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Operating instructions Density Determination Set for Analytical Balance KERN ABJ / ABS

KERN ABS-A02

Version 1.0
04/2010
GB

ABS-A02-BA-e-1010

GB

KERN ABS-A02

Version 1.0 04/2010
Operating instructions
Density Determination Set for Analytical Balance
KERN ABJ / ABS

English

Contents:

1 Introduction

- In order to guarantee a safe and trouble-free operation, please read carefully the operating instructions.
- These operating instructions only describe the operation of the density determination set. For further information on how to operate your balance please refer to the operating instructions supplied with each balance.

1.1 Scope of supply

⇨ Check packaging and density determination set immediately when unpacking for possible visible damage.

⇨ Make sure that all parts are completely present.

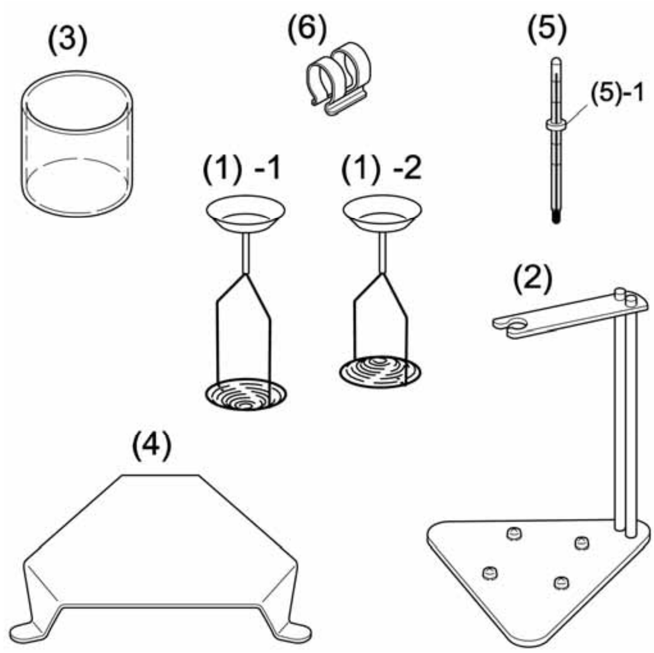


Fig. 1 Scope of delivery

No.	Designation	Qty.
(1) -1	Combination weighing tray (for samples d > 1 g/cm^3)	1
(1) -2	Combination weighing tray (for samples d < 1 g/cm^3)	1
(2)	Weighing tray holder	1
(3)	Glass container	1
(4)	Platform for glass container	1
(5)	Thermometer	1
(5) -1	Rubber stop for thermometer	1
(6)	Holder for thermometer	1
	Glass sinker, see fig. 4	1
	Operating instructions	1

