Funnel vs. Syringe: Choosing the Right Filling Method for Reliable Density Measurements

Relevant for: all users of the compact density meter

Reliable density measurements require different filling methods based on sample properties. This report compares syringe and funnel filling techniques for various liquids, from low-viscosity solvents to foaming and viscous substances, providing guidance on choosing the appropriate method.

1 Introduction

Accurate and reproducible filling of the measuring cell is essential for achieving reliable results in digital density measurement.

Compact DMA density meters support multiple filling methods to accommodate different sample properties and workflows:

- *Syringe filling*: The sample is drawn into a syringe and then dispensed into the measuring cell.
- *Funnel filling*: The sample is simply poured into the funnel, and the measuring cell is filled by gravity.
- *Peristaltic pump filling*: Samples are automatically filled from a sample vial into the measuring cell.
- *Aerosol adapter filling*: Used to introduce volatile liquids from aerosol cans into the measuring cell.

This report focuses on the two manual filling techniques – funnel and syringe filling – to help users choose the appropriate method. Nine different samples, ranging from low-viscosity solvents to foaming liquids and viscous substances, were analyzed.

2 Experimental

Samples with different properties were selected to compare the two filling techniques (Table 1).

Table 1: Samples.

Sample	Property
H_2O dest.	Low-viscous
Ethanol 96%	Volatile, low-viscous
Dodecane	Low-viscous, low-density
APS3 density standard	Oily, standard reference (dyn. visc. = 3.620 mPa s @ 20°C)
APN35 density standard	Oily, standard reference (dyn. visc. = 72.42 mPa s @ 20°C/ 26.99 mPa s @ 40°C)
All-purpose cleaner	Foaming, slightly viscous
Biodiesel	Slightly viscous
Milk	Foaming, protein-containing
Banana juice (30%)	Moderate viscous, particle-containing

All measurements were performed at 20°C (except for APN35, which was measured at 40°C) using a 3-digit compact DMA density meter set to the most precise measurement performance. A standard 10 mL plastic syringe and a funnel made of stainless steel 1.4301 (Mat. No. 386784) were used for filling. Five consecutive measurements were performed for every sample with each filling method, using 10 mL of liquid per fill. The

measuring cell was cleaned only when switching between samples or between filling techniques. Filling times for selected samples were recorded to assess the impact of viscosity.

3 Results and Discussion

Table 2 compares the mean density values (n=5) and their standard deviation for samples filled with a syringe and funnel.

Table 2: Mean density and standard deviation (n=5) of the measured samples filled with syringe and funnel.

Sample	Syringe filling Density ± Std. Dev. [g/cm³]	Funnel filling Density ± Std. Dev. [g/cm³]
H_2O dest.	0.9982 ± 0.00001	0.9982 ± 0.00002
Ethanol 96%	0.8077 ± 0.00001	0.8077 ± 0.00002
Dodecane	0.7488 ± 0.00001	0.7488 ± 0.00001
APS3 density standard (dyn. visc. = 3.620 mPa s @ 20°C)	0.8159 ± 0.00006	0.8159 ± 0.00001
APN35 density standard (dyn. visc. = 26.99 mPa s @ 40°C)	0.8423 ± 0.00007	0.8423 ± 0.00001
All-purpose cleaner	1.0010 ± 0.00002	1.0011 ± 0.00002
Biodiesel	0.8286 ± 0.00003	0.8286 ± 0.00002
Milk	1.0312 ± 0.00001	1.0314 ± 0.00010
Banana juice (30%)	1.0585 ± 0.00011	1.0589 ± 0.00039

For the majority of the samples, both syringe and funnel filling produced nearly identical results in terms of mean density and repeatability. The standard deviations were equal to or lower than 0.00003 g/cm³, indicating that either filling technique is suitable for such sample types.

Differences became evident with samples that present handling challenges. For example, banana juice, which contains particles and has moderate viscosity, exhibited a higher standard deviation when filled using the funnel (± 0.00039 g/cm³) compared to syringe filling (± 0.00011 g/cm³). These observations suggest that syringe filling offers better control and consistency for semi-viscosity or particle-containing samples.

Also milk showed limitations with funnel filling. A decrease in measured density was observed over five consecutive fillings, likely due to sample residue accumulation. The standard deviation for funnel-filled milk was ten times higher (± 0.00010 g/cm³) than that of syringe-filled milk (± 0.00001 g/cm³), indicating compromised repeatability. Removing milk residues from the funnel was challenging, as rinsing alone was ineffective and manual wiping with a tissue was necessary. The results indicate that semi-viscosity or particle-containing samples are best filled with a syringe to ensure consistent measurements.

Tip: The funnel can also be used for syringe filling. Simply connect the Luer extension (comes with the funnel) to the tip of the syringe. Then stick the syringe directly into the funnel. When clogging occurs, rinsing or emptying the measuring cell with a syringe is necessary.

