

Density Kit

For Solids and Liquids Determination



MS-DNY-54

MS-DNY-43

ML-DNY-43

JEW-DNY-43

METTLER TOLEDO

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1 Introduction

Thank you for purchasing the density determination kit for your METTLER TOLEDO balance. With the aid of this kit you can use your balance for the determination of density of solids and liquids.

These instructions describe working with the density determination kit. Please see the operating instructions enclosed with your balance on how to operate the balance.

Note:

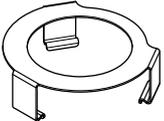
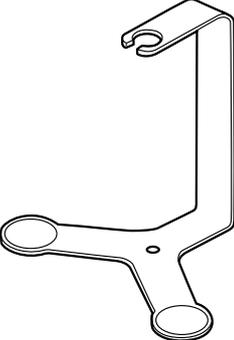
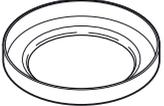
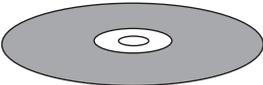
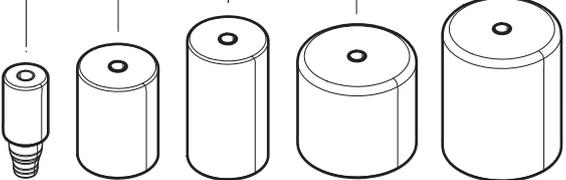
- Balances with initially installed software version V1.30 and later:
The density application is available.
- Balances with initially installed software version earlier V1.30:
Software and TDNR update required for density application. Please contact METTLER TOLEDO custom service.



Please heed and comply with all cautionary notes listed in the operating instructions of your balance .

2 Standard Equipment

The kit for the density determination of solids contains the individual parts shown in the table below.

Platform 	Bracket 	Universal basket for non-floating and floating solids (30004211) 																																																																																						
Pan 	Precision thermometer with holder (00238767) (optional calibrated version with certificate, 11132685) 	Wetting agent (0072409) 																																																																																						
Screw 	Draft shield element (except MS-DNY-54) 	Operating instructions on CD (11781524) 																																																																																						
Compensation weights depending on the kit																																																																																								
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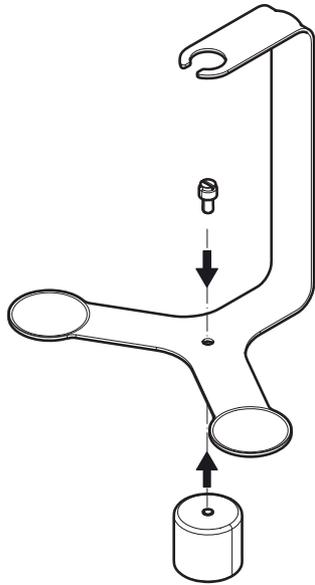
For the density determination of liquids, you need the kit and also the optional **10 cm³ sinker** (00210260)

Calibrated sinker with certificate (00210672)

New certificate (Recalibrated sinker) (00210674)



3 Preparing the Balance for Density Determinations

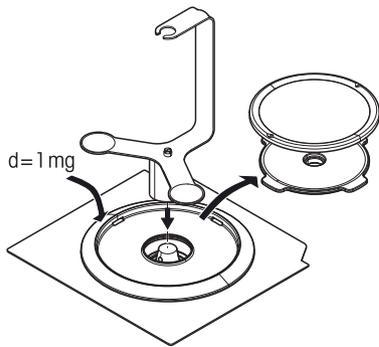


1 Installing the compensation weight

For choosing the right compensation weight see table in chapter "Standard Equipment"

Fasten the respective compensation weight to the bracket with the screw.

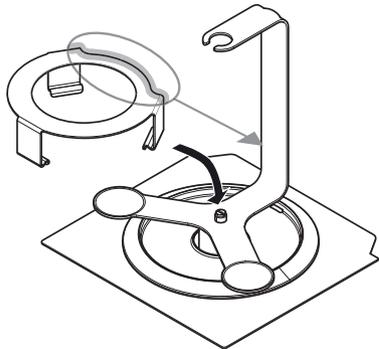
Attention: Be sure to fasten the screw lightly enough to ensure a good grounding contact.



a) Remove the weighing pan and the weighing pan support (if present) from the weighing chamber.

b) **For models d = 1 mg:** Place the draft shield element.

