum naptha, Petroleum ether, n-nonane, cyclohexane, …	ethanol
Battery acid	Tap water	Ultra-pre (bi-distilled or deionized) water
Liquid soap & detergent, shampoo	Tap water	Ultra-pre (bi-distilled or deionized) water
Salad dresssing, mayonnaise	Petroleum naptha, dish washing agent in water	Ethanol
Sun tan lotion	Tap water	Ethanol
Spirits	Tap water	Ultra-pre (bi-distilled or deionized) water
Grape juice, syrup	Warm tap water	Ultra-pre (bi-distilled or deionized) water
Milk*	Tap water, enzymatic lab cleaner	Ultra-pre (bi-distilled or deionized) water
98% H_2SO_4	70% H_2SO_4	40% H_2SO_4 followed by ultra-pure (bi-distilled or deionized) water

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*Do not introduce ethanol or other alcohols into instrument without first flushing all milk products from instruments.