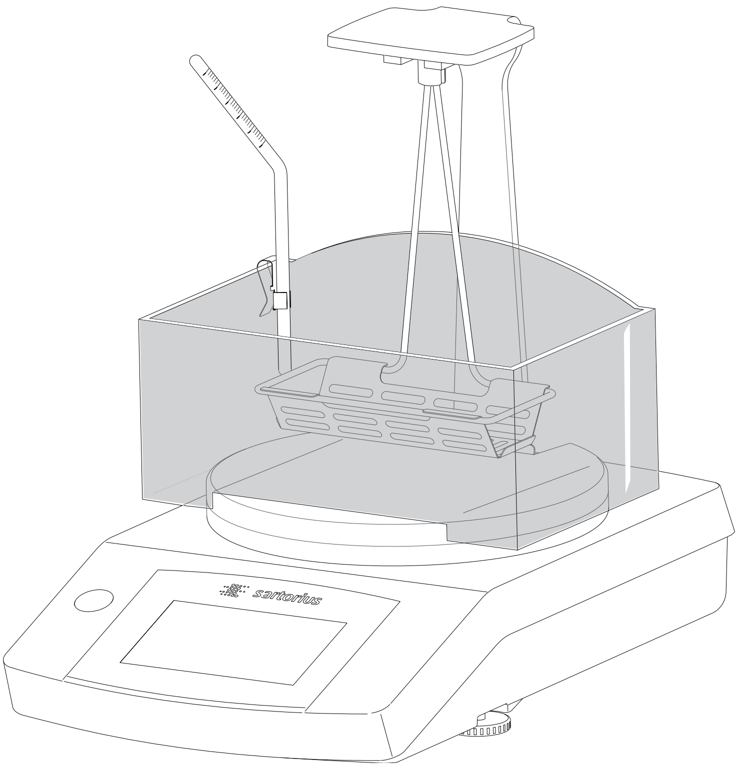
User's Manual | Betriebsanleitung | Mode d'emploi |
Instrucciones de funcionamiento | 操作指南

Sartorius YDK04

Density Determination Kit | Dichtebestimmungsset
Dispositif de détermination de masses volumiques |
Kit para la determinación de la densidad | 密度测定套件



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Contents

The new Sartorius Density Determination Kit is a high-quality accessory to your electronic balance.

With this accessory, Sartorius is making your daily work easier.

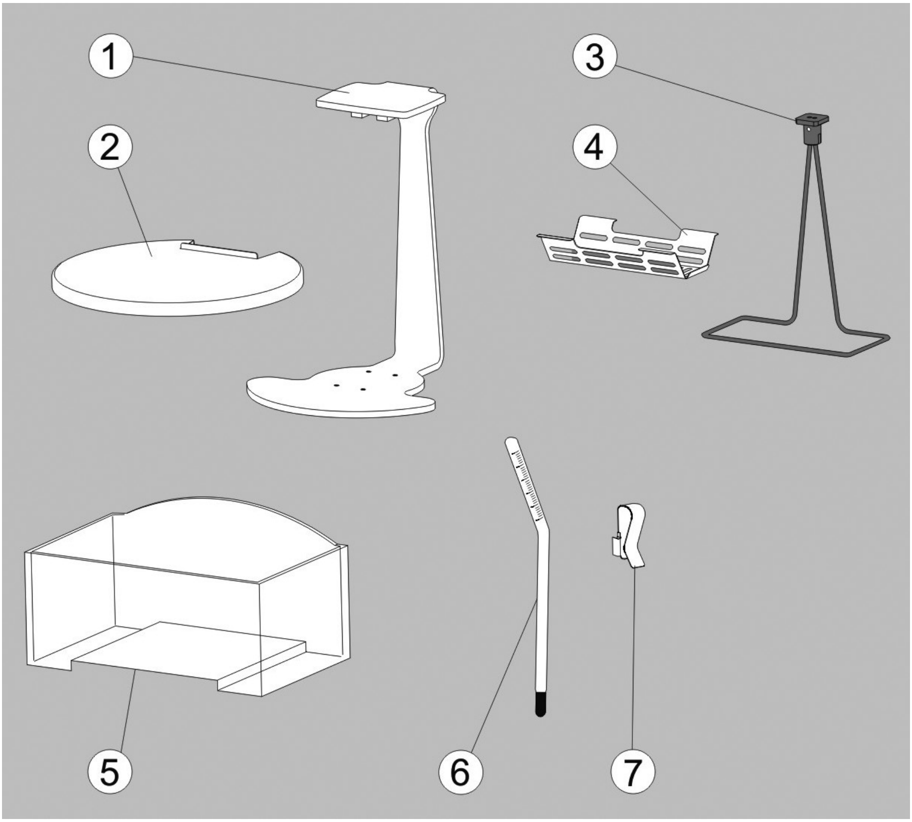
Please read through the set-up and user's manual carefully before setting up the balance and starting your work with the density determination kit.