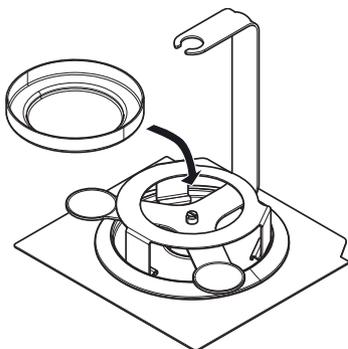
c) Place the bracket with the installed compensation weight on the weighing cone.



a) Place the platform on the draft shield element.

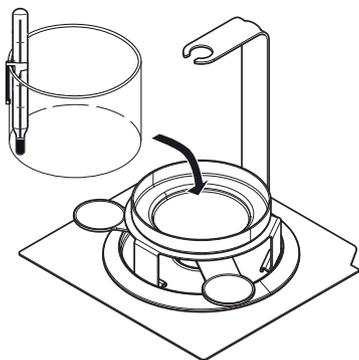
b) Turn the bracket so it is aligned with the platform.

Attention: The bracket must not touch the platform under any circumstances!



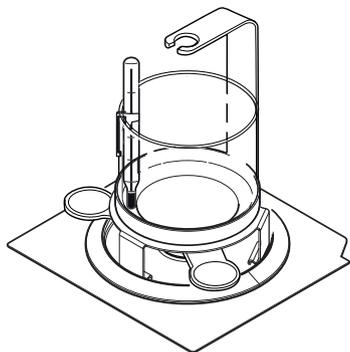
4 Place the pan on the platform.

- 5** a) Suspend the supplied thermometer from the edge of the beaker.
b) Place the beaker on the pan



- 6** **Your balance is ready for density measurements.**

Note: If the balance has been switched off while measuring (e.g. power failure), set up the kit as shown before restarting the balance.



4 Principle of the Density Determination

The density ρ is the quotient of the mass m and the volume V .

$$\rho = \frac{m}{V}$$

The international system of units specifies kg/m^3 as the unit of density. However, the unit g/cm^3 is better suited to lab purposes.

Density determinations are frequently performed by **Archimedes' principle**, which is also used with the density determination kit for the balances. This principle states that every solid body immersed in a fluid apparently loses weight by an amount equal to that of the fluid it displaces.

The procedure for the density determination by Archimedes' principle depends on whether the **density of solids or liquids** has to be determined.

5 Density Determination of Solids

5.1 Fundamentals

The density of a solid is determined with the aid of a liquid whose density ρ_0 is known (water or ethanol are usually used as auxiliary liquids). The solid is weighed in air (A) and then in the auxiliary liquid (B). The density ρ can be calculated from the two weighings as follows:

Density:

$$\rho = \frac{A}{A-B} (\rho_0 - \rho_L) + \rho_L$$

Volume:

$$V = \alpha \frac{A - B}{\rho_0 - \rho_L}$$

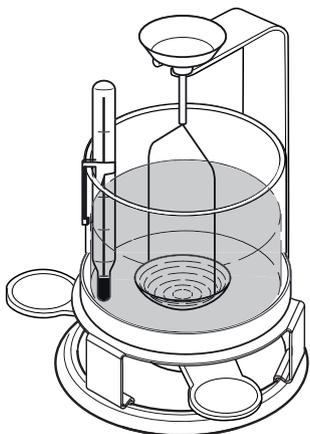
ρ	=	Density of the sample
A	=	Weight of the sample in air
B	=	Weight of the sample in the auxiliary liquid
V	=	Volume of the sample
ρ_0	=	Density of the auxiliary liquid
ρ_L	=	Density of air (0.0012 g/cm ³)
α	=	Weight correction factor (0.99985), to take the atmospheric buoyancy of the adjustment weight into account

5.2 Performing the Density Determination of Solids

Note: These instructions explain how to work with the density determination kit. They describe the procedure for performing a density determination manually.