English

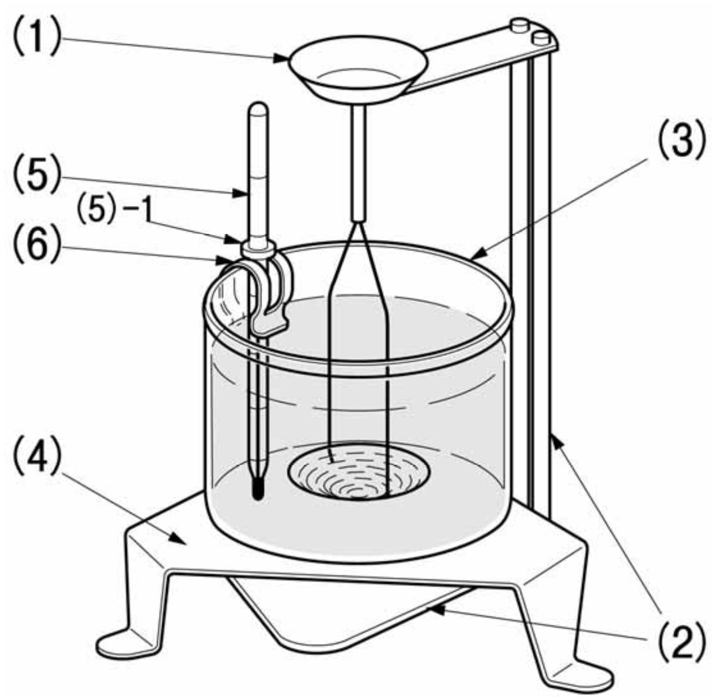


Fig. 2: Installed density set **KERN ABS-A02**

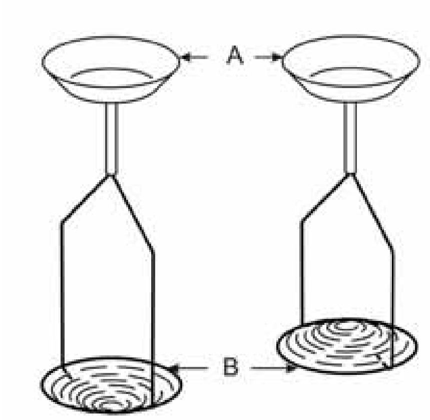


Fig. 3: Combination weighing trays

A Upper sample dish (weight of the sample in air)

B Lower sample dish (weight of the sample in measuring liquid)

Fig. 4: Glass sinker

2 Principle of Density Determination

Three physical magnitudes are the **volume** and the **mass** of bodies as well as the **density** of matter. In density mass and volume are related.

Density [ρ] is the relation of mass [m] to volume [V].

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

SI-unit of density is kilogram divided by cubic meter (kg/m^3). 1 kg/m^3 equals the density of a homogenous body that, for a mass of 1 kg, has the volume of 1 m^3.
Additional frequently applied units include:

$$1\frac{g}{cm^3},\quad 1\frac{kg}{m^3},\quad 1\frac{g}{l}$$

The application of this density determination set in combination with the KERN ABS/ABJ balances provides fast and safe determination of solids and fluids. Our set uses the "**Principle of Archimedes**" to determine density:

BUOYANCY IS A FORCE. IT AFFECTS A BODY THAT IS IMMERSED INTO A FLUID. THE BUOYANCY OF THE BODY EQUALS THE WEIGHT FORCE OF THE DISPLACED FLUID. THE FORCE OF BUOYANCY ACTS VERTICALLY UPWARDS.

Thus, density is calculated according to the formulae below:

Determining density of solid bodies

Our balances enable weighing of solids in air [A] as well as water [B]. If the density of the buoyancy medium is known [ρ_o] the density of the solid [ρ] is calculated as follows:

$$\rho = \frac{A}{A-B}\,\rho_o$$

ρ = density of sample
A = weight of the sample in air
B = weight of sample in measuring fluid
ρ_o = density of measuring fluid

English

Determining density of liquids

The density of a fluid is determined with the help of a sinker providing a known volume [V]. The sinker is weighed in air [A] as well as in the sample fluid [B]. According to the Archimedes' Principle a body immersed in a fluid experiences a force of buoyancy. [G]. This force equals the weight force of the fluid displaced by the volume of the body.
The volume [V] of the immersed body equals the volume of the displaced fluid.

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

G = buoyancy of sinker

Buoyancy of sinker =
Weight of the sinker in air [A] - weight sinker in sample liquid [B]

From this follows:

$$\rho = \frac{A-B}{V}$$

ρ = density of sample fluid
A = weight of sinker in air
B = weight of sinker in sample fluid
V = volume of sinker*

* If the volume of the sinker is unknown, this can be determined by a solid body density measurement e.g. in water and be calculated as follows.

$$V = \frac{A-B}{\rho_w}$$

V = volume of sinker
A = weight of sinker in air
B = weight of sinker in water
ρ_W = density of water

2.1 Influencing magnitudes and error sources

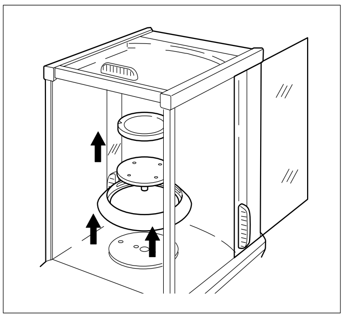
⇨ Air pressure
⇨ temperature
⇨ Volume deviance of the sinker (± 0.005 cm^3)
⇨ Surface tension of the liquid
⇨ Air bubbles
⇨ Immersion depth of the sample dish of sinker
⇨ Porosity of the solid