If you equip your balance with a density determination program, the program will then determine the density for you.

In this particular case, please refer exclusively to the set-up guide and work instructions.

The density determination should then be carried out as described in the instructions for the density determination program.

Kit Components



1 Beam

2 Cover plate

3 Immersion frame

4 Sample holder (pan hanger assembly)

5 Container

6 Thermometer

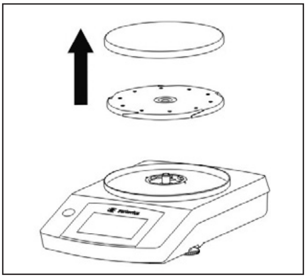
7 Fastening clamp

Getting Started

The YDK04 density determination kit can be used with the following balances:

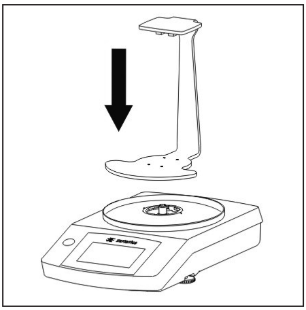
- Secura®
  Type 1102, 2102, 3102, 5102
- Quintix®
  Type 612, 1102, 2102, 3102, 5102
- Practum®
  Type 612, 1102, 2102

Preparing the Balance
Before placing the beam on the balance, the balance will need to be modified.

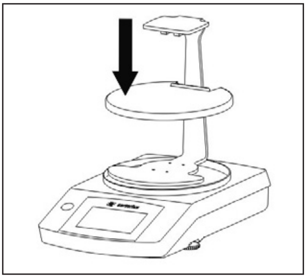


▶ Remove the weighing pan and pan support for the balance.

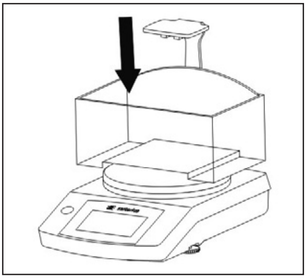
Installing the Density Determination Kit
To install the density determination kit on the balance, proceed as follows:



▶ Mount the beam on the stud of the balance.

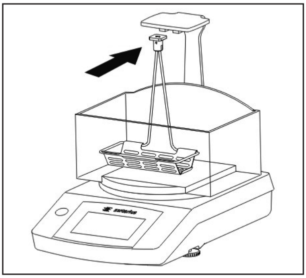


▶ Mount the cover plate on the beam you have just attached.
When doing this, ensure the cover plate is exactly positioned and centered.

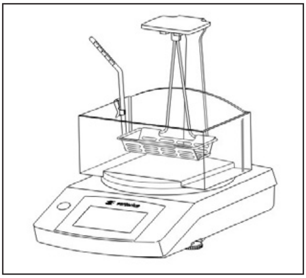


▶ Fill the container with liquid (e.g. water or ethanol) and place the container on the mounted cover plate.

▶ Insert the sample holder (pan hanger assembly) into the immersion frame.



▶ Attach the immersion frame, with the sample holder mounted on it, to the beam.
Make sure that the sample holder is fully immersed in the liquid. Add more liquid if necessary.
When immersing the sample holder, make sure that there are no air bubbles in the sample holder.



▶ Use the fastening clamp to fasten the thermometer to the container (where this is required).

Method Used to Determine Density

To determine the density of a solid object, the measurement system employed here uses the “Archimedes’ principle”:

An object immersed in liquid will be subject to an upward buoyant force. This force is equal to the weight of the liquid displaced by the object.