If you need information about operating your balance, please refer to the Operating Instructions which you received with the balance. The Operating Instructions include instructions for working with the **density determination application** which is built into the balance (from balance software version 1.30).

For the density determination of solids, use the the universal basket for non-floating or floating solids.

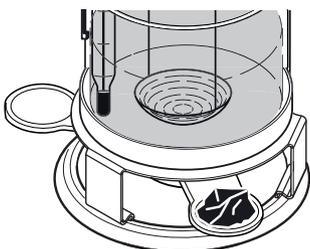


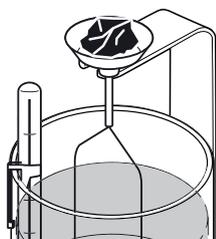
- ▶ Prepare the balance for the density determination as described in Section for preparing the balance.
- a) Fill the beaker with auxiliary liquid (liquid of known density ρ_0 , usually distilled water or ethanol). Add enough liquid to ensure that the solid is covered by at least 1 cm liquid after immersion.
- b) Suspend the universal holder for solids from the bracket (the adjacent illustration shows the universal basket prepared for non-floating solids).

Ensure that **no air bubbles** adhere to the immersed part of the basket (remove any air bubbles by moving the basket or by means of a fine brush).

Weigh in air:

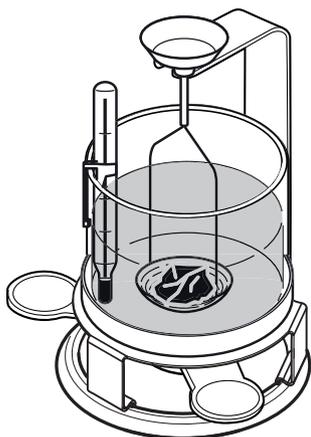
- a) Close the draft shield doors and tare the balance.
- b) Place the solid in one of the two weighing pans of the bracket.
- c) Wait until the weight display of the balance is stable (stability detector fades).
- d) Note the displayed weight A (weight of sample in air).





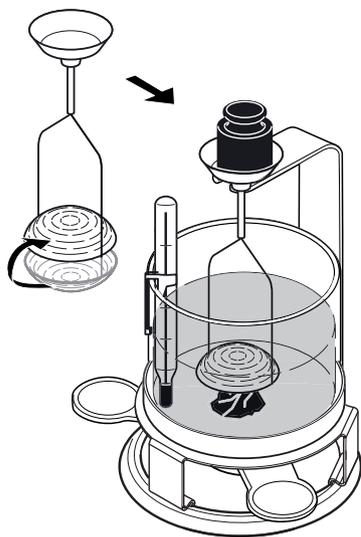
Note for 0.01 mg and 0.1 mg models:

When **solids with a weight greater than 20 g** are weighed in air, place in the pan at the top of the basket (above 20 g cornerload errors may appear on one arm in the weighing).



Weigh in liquid:

- a) Remove the solid from the pan, close the draft shield doors and tare the balance.
- b) Place the solid in the basket. Ensure that no air bubbles adhere to the solid (remove any air bubbles with a fine brush).
- c) Wait until the balance has reached stability and note the displayed weight B (weight of sample in the auxiliary liquid).
- d) Now determine the density ρ of the solid according to the preceding formula.



Note for solids with a density less than 1 g/cm³:

The universal basket must be prepared for floating solids by rotating the basket. So that it holds the solid body below the surface of the auxiliary liquid. If the buoyancy of the solid is greater than the weight of the basket, the basket must be weighted by placing an additional weight on the top weighing pan of the bracket. **After loading the additional weight, tare the balance and restart the density determination procedure by first weighing the solid in air (A) and then in the auxiliary liquid (B).**

5.3 Improving the Accuracy of the Result

The following tips should help you improve the accuracy of the results in the density determination of solids.

Temperature

Solids are generally so insensitive to temperature fluctuations that the corresponding density changes are of no consequence. However, as work is performed with an auxiliary liquid in the density determination of solids following Archimedes' principle, their temperature must be taken into account as the temperature has a greater effect with liquids and causes density changes of order of magnitude 0.1 to 1‰ per °C. This effect is already apparent in the third decimal place of the result.