English

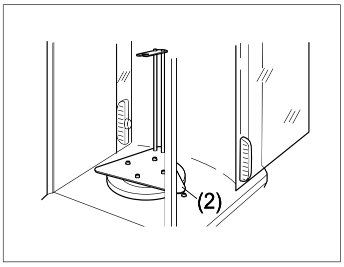
3 Installing the density determination set

- If necessary, carry out necessary adjustment before installation of the density set.
- When the density set is installed, correct adjustment is not possible.
- For reasons of adjustment, take away the density set and place the standard weighing plate.

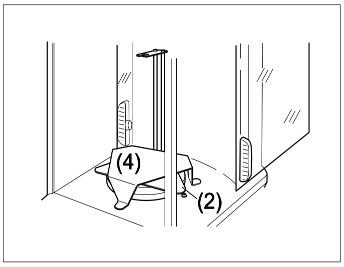
1. Switch off balance and separate it from the power supply.
2. Remove standard weighing plate, screening ring and weighing plate carrier.



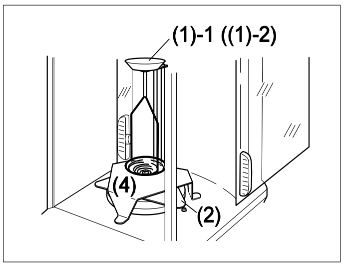
3. Insert balance tray holder carefully



4. Place the platform for glass containers in a way that it does not touch the balance tray holder.

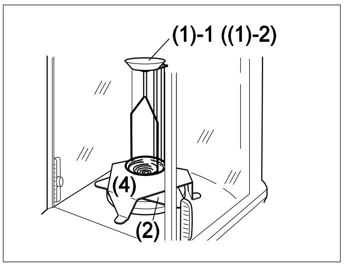


5. Hook up the combination weighing tray. Ensure that it hangs centrically in the recess of the weighing tray holder.

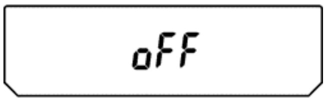


English

6. Close the glass doors. Connect balance to power supply, the balance will carry out a self-test. The balances of the ABJ series also carry out an adjustment with the internal adjustment weight.

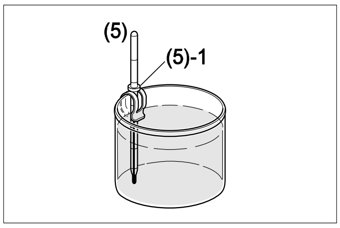


   Wait until “off“ appears.



7. Press the **ON/OFF** key, the gram display will appear.

8. Fix the thermometer according to the illustration on the glass container. Fill the glass container with measuring or sample liquid.



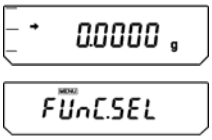
9. Take away the combination weighing tray and put the glass container in the center of the platform.
10. Hook up again the combination weighing tray. Make sure that it does not touch the glass container.
11. Heat the liquid, the instruments or the sinker until the temperature is constant. Observe the warm-up time of the balance.

4 Density determination of solids

for the density determination of solid material, the solid is weighed first in air and then in the measuring liquid. From the weight difference results the buoyancy from where the software calculates the density.

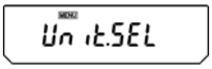
4.1 Activate function

In the „Unit.SEL“ menu the density determination function for solid material „**U- ▾d**“ can be activated, which then will be available for the operator without needing to enter the menu each time. The activated function then can be called-up directly via the **UNIT/** button.



⇨ At the gram display, press the **CAL/MENU** button repeatedly until „FUnC.SEL“ is displayed.

⇨ Press the **TARE/** button.



(Example)

⇨ Press the **CAL/MENU** button repeatedly until „Unit.SEL“ will be displayed.

⇨ Press the **TARE/** button.

