# DENSITY METERS FOR PACKAGE CHECKING

## 2018 NCWM Interim Meeting
## St. PeteBeach, Florida

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**Division of Weights, Measures & Consumer Protection**

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# Reference Temperatures for Liquids

<table>
<tr><td colspan="3" align="center"><strong>Table 3-1.<br>Reference Temperatures for Liquids</strong></td></tr>
<tr><th>If the liquid commodity is:</th><th>Volume is determined at the reference temperature of:</th><th>Code of Federal Regulation Reference*</th></tr>
<tr><td>Beer</td><td>4 °C (39.1 °F)</td><td>27 CFR, Part 7.10</td></tr>
<tr><td>Distilled Spirits</td><td>15.56 °C (60 °F)</td><td>27 CFR, Part 5.11</td></tr>
<tr><td>Frozen food - sold and consumed in the frozen state</td><td>At the frozen temperature</td><td>21 CFR §101.7(b)(2)(i)</td></tr>
<tr><td>Petroleum</td><td>15.6 °C (60 °F)</td><td>16 CFR §500.8(b)</td></tr>
<tr><td>Refrigerated food (e.g., milk and other dairy products labeled "KEEP REFRIGERATED")</td><td>4 °C (40 °F)</td><td>21 CFR §101.7(b)(2)(ii)</td></tr>
<tr><td>Other liquids and wine (e.g., includes liquids sold in a refrigerated state for immediate customer consumption such as soft-drinks, bottled water and others that do not require refrigeration)</td><td>20 °C (68 °F)</td><td>Food: 21 CFR 101.7(b)(2)(iii)<br>Non-Food: 16 CFR §500.8(b)<br>Wine: 27 CFR, Part 4.10 (b)</td></tr>
<tr><td colspan="3">*The Code of Federal Regulations can be accessed online at: <em>www.gpoaccess.gov/</em></td></tr>
</table>

(Amended 2010)

# NIST Handbook 105-2
## Specifications & Tolerances for Field Standard Measuring Flasks

| Cap at 20°C | in^3 | cm^3 | tol, cm^3 | tol |
|---|---|---|---|---|
| 1 gal | 231 | 3785.4 | 1.20 | 0.032% |
| 1/2 gal | 115.5 | 1892.7 | 1.00 | 0.053% |
| 1 qt | 57.8 | 946.4 | 0.70 | 0.074% |
| 1 pt | 28.88 | 473.2 | 0.40 | 0.085% |
| 1/2 pt | 14.44 | 236.6 | 0.30 | 0.127% |
| 1 gill | 7.22 | 118.3 | 0.20 | 0.169% |
| 2 fl oz | 3.61 | 59.1 | 0.30 | 0.507% |

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# Volumetric Flask Method Temperature Requirements & Tolerances

- HB 133
  - when determining the density with volumetric flask, must maintain temperature within +/- 2°C (5°F) of reference temperature
  - A partial immersion thermometer (or equiv) at least 1°C (1°F) graduations, w/tolerance of +/- 1°C (2°F)

# Uncertainty of Flask Method

| | Motor Oil SAE 0W-30 http://www.viscopedia.com/viscosity-tables/substances/engine-oil/ | | | | | |
|---|---|---|---|---|---|---|
| | density at 20°C .8498, coeff factor 0.00063/°C (0.00035/°F) | | | | | |
| | °C | factor/°C | tol, +/-% | °F | factor/°F | tol, +/-% |
| therm, tol | 1 | 0.00063 | 0.063% | 2 | 0.00035 | 0.070% |
| Δ ° allowed | 2 | 0.00063 | 0.126% | 5 | 0.00035 | 0.175% |

| Product: Motor Oil, 1 qt | error | % squared |
|---|---|---|
| 1 pt Flask Tolerance | 0.085% | 0.00000072 |
| Thermometer Tolerance | 0.070% | 0.00000049 |
| Range Allowed +/-5°F | 0.175% | 0.00000306 |
| sum of squares | | 0.00000428 |
| Unc of flask method | 0.21% | |

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# Uncertainty of Flask Method

| | °C | factor/°C | tol, +/-% | °F | factor/°F | tol, +/-% |
|---|---|---|---|---|---|---|
| **Motor Oil SAE 0W-30** | | | | | | |
| http://www.viscopedia.com/viscosity-tables/substances/engine-oil/ | | | | | | |
| density at 20°C .8498, coeff factor 0.00063/°C (0.00035/°F) | | | | | | |
| therm, tol | 1 | 0.00063 | 0.063% | 2 | 0.00035 | **0.070%** |
| Δ ° allowed | 2 | 0.00063 | 0.126% | 5 | 0.00035 | **0.175%** |
| **mineral spirits  (ShellSol D100S)** | | | | | | |
| density at 15°C 0.803, coeff factor = 0.0009/°C (0.0005/°F) | | | | | | |
| therm, tol | 1 | 0.0009 | 0.090% | 2 | 0.0005 | **0.100%** |
| Δ ° allowed | 2 | 0.0009 | 0.180% | 5 | 0.0005 | **0.250%** |