To obtain accurate results, we recommend that you always take the temperature of the auxiliary liquid into account in all density determinations. You can take the appropriate values from a book of tables. You will find tables for distilled water and ethanol in Section 6.

Surface tension of the auxiliary liquid

Adhesion of the auxiliary liquid to the suspension wires of the basket causes an apparent weight increase of up to 3 mg.

As the basket is immersed in the auxiliary liquid in both weighings of the solid (in air and in the auxiliary liquid) and the balance is tared before every measurement, the influence of the apparent weight increase can be neglected.

If the greatest possible accuracy is required, use a few drops of the wetting agent supplied.

6 Density Determination of Liquids

6.1 Fundamentals

The density of a liquid is determined using a sinker of known volume. The sinker is weighed in air and then in the liquid whose density is to be determined. The density ρ can be determined from the two weighings as follows:

$$\rho = \alpha \frac{A-B}{V} + \rho_L$$

With an electronic balance it is possible to determine the weight of the displaced liquid P ($P = A-B$), and thus the buoyancy, allowing the preceding formula to be simplified to:

Density:

$$\rho = \alpha \frac{P}{V} + \rho_L$$

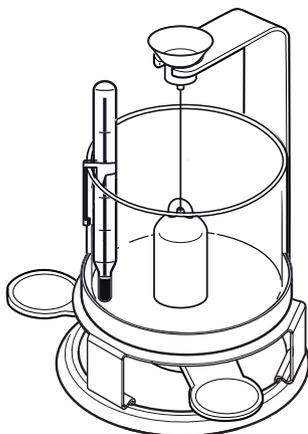
- ρ = Density of the liquid
- A = Weight of the sinker in air
- B = Weight of the sample in the liquid
- V = Volume of the sinker
- ρ_L = Density of air (0.0012 g/cm^3)
- α = Weight correction factor (0.99985), to take the atmospheric buoyancy of the adjustment weight into account
- P = Weight of the displaced liquid ($P = A-B$)

6.2 Performing the Density Determination of Liquids

Note: These instructions explain how to work with the density determination kit. They describe the procedure for performing a density determination manually.

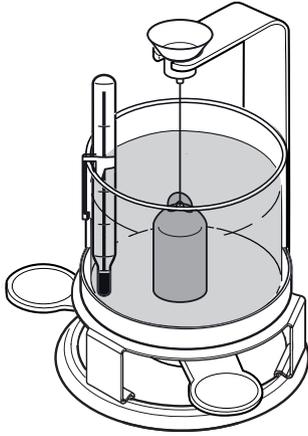
If you need information about operating your balance, please refer to the Operating Instructions which you received with the balance. The Operating Instructions include instructions for working with the **density determination application** which is built into the balance (from balance software version 1.30).

For the density determination of liquids, use the optional sinker.



Weigh sinker in air:

- ▶ Prepare the balance for the density determination as described in Section for preparing the balance.
- a) Suspend the sinker from the bracket and ensure that it does not touch either the beaker or the thermometer.
- b) Tare the balance.



Weigh sinker in liquid:

- a) Add the liquid whose density you wish to determine to the beaker (up to approx. 1 cm above the suspension eye of the sinker). Ensure that no air bubbles adhere to the sinker (remove any air bubbles with a fine brush).
- b) Wait until the weight display of the balance is stable (stability detector fades) and note the displayed value P (Weight of displaced liquid).
- c) Now determine the density ρ of the liquid (at the temperature read off on the thermometer), according to the preceding formula.

6.3 Improving the Accuracy of the Result

The following tips will help you improve the accuracy of the results in the density determination of liquids.

Volume tolerance of the sinker

The optional sinker 210260 recommended for the density determination of liquids corresponds to the requirements of the German Weights and Measures Regulation (EO 13–4, paragraph 9.21). The volume of the sinker 210260 including the upper half of the suspension wire is so adjusted that the maximum error in the density determination of water at a temperature of 20°C is $\pm 0.0005 \text{ g/cm}^3$.

7 Supplementary Information

This section offers information on the influencing factors which can have an adverse effect on the accuracy of the experimental results. In addition, you will find density tables for distilled water and ethanol in this section.