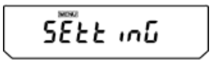
(deactivated)

(activated)

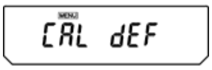
⇨ Press the **CAL/MENU** button repeatedly until „**U- ▾d**“ will be displayed.
If the function of density determination already has been activated, the standstill display (➡) will appear. In this case press the **ON/OFF** button repeatedly, the balance returns into the menu/weighing mode.
If the function for density determination of solid material is deactivated, activate it by the **TARE/** button.
The standstill display (➡) will appear.
Press the **ON/OFF** button repeatedly, the balance returns into the menu/weighing mode.

English

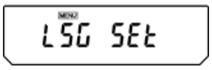
4.2 Input „Density measuring liquid“



⇨ In the gram display press the **CAL/MENU** button repeatedly until „SettinG“ appears.



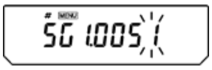
⇨ Press the **TARE/** button.



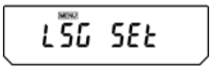
⇨ Press the **CAL/MENU** button repeatedly until “LSG SEt“ appears


(Example)

⇨ Press the **TARE/** button, the currently set density is displayed. In the upper part of the display panel, the MENU symbol and the # symbol appear in order to indicate numerical input status. The first digit is flashing and can be changed.


(Example)

⇨ Use the **UNIT/** button to increase the numerical value of the flashing digit.
Use the **PRINT/** button to shift the digit selection to the right, the active digit is flashing
Confirm input by the **TARE/** button.



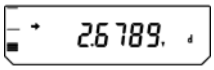

⇨ Repeatedly press the **ON/OFF** key until the balance is in weighing mode.

English

4.3 Measurement „Density solid material“

1. Repeatedly press the **UNIT/** button until the balance is in density determination mode for solid material „▾**d**". If the weight is measured in air, additionally a „g“ will be displayed.

2. Press the **TARE/** button. Place sample in the upper sample dish.
3. When standstill control is complete, press the **CAL/MENU** button.



4. Place sample in the lower sifting bowl. When standstill control is complete, the density of the sample will be shown in the display. Remove the sample.
   May be that „oL“ will be displayed, but in that step this isn’t any error message and can be ignored.
5. For other measurements start at step 2 by pressing the **CAL/MENU** button.

English

4.3.1 Density determination of solid material with a density of less than 1 g/cm^3

At solid material with density less than 1 g/cm^3 , a density determination with two different methods is possible.

Method 1:

As measuring density a liquid with less density than that of the solid material, e.g. ethanol approx. 0.8 g/cm^3.

This method should be applied when the density of the solid is just slightly different from that of the distilled water.

Using ethanol is not recommended, when the solid material is being attacked.

⚠ When working with ethanol, you must observe the applicable safety regulations.

Method 2:

Here the sample is not placed upon, but **under** the sifting bowl. For this purpose use the combination weighing tray (1) -2.

⇨ Activate function, see chap. 4.1.

⇨ Input parameter measuring liquid, see chap. 4.2.

⇨ Density measurement see chapter 4.3, in step 4 place the sample under the sifting bowl. If the buoyancy of the sample is so much that the combination weighing tray is lifted, place a dummy weight on it and tare it away when weighing in air.

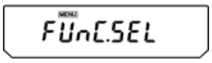
English

5 Determining density of liquids

For density determination of liquids, a glass sinker is used, whose volume is known. The glass sinker is weighed first in air and then in the liquid whose density is to be determined. From the weight difference results the buoyancy from where the software calculates the density.

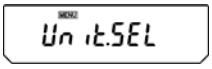
5.1 Activate function

In the “Unit.SEL” menu the density determination function for liquids “**U- d**“ can be activated, which then will be available for the operator without needing to enter the menu each time. The activated function then can be called-up directly via the **UNIT/** button.



⇨ In weighing mode, press the **CAL/MENU** button repeatedly until „FUnC.SEL“ is displayed.

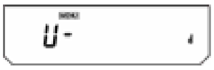
⇨ Press the **TARE/** button.



(Example)

⇨ Press the **CAL/MENU** button repeatedly until „Unit.SEL“ will be displayed.

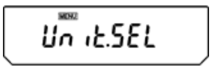
⇨ Press the **TARE/** button.