Using a hydrostatic balance, which enables you to weigh the solid object in air and in water, it is possible to determine the **density of a solid object**, if the density of the buoyancy medium is known:

$$\rho = \frac{W(a) \cdot \rho(fl)}{W(a) - W(fl)}$$

Where:
ρ = the density of the solid object
$\rho(fl)$ = the density of the liquid
$W(a)$ = the weight of the solid object in air
$W(fl)$ = the weight of the solid object in liquid

Sources of Error and Options for Correction

The above formula to determine the density of solid objects is sufficiently accurate for determining the density to two decimal places depending on samples volume. This density kit is designed for determining density of 10 g – 2 kg weight of samples.

Depending on the accuracy required, the following error and correction factors will need to be considered:
- effect of temperature on the density of the bouyancy liquid
- air bouyancy when weighing in air
- changes in the immersion depth of the immersion frame when immersing the sample
- adhesion of the liquid to the immersion frame
- air bubbles sticking to the sample.

Some of the errors can be corrected mathematically. To do this, you have to:
- measure the temperature of the liquid and correct the liquid density accordingly.

Effect of Temperature on the Liquid Density
The density of the buoyancy liquid is temperature dependent. The density change per °C temperature change is of the order of:
- 0.02% for distilled water
- 0.1% for alcohols and hydrocarbons. In other words, this can show up in the third decimal place during density determination.

To correct the liquid density based on temperature, proceed as follows:
- measure the temperature of the liquid using the thermometer supplied.
- the density of the most common buoyancy liquids, water and ethanol, at the measured temperature can then be found in the table provided and used for ρ (fl).

Air Buoyancy
Depending on the temperature, humidity and air pressure, a 1 cm^3 volume of air will have a weight of around 1.2 mg. When weighing in air, the object experiences a corresponding buoyancy per cm^3 of its volume. The error that results if the air buoyancy is not allowed for shows up in the third decimal place and should therefore be corrected.

The buoyancy force is taken into account in the following formula:

$$\rho = \frac{W(a) \cdot [\rho(fl) - \rho(a)]}{W(a) - W(fl)} + \rho(a).$$

Where $\rho(a) = 0.0012\ g/cm^3$ = density of air under normal conditions (temperature 20°C, pressure 101.325 kPa).

Immersion Depth
The sample holder to collect and/or immerse the sample during the weighing in liquid is fastened rigidly to two wires and plunges about 30 mm deep into the liquid. Since the balance is tared prior to each measurement, the additional buoyancy from the submerged part of the measurement setup is not factored into the determination of the density.

When weighing in liquid, a volume of liquid corresponding to the volume of the sample body gets displaced.
This causes the fastening wires on the pan to plunge deeper and generate additional buoyancy, creating an error in the density determination.

The following formula will correct the error:

$$\rho = \frac{W(a) \cdot [\rho(fl) - \rho(a)]}{Corr\,[W(a) - W(fl)]} + \rho(a)$$

Adhesion of the Liquid to the Wire
When immersing the **sample holder** in the buoyancy liquid, liquid creeps up the wire because of adhesion forces and creates a few additional milligrams of weight.

Since the **sample holder** is in the buoyancy medium both when weighing in air and when weighing in liquid, and the balance is tared at the beginning of each measurement, the influence of the liquid meniscus can be ignored.

In order to reduce the surface tension and the friction of the liquid on the wire, around three drops of a surfactant (Mirasol Antistatic or a conventional detergent) are added to the vessel's distilled water contents.

With the buoyancy liquid creeping up the wire, the weight value may still slowly change after the "g" has appeared.

For this reason, the weight value should be read as soon as the "g" appears.

Air Bubbles
The measurement errors which occur as a result of air bubbles sticking to the sample can be evaluated as follows: If the air bubble has a diameter of 0.5 mm, this will produce an additional buoyancy of less than 0.1 mg when weighing in water. If the air bubble has a diameter of 1 mm, the additional buoyancy will be around 0.5 mg, and if the diameter is around 2 mm, roughly 4.2 mg. It is therefore imperative that larger air bubbles are taken off with a fine brush or similar.

Moisture can also be added in advance in a separate container.

Density Determination

Determining Density of Solid Objects

Preparation
(the description uses distilled water)
- Align the container in the center of the base plate; the beam acts as the stopper at the back.
- Fill with distilled water up to approx. 5 mm below the edge.
- Add three drops of surfactant to the distilled water.
- Use the clamp to fasten the thermometer to the edge of the beaker.
- Clean the sample holder with solvent (paying particular attention to the immersed wires) and hook on to the beam.