7.1 Influencing Factors

In addition to temperature, air buoyancy and surface tension of the liquid, the following factors can affect the experimental results:

- Immersion depth of the basket or the sinker
- Air bubbles
- Porosity of the solid body

Immersion depth of the basket or sinker

The sinker for the **density determination of liquids** is suspended from a platinum wire of **0.2 mm diameter**. In water the wire experiences a **buoyancy of approx. 0.3 mg per 10 mm immersion depth**.

Example: If the liquid is 10 mm above the suspension eye of the sinker, approx. 40 mm wire are immersed. This results in a buoyancy of 1.2 mg at densities around 1. Owing to division of the buoyancy by 10 cm³ (= volume of the sinker), the error in the result is negligibly small and need not be corrected.

The immersible part of the basket for the **density determination of solids** comprises 2 wires **each of diameter 0.6 mm**. With a liquid density of 1, this results in a **buoyancy of approx. 0.4 mg per millimeter immersion depth**.

In the weighing of the solid in air, the immersion depth of the basket remains the same. The buoyancy force on the basket is thus constant and can therefore be neglected. However, it is important to ensure that the **liquid level is not changed** between weighings (the change in the liquid level by immersion of the solid is usually insignificant)

Air bubbles

With poorly wetting liquids (e.g. water without wetting agent), it is possible that air bubbles remain adhered to the immersed parts (solid, sinker, basket) and influence the result owing to their buoyancy. A bubble with a diameter of 1 mm causes a buoyancy of 0.5 mg, whereas one of diameter 2 mm results in a buoyancy as high as 4 mg. To avoid air bubbles, we advise the following **precautionary measures**:

Use enclosed or commercial wetting agent or organic liquids (the density change experienced by distilled water on the addition of wetting agent can be neglected).

- Degrease solvent-resistant solids
- Clean basket and sinker at regular intervals, never touched parts which are immersed with your hand
- Gently shake basket and sinker on first-time immersion to dislodge any air bubbles
- Remove tenaciously adhering air bubbles with a fine brush
- Use enclosed or commercial wetting agent or organic liquids (the density change experienced by distilled water on the addition of wetting agent can be neglected).

Porosity of the solid

When solid bodies are immersed in a liquid, usually not all the air in the pores is displaced. This leads to buoyancy errors and thus the density of porous bodies can only be determined approximately.

7.2 Density Table for Distilled Water

Density Table for Distilled Water

T/°C	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
10.	0.99973	0.99972	0.99971	0.99970	0.99969	0.99968	0.99967	0.99966	0.99965	0.99964
11.	0.99963	0.99962	0.99961	0.99960	0.99959	0.99958	0.99957	0.99956	0.99955	0.99954
12.	0.99953	0.99951	0.99950	0.99949	0.99948	0.99947	0.99946	0.99944	0.99943	0.99942
13.	0.99941	0.99939	0.99938	0.99937	0.99935	0.99934	0.99933	0.99931	0.99930	0.99929
14.	0.99927	0.99926	0.99924	0.99923	0.99922	0.99920	0.99919	0.99917	0.99916	0.99914
15.	0.99913	0.99911	0.99910	0.99908	0.99907	0.99905	0.99904	0.99902	0.99900	0.99899
16.	0.99897	0.99896	0.99894	0.99892	0.99891	0.99889	0.99887	0.99885	0.99884	0.99882
17.	0.99880	0.99879	0.99877	0.99875	0.99873	0.99871	0.99870	0.99868	0.99866	0.99864
18.	0.99862	0.99860	0.99859	0.99857	0.99855	0.99853	0.99851	0.99849	0.99847	0.99845
19.	0.99843	0.99841	0.99839	0.99837	0.99835	0.99833	0.99831	0.99829	0.99827	0.99825
20.	0.99823	0.99821	0.99819	0.99817	0.99815	0.99813	0.99811	0.99808	0.99806	0.99804
21.	0.99802	0.99800	0.99798	0.99795	0.99793	0.99791	0.99789	0.99786	0.99784	0.99782
22.	0.99780	0.99777	0.99775	0.99773	0.99771	0.99768	0.99766	0.99764	0.99761	0.99759
23.	0.99756	0.99754	0.99752	0.99749	0.99747	0.99744	0.99742	0.99740	0.99737	0.99735
24.	0.99732	0.99730	0.99727	0.99725	0.99722	0.99720	0.99717	0.99715	0.99712	0.99710
25.	0.99707	0.99704	0.99702	0.99699	0.99697	0.99694	0.99691	0.99689	0.99686	0.99684
26.	0.99681	0.99678	0.99676	0.99673	0.99670	0.99668	0.99665	0.99662	0.99659	0.99657
27.	0.99654	0.99651	0.99648	0.99646	0.99643	0.99640	0.99637	0.99634	0.99632	0.99629
28.	0.99626	0.99623	0.99620	0.99617	0.99614	0.99612	0.99609	0.99606	0.99603	0.99600
29.	0.99597	0.99594	0.99591	0.99588	0.99585	0.99582	0.99579	0.99576	0.99573	0.99570
30.	0.99567	0.99564	0.99561	0.99558	0.99555	0.99552	0.99549	0.99546	0.99543	0.99540