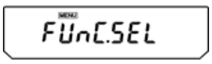


(deactivated)

(activated)

⇨ Press the **CAL/MENU** button repeatedly until „**U-   d**“ will be displayed.
If the function of density determination already has been activated, the standstill display (➡) will appear. In this case press the **ON/OFF** button repeatedly, the balance returns into the menu/weighing mode.
If the function for density determination of solid material is deactivated, activate it by the **TARE/** button. The standstill display (➡) will appear.
Press the **ON/OFF** button repeatedly, the balance returns into the menu/weighing mode.





5.2 Determine volume of the glass sinker

If the volume of the glass sinker is unknown, it must be determined and calculated as follows.

⇨ Fill water into the container and heat it until the temperature is constant. Read temperature on the thermometer.

⇨ If necessary, press the **UNIT/** button until the gram display appears.

⇨ Remove the combination weighing tray if necessary.
May be that „ol“ will be displayed, but in that step this isn't any error message and can be ignored.

⇨ Suspend the glass sinker and tare by the **TARE/** button.

⇨ Place the water container on the platform and immerse the glass sinker. The balance displays the difference „weight in air – weight in water“.
Note the value (without sign) and calculate the volume of the glass sinker according to the following formula.

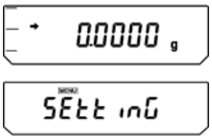
$$V = \frac{M}{\rho}$$

V = volume of glass sinker
M = difference „weight in air – weight in water“
ρ = density of water considering the temperature, see table 1.

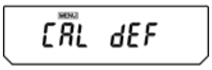
Tab. 1: Density table of water

Temperature [°C]	Density ρ [g/cm^3]	Temperature [°C]	Density ρ [g/cm^3]	Temperature [°C]	Density ρ [g/cm^3]
10	0.9997	19	0.9984	28	0.9963
11	0.9996	20	0.9982	29	0.9960
12	0.9995	21	0.9980	30	0.9957
13	0.9994	22	0.9978	31	0.9954
14	0.9993	23	0.9976	32	0.9951
15	0.9991	24	0.9973	33	0.9947
16	0.9990	25	0.9971	34	0.9944
17	0.9988	26	0.9968	35	0.9941
18	0.9986	27	0.9965		

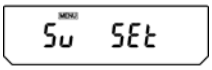
5.3 Enter volume of the glass sinker



⇨ In the gram display press the **CAL/MENU** button repeatedly until „SettinG“ appears.



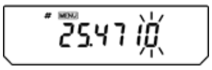
⇨ Press the **TARE/** button.



⇨ Press the **CAL/MENU** button repeatedly until „Sv SEt“ appears

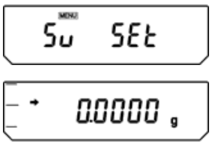
(Example)

⇨ Press the **TARE/** button, the currently set volume is displayed. In the upper part of the display panel, the MENU symbol and the # symbol appear in order to indicate numerical input status. The first digit is flashing and can be changed.



(Example)

⇨ Use the **UNIT/** button to increase the numerical value of the flashing digit.
Use the **PRINT/** button to shift the digit selection to the right, the active digit is flashing
Confirm input by the **TARE/** button.



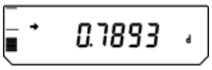
⇨ Repeatedly press the **ON/OFF** key until the balance is in weighing mode.

English

5.4 Measurement „Density liquid“

1. Suspend the glass sinker.
   If no glass sinker is suspended, may be „oL“ will be displayed, however in this step it is no error message and can be ignored.
2. Repeatedly press the **UNIT/** button until the balance is in density determination mode for liquids "**d**". If the weight is measured in air, additionally a „g“ will be displayed.

3. Press the **TARE/** button.
4. When standstill control is complete, press the **CAL/MENU** button
5. Remove the glass sinker.
6. Put the container with the sample liquid on the platform.



7. Suspend again the glass sinker and immerse it into the liquid completely and without bubbles.
8. When standstill control is complete, the density of the sample liquid will be shown in the display.
   Remove glass sinker and container.
   If no glass sinker is suspended, may be „oL“ will be displayed, however in this step it is no error message and can be ignored.