The certified reference material APN35, with a viscosity of 72.42 mPa·s at 20 °C, could not be filled using the funnel at room temperature. To enable funnel filling, the sample was heated to 40 °C, reducing its viscosity to 26.99 mPa·s. Under these conditions, funnel filling resulted in better repeatability (± 0.00001 g/cm³) compared to syringe filling (± 0.00007 g/cm³). Similarly, the APS3 standard (viscosity 3.62 mPa·s at 20 °C) also showed lower standard deviation when filled via funnel (± 0.00001 g/cm³) compared to syringe (± 0.00006 g/cm³). Although these differences are small in absolute terms, they indicate that funnel filling can provide slightly more consistent results for certain samples, provided the viscosity remains within the practical range for gravitational filling.

The influence of viscosity on funnel filling performance was clearly evident during the measurements. As viscosity increased, the time required to fill the measuring cell via funnel also increased significantly. For instance, distilled water (1.0 mPa·s) filled the cell in approximately 12 seconds, while APS3 (3.62 mPa·s) required around 37 seconds. In contrast, the high-viscosity standard APN26 (49.56 mPa·s) took roughly 7.5 minutes to fill 10 mL—despite being close to the upper viscosity limit for funnel filling (Figure 1).

Beyond this threshold, gravitational filling becomes increasingly impractical, as sample flow slows down significantly and risks clogging or incomplete filling. This trend underlines the practical limitation of the funnel method, which is best suited for low-viscosity samples (<50 mPa·s), and highlights the need for alternative filling methods such as syringes or peristaltic pumps for more viscous media.

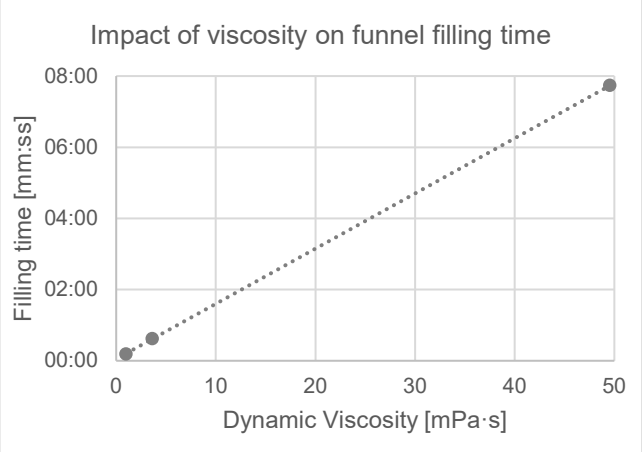

Figure 1: Correlation of the viscosity and filling time for funnel filling. Mean value for the filling time with n=3.

3.1 Syringe vs. Funnel Filling: A Practical Guidance

Table 3: Strengths and limitations of funnel and syringe filling.

Aspect	Syringe filling	Funnel filling
Viscosity range	Suitable for all viscosities (even pastes); may cause dripping with low-viscosity or volatile samples	Best for low-viscosity liquids
Foaming sensitivity	Less risk of foam entry	Foaming samples must be poured carefully
Particle compatibility	Recommended for samples with particles	Not recommended for particle-containing samples
Ease of use	Requires a separate container to fill the syringe	Very easy – the sample is poured directly from the sample container into the funnel
Clogging risk	No clogging; user controls pressure and flow	Possible; a syringe may be needed to remove the clogging
Cleaning	Less cleaning liquid is needed; moving the plunger back and forth improves cleaning performance	Requires more cleaning liquid; may require tissue or wiping for dried residues on the funnel wall
Consumable usage	Syringes are consumables and must be replaced regularly	No consumables needed

4 Conclusion

This application report compares two manual sample filling methods—syringe filling and funnel filling—for use with compact DMA density meters. Nine representative liquids, including solvents, standards, and challenging samples like milk and banana juice, were evaluated with respect to measurement accuracy, repeatability, and handling performance.

For simple, low-viscosity samples, both techniques yielded comparable measurement accuracy.

However, differences emerged when analyzing more complex liquids: syringe filling offered better control and consistency for foaming or particle-containing samples, whereas funnel filling demonstrated slightly improved repeatability for certain viscous standards.

The study also demonstrated that viscosity strongly influences funnel filling time. Low-viscosity samples filled in seconds, while samples near 50 mPa·s required several minutes and risked clogging.

These findings underscore the importance of selecting a filling technique appropriate to the sample's properties to ensure reliable density measurements. A variety of methods are available to accommodate different sample types:

- *Syringe filling*: allows precise control and supports samples with viscosities up to 35,000 mPa·s. Ideal for particle-containing or high-viscosity samples.
- *Funnel filling*: quick and user-friendly filling of low-viscosity samples. Limited to liquids with viscosities up to 50 mPa·s.
- *Peristaltic pump filling*: user-independent, ideal for repetitive tasks. Supports viscosities up to 3,000 mPa·s.
- *Aerosol adapter filling*: enables safe and controlled transfer without depressurizing the can.

By adapting the filling method to the specific requirements of the sample, optimal accuracy, repeatability, and ease of use across a wide range of applications can be ensured.

Contact Anton Paar GmbH

LDC-application@anton-paar.com |

www.anton-paar.com