7.3 Density Table for Ethanol

Density Table for Ethanol

T/°C	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
10.	0.79784	0.79775	0.79767	0.79758	0.79750	0.79741	0.79733	0.79725	0.79716	0.79708
11.	0.79699	0.79691	0.79682	0.79674	0.79665	0.79657	0.79648	0.79640	0.79631	0.79623
12.	0.79614	0.79606	0.79598	0.79589	0.79581	0.79572	0.79564	0.79555	0.79547	0.79538
13.	0.79530	0.79521	0.79513	0.79504	0.79496	0.79487	0.79479	0.79470	0.79462	0.79453
14.	0.79445	0.79436	0.79428	0.79419	0.79411	0.79402	0.79394	0.79385	0.79377	0.79368
15.	0.79360	0.79352	0.79343	0.79335	0.79326	0.79318	0.79309	0.79301	0.79292	0.79284
16.	0.79275	0.79267	0.79258	0.79250	0.79241	0.79232	0.79224	0.79215	0.79207	0.79198
17.	0.79190	0.79181	0.79173	0.79164	0.79156	0.79147	0.79139	0.79130	0.79122	0.79113
18.	0.79105	0.79096	0.79088	0.79079	0.79071	0.79062	0.79054	0.79045	0.79037	0.79028
19.	0.79020	0.79011	0.79002	0.78994	0.78985	0.78977	0.78968	0.78960	0.78951	0.78943
20.	0.78934	0.78926	0.78917	0.78909	0.78900	0.78892	0.78883	0.78874	0.78866	0.78857
21.	0.78849	0.78840	0.78832	0.78823	0.78815	0.78806	0.78797	0.78789	0.78780	0.78772
22.	0.78763	0.78755	0.78746	0.78738	0.78729	0.78720	0.78712	0.78703	0.78695	0.78686
23.	0.78678	0.78669	0.78660	0.78652	0.78643	0.78635	0.78626	0.78618	0.78609	0.78600
24.	0.78592	0.78583	0.78575	0.78566	0.78558	0.78549	0.78540	0.78532	0.78523	0.78515
25.	0.78506	0.78497	0.78489	0.78480	0.78472	0.78463	0.78454	0.78446	0.78437	0.78429
26.	0.78420	0.78411	0.78403	0.78394	0.78386	0.78377	0.78368	0.78360	0.78351	0.78343
27.	0.78334	0.78325	0.78317	0.78308	0.78299	0.78291	0.78282	0.78274	0.78265	0.78256
28.	0.78248	0.78239	0.78230	0.78222	0.78213	0.78205	0.78196	0.78187	0.78179	0.78170
29.	0.78161	0.78153	0.78144	0.78136	0.78127	0.78118	0.78110	0.78101	0.78092	0.78084
30.	0.78075	0.78066	0.78058	0.78049	0.78040	0.78032	0.78023	0.78014	0.78006	0.77997

Density of C₂H₅OH according to the "American Institute of Physics Handbook".

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