For further measurements

- ⇨ Clean and dry container and sinker carefully
- ⇨ Suspend again the glass sinker
- ⇨ Press the **CAL/MENU** button
- ⇨ Start with step 3

6 Preconditions for Precise Measurements

There are numerous error possibilities during density determination.
Accurate knowledge and caution are required to achieve precise results when applying this density set in combination with the balance.

6.1 Calculation of Results

The balance displays results for density determination by giving four decimal places. However, this does not mean that the results are accurate down to the last decimal place as this would be the case for a calculated value. Therefore all weighing results used for calculations have to be examined closely.

Example for density determination of solids:
To ensure high-grade results, numerators as well as common denominators of the formula below must show the desired accuracy. If either of them is instable or flawed, the result, too, will be instable or flawed.

$$\rho = \frac{A}{A-B} \rho_o$$

ρ = density of sample
A = weight of the sample in air
B = weight of sample in measuring fluid
ρ_o = density of measuring fluid

The use of a heavy sample contributes to the accuracy of a result. This increases the numerical value. The use of a light-weight sample, too, contributes to the accuracy of a result because this increases buoyancy (A-B). As a consequence, the result of the common denominator increases. Bear also in mind that the accuracy of the density of the measuring fluid ρ_o enters into the common denominator and, thus, has considerable influence on the accuracy of the result.
The result for the density of the sample cannot be more accurate than the least accurate of the aforementioned individual entities.

English

6.2 Influence Factors for Measurement Errors

6.2.1 Air bubbles

A small bubble of, for example, 1mm^3 will have a considerable influence on the measurement if the sample is small. Buoyancy will be increased by approximately 1mg resulting immediately in an error of 2 digits. Hence, it has to be ensured that no air bubbles cling to the solid immersed in the fluid. The same applies to the glass sinker that is immersed in the test fluid.
Take great care when removing air bubbles by swirling, to prevent the fluid from spurting out and splashing onto the sifting bowl or from water splashing. Moisture on the suspension bracket of the sifting bowl results in increased weight.
Do not touch the solid sample or glass sinker with bare fingers. An oily surface causes air bubbles when immersing the specimen in fluids.
Do not place solid samples (in particular flat objects) in the sifting bowls outside the liquid as this would result in air bubbles when immersed together. For this reason examine the bottom of the sifting bowl for air bubbles after the specimen had been immersed in fluid.

English

6.2.2 Solid body sample

A sample possessing too great a volume that is immersed in fluid will result in an increase in fluid level inside the glass pitcher. As a result, part of the suspension bracket of the sifting bowl will also be immersed causing buoyancy to increase. As a consequence the weight of the specimen in the fluid will drop.
Samples that change the volume or assimilate fluid are unsuitable for measurement.

6.2.3 Liquids

Water temperature is another factor to be taken into consideration. The density of water changes by c. 0.01% per degree Celsius. A temperature measurement showing an error of 1 degree Celsius results in an inaccurate fourth decimal place.

6.2.4 Surface

The suspension bracket of the sifting bowl penetrates the surface of the fluid. This state undergoes continuous change. If the sample or the glass sinker is relatively small, the surface tension will impair repeatability. The addition of a small amount of detergent makes the surface tension negligible and increases repeatability.

6.2.5 Glass Sinker for Measuring Fluids

To save test fluids used for density determination of fluids, use a small glass beaker and an accordingly sized glass sinker. However, it needs to be pointed that a large glass sinker achieves higher accuracy.
It is desirable that the buoyancy and the volume of the glass sinker are determined as accurately as possible. For the determination of fluid density these results are applied to the common denominator as well as the numerator of the formula.

6.3 General information

6.3.1 Density / Relative Density

Relative density follows from the weight of a sample divided by the weight of water (at 4° Celsius) of the same volume. For this reason relative density does not have a unit. Density equals mass divided by volume.
The application of the relative density instead of the density of a fluid in a formula produces an incorrect result. In the case of fluids only their density is physically meaningful.