Measurement Procedure

Determining the Sample Weight in Air
- Tare the balance.
- Place the sample on the beam weighing pan and weigh it.
- Make a note of the weight value W (a).

Determining the Buoyancy
G = W (a) – W (fl)
- Tare the balance with the sample on the beam.
- Lay the sample in the sample holder[1]).
- Make a note of the absolute value of buoyancy G, with a minus sign in front.

Calculating the Density
- Read off the temperature.
- Locate the density value ρ (fl) in the table using the temperature you have read off.
- Calculate the density using the following formula:

$$\rho = \frac{W(a) \cdot [\rho(fl) - 0.0012\ g/cm^3]}{Corr\ G} + 0.0012\ g/cm^3$$

W (a) and G in g; ρ (fl) in g/cm^3
G = W (a) – W (fl)

[1]) (If you have to remove the sample holder from the measurement equipment to do this, make sure that no additional air bubbles become attached upon re-immersion in the liquid; it is better to add the sample directly with forceps or similar.)

Tables

Density Values of H_2O at Temperature T (in °C)

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

Density Values of Ethanol at Temperature T (in °C)

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

Appendix

To gain a better understanding of the process, the theory behind the formulas and the correction factor is explained here.

Basic Principles

$$\text{Density} = \frac{\text{Mass (g)}}{\text{Volume (cm}^3\text{)}}$$

The Archimedes' principle states:
An object immersed in liquid will be subject to a buoyant force (G). This force is equal to the weight of the liquid displaced by the object.
The volume of the immersed object V (k) is equal to the volume of the displaced liquid V (fl).

The following are determined:
1. Weight in air W (a)
2. Buoyancy of the object in the liquid (G)

The density of an object is:

$$\rho = \frac{\text{mass of object}}{\text{volume of object}} = \frac{W\ (a)}{V\ (s)} = \frac{W\ (a)}{V\ (fl)}$$

If the density ρ (fl) of the displaced liquid is known:

$$V\ (fl) = \frac{\text{Mass (fl)}}{\rho\ (fl)} = \frac{G}{\rho\ (fl)}$$

Thus:

$$\rho = \frac{W\ (a) \cdot \rho\ (fl)}{G}$$

Calculation
The density of a solid object is calculated based on the ratio
$\rho : W\ (a) = \rho\ (fl) : W\ (a) - W\ (fl)$
Thus:

$$\rho = \frac{W\ (a) \cdot \rho\ (fl)}{W\ (a) - W\ (fl)}$$

W (a) – W (fl) = G = buoyancy of the sample

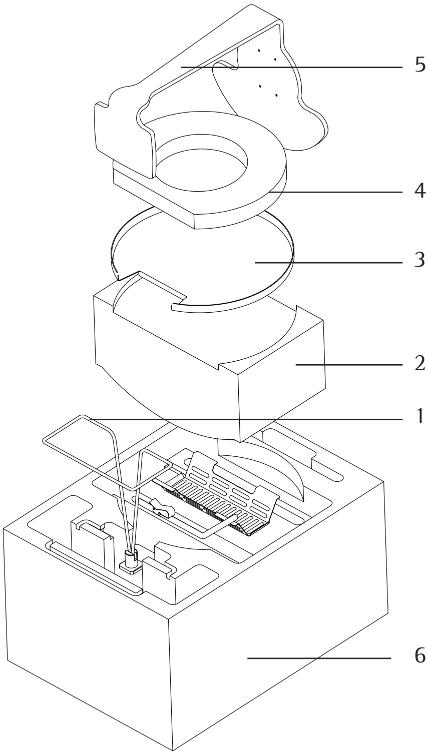
Where:

ρ	= the density of the solid object
ρ (fl)	= the density of the liquid
W (a)	= the weight of the solid object in air
W (fl)	= the weight of the solid object in liquid

Packing the Density Determination Kit for Shipping

To pack the density determination kit for shipping, proceed as follows:

Make sure to place the container and cover plate in the inner foam piece exactly as shown in the illustration. Otherwise you will not be able to place the density determination kit in its correct position in the carrying case.



▶ Insert the immersion frame (1) the inner foam piece (6).

▶ Insert the container (2) into the inner foam piece (6).

▶ Put the cover plate (3) on the container.

▶ Lay the round cushion (4) on the cover plate.

▶ Insert the beam (5) over the round cushion into the inner foam piece from above.