# Uncertainty of Flask Method

| Motor Oil, 1 qt | error | % squared |
|---|---|---|
| 1ptFlaskTol | 0.085% | 0.00000072 |
| ThermTol | 0.070% | 0.00000049 |
| Δ +/-5°F | 0.175% | 0.00000306 |
| sum of squares | | 0.00000428 |
| Unc of flask method | | **0.21%** |

| Paint Thinner, 1 qt | error | % squared |
|---|---|---|
| 1ptFlaskTol | 0.085% | 0.00000072 |
| ThermTol | 0.100% | 0.00000100 |
| Δ +/-5°F | 0.250% | 0.00000625 |
| sum of squares | | 0.00000797 |
| unc below expressed as % | | 0.00282356 |
| Unc of flask method | | **0.28%** |

# Density Meter - how does it work?
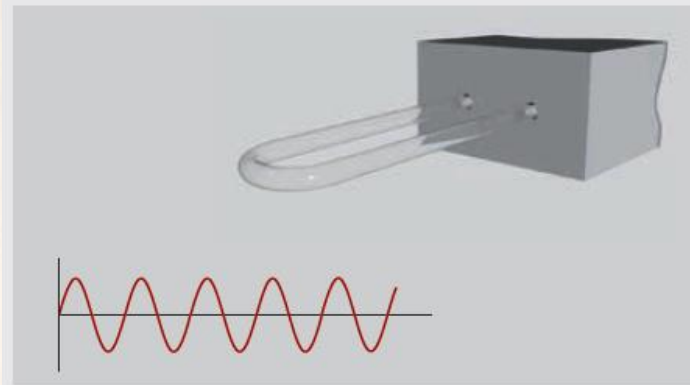


Oscillation of a U-tube filled with air
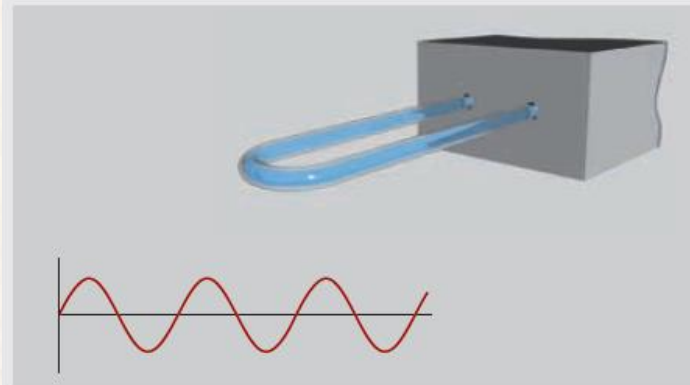
Oscillation of a U-tube filled with water

# Technical Specifications

| | |
|---|---|
| **Measuring range** | Density: 0 g/cm³ to 3 g/cm³ |
| | Temperature: 0 °C to 40 °C<br>(32 °F to 104 °F)* |
| | Viscosity: 0 mPa·s to 1000 mPa·s |
| **Accuracy**\*\* | 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) |

# Density Meter

| Paint Thinner | error | % squared | | | |
|---|---|---|---|---|---|
| Meter Accur (0.001/0.8) | 0.125% | 0.00000156 | | | |
| ThermTol | 0.018% | 0.00000003 | | | |
| Δ +/-5°F is not used. Rdg is compensated. | | | | | |
| sum of squares | | 0.00000159 | | | |
| sq root of sum of sq | | 0.00126289 | | | |
| Unc of density meter | | **0.13%** | | | |
| | | | | | |
| | **mineral spirits (ShellSol D100S)** | | | | |
| | density at 15°C 0.803, coeff factor = 0.0009/°C (0.0005/°F) | | | | |
| therm, tol | 0.2 | 0.0009 | 0.018% | 0.36 | 0.0005 | 0.018% |
| Δ ° allowed | 0 | 0.0009 | 0.000% | 0 | 0.0005 | 0.000% |
| intrument accuracy | | 0.0009 | 0.125% | | | |

# Current Method vs Density Meters

| Product | Flask / Product temp | Dens @ ref temp | Flask vs 4-place Density Meter | | Flask vs Portable Density Meter | |
| | | | No Flask adj for temp | Flask Adj | No Flask adj for temp | Flask Adj |
|---|---|---|---|---|---|---|
| | °F | g/cc | | | | |
| Milk, Skim | 42.3 | 1.0359 | -0.03% | **0.01%** | 0.00% | **0.03%** |
| Milk, Homo | 42.8 | 1.0348 | -0.04% | **0.01%** | -0.10% | **-0.05%** |
| Paint Thinner | 65.0 | 0.7652 | -0.42% | **-0.08%** | -0.60% | **-0.27%** |
| DEF | 66.1 | 1.0897 | -0.06% | **0.04%** | 0.08% | **0.06%** |

# Density Meter

- **Measure at ambient temp**
- **Compensate to reference temperature using appropriate factor**
- **High viscosity (motor oil, veg oil, syrup, etc.) must be corrected**
- **Check calibration with distilled water**
- **Reading is in true mass. Final step is to adjust to apparent mass.**
  – else error of 0.09% (DEF), 0.14% (paint thinner)

# Next….Density Meters for meter testing?

- **Diesel Exhaust Fluid (dispense into new poly containers)**
- **Motor oil**
- **Antifreeze**
- **Agriculture chemicals**
- **Industrial chemicals and products**

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THE END… QUESTIONS?
THANK YOU!