6.3.2 Drift of Balance Display

The drifting of a balance does not influence the final result of the density determination although the shown weight of weighing in air is affected. Accurate values are merely required if the density of fluids is determined by means of a glass sinker.
When changing the ambient temperature or location, an adjustment of the balance is necessary. For this purpose remove the density set and carry out adjustment using the standard weighing tray (see operating instructions supplied with the balance.
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English

7 Density Table for Fluids

Temperatur e [°C]	Density ρ [g/cm³]		
	Water	Ethyl alcohol	Methyl alcohol
10	0.9997	0.7978	0.8009
11	0.9996	0.7969	0.8000
12	0.9995	0.7961	0.7991
13	0.9994	0.7953	0.7982
14	0.9993	0.7944	0.7972
15	0.9991	0.7935	0.7963
16	0.9990	0.7927	0.7954
17	0.9988	0.7918	0.7945
18	0.9986	0.7909	0.7935
19	0.9984	0.7901	0.7926
20	0.9982	0.7893	0.7917
21	0.9980	0.7884	0.7907
22	0.9978	0.7876	0.7898
23	0.9976	0.7867	0.7880
24	0.9973	0.7859	0.7870
25	0.9971	0.7851	0.7870
26	0.9968	0.7842	0.7861
27	0.9965	0.7833	0.7852
28	0.9963	0.7824	0.7842
29	0.9960	0.7816	0.7833
30	0.9957	0.7808	0.7824
31	0.9954	0.7800	0.7814
32	0.9951	0.7791	0.7805
33	0.9947	0.7783	0.7896
34	0.9944	0.7774	0.7886
35	0.9941	0.7766	0.7877

English

8 Uncertainty of Measurement for Density Determination of Solids

This table shows the approximate readability of the balance in connection with the density set. Observe that these values have only been determined by calculation and that influent parameters such as described in chapter 6 have not been taken into consideration.

Approximate display at density measurements (when using a balance with a readability of 0.1 mg)						
Weight of sample (g) / Density of sample [g/cm^3]	1	5	10	100	200	300
1	0.001	0.0001	0.0001	0.0001	0.0001	0.0001
3	0.002	0.0004	0.0003	0.0001	0.0001	0.0001
5	0.003	0.001	0.0004	0.0002	0.0002	0.0002
8	0.004	0.001	0.0006	0.0003	0.0003	0.0003
10	0.005	0.001	0.0008	0.0004	0.0003	0.0003
12	0.006	0.002	0.001	0.0004	0.0004	0.0004
20	0.01	0.003	0.001	0.001	0.001	0.001

Reading example for table:
In a balance with a resolution of 0.0001 g and a sample with a weight of 5 g, whose density is 3 g/cm^3, the display graduation is at 0.004 g/cm^3.

9 User Instructions

- To form a reproducible mean value several density measurements are necessary
- Remove fat from solvent-resistant sample /glass sinker /beaker.
- Regularly clean sample dishes/glass sinker/beaker, do not touch immersed part with your hands
- Dry sample/glass sinker/pincers after each measurement.
- Adjust sample size to sample dish (ideal sample size > 5 g).
- Only use distilled water.
- When immersing for the first time, lightly shake sample dishes and sinker, in order to dissolve air bubbles.
- Always ensure that, when re-immersing into the liquid no additional bubbles adhere; it is better to use pincers to place the sample.
- Remove firmly adherent air bubbles with a fine brush or a similar tool.
- To avoid adherent air bubbles smoothen samples with rough surface.
- Take care that no water drips onto the upper sample dish when weighing with the help of tweezers.
- In order to reduce the surface tension of water and the friction of the liquid on the wire, add three drops of a common detergent (washing-up liquid) to the measuring liquid (density modification of dest. water occurring due to the addition of tensides can be ignored).
- Oval samples can be held more easily with pincers when you cut grooves into them.
- The density of porous solids may only be determined approximately. Buoyancy errors occur when not all the air is eliminated from the pores during immersion in the measuring fluid.
- To avoid great vibrations of the balance, place sample carefully.
- Avoid static charge, e. g. dry glass sinker with cotton cloth only.
- If the density of your solid only deviates slightly from that of distilled water, ethanol may be used as measuring fluid. However, check beforehand whether the sample is solvent-proof. In addition you must observe the applicable safety regulations when working with ethanol.
- Handle glass sinker with care
(no warranty claims in case of damage).