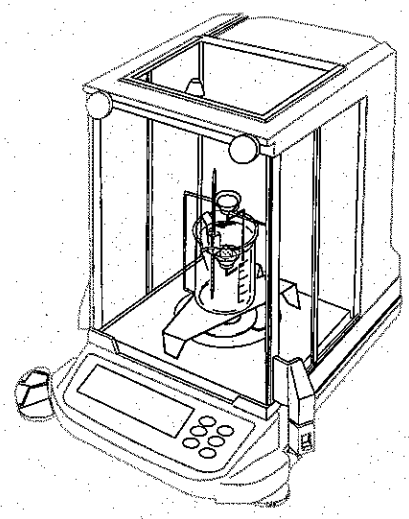
AD-1653

SPECIFIC GRAVITY MEASURING KIT

INSTRUCTION MANUAL

SPECIFIC GRAVITY MEASURING KIT



A&D Company, Limited

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Welcome!

Thank You for Your A&D Purchase!

This is the Instruction Manual for the AD1653 Specific Gravity Measuring Kit.

The AD1653, when combined with our electronic balance (FR Series, HA Series, HX-100, FX-300 or FA-200, HR Series, GR Series, HF-200, HF-300, HF-400, HM Series), allows the density of a solid and liquid to be measured easily.

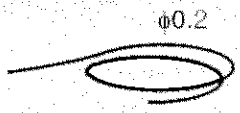
Before using the AD1653, please read this manual thoroughly.

Best Conditions for Measuring

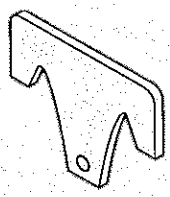
- This specific gravity measuring kit allows the density or specific gravity of a solid or liquid to be measured. However, the results of measurements may be affected by various factors that could cause errors, thus can not be guaranteed.
- Do not use the specific gravity measuring kit for measuring the density or specific gravity of chemically active substances.
- After using the specific gravity measuring kit, clean all surfaces to remove rust and oxides.
- A balance is a precision instrument, so avoid shocks or excessive loads.
- Maintain the air, sample and water at a constant temperature during the measurement.

1. The Kit Includes

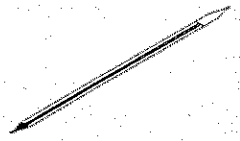
Float
00: B44342A



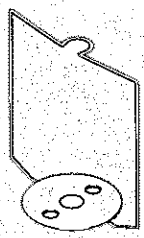
Wire
00: B49799



Float hook
04: C42200

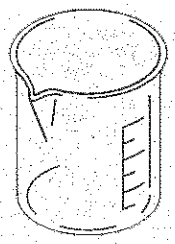


Thermometer
00: B44813A

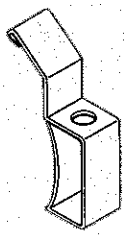


Density pan stand
09: B31161A

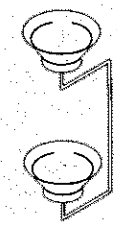
Beaker stand
04: B31158



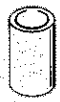
Beaker
10: PYLEX-300ML



Thermometer clamp
10: 1-608-02

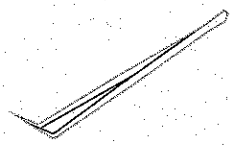


Density pan
PM: 1653-1

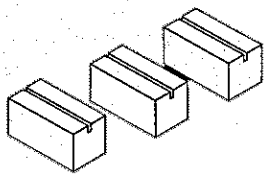


Attachment for FX
05: C42219

Attachment for HX
05: C42220

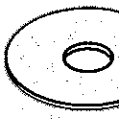


Tweezers
10: SHIKAYO

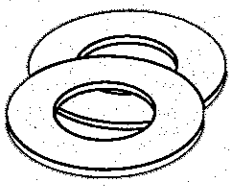


Beaker stand spacer
05: C42223
Three pieces

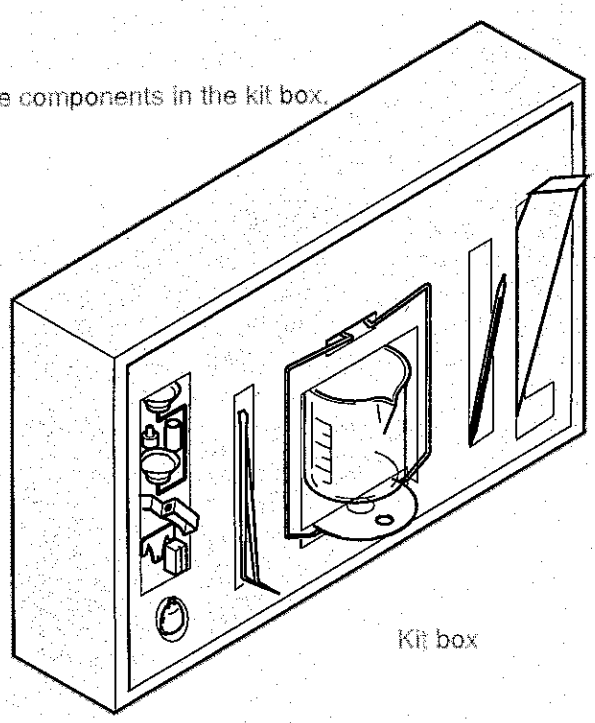
After use, store the components in the kit box.



Balance weight
small(A)
04: B48920



Balance weight
large(B)
04: C43701
Two pieces



Kit box

2. Principle of Density Measurement

Density

Density refers to the total amount of mass of a sample per unit volume.

$$\rho = \frac{M}{V} \text{ (Unit: g/cm}^3\text{, etc.)}$$

ρ : Density
M : Mass
V : Volume

Specific Gravity

Specific gravity refers to the ratio of the density of a sample to the density of pure water (with the same volume as that of the sample) at 4°C at 0.1013250 MPa.

$$S = \frac{M}{V \bullet \rho_4} \text{ (No unit)}$$

S : Specific gravity
M : Mass
V : Volume
ρ_4 : Density of water at 4°C (0.99997 g/cm^3 ≒ 1.000 g/cm^3)

Archimedes' Principle of Density Measurement

Archimedes' Principle

A body immersed in a fluid undergoes an apparent loss in weight equal to the weight of the fluid it displaces.

The AD1653 is combined with an electronic balance to measure the density of a sample, based on the Archimedes' principle.

Density of a Solid

The density of a solid can be obtained according to the weight of the sample in air, weight in liquid and the density of the liquid.

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

ρ : Density of sample
A : Weight in air
B : Weight in liquid
ρ_0 : Density of liquid
d : Density of air (approx. 0.001 g/cm^3)

Density of a Liquid

The density of a liquid can be obtained according to the weight in air, weight in liquid, and volume of a float.

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

ρ : Density of liquid
A : Weight of float in air
B : Weight of float in liquid
V : Volume of float
d : Density of air (approx. 0.001 g/cm^3)

3. Error Factors

There are several things that can effect the accuracy of a density measurement.

Buoyancy of Air

When the density of a liquid is measured, an upward force, 0.0010 to 0.0014 g/cm^3, is exerted in proportion to the volume of the liquid.

The buoyancy in air per 1 cm^3 is found by:

$$d\ (g/cm^3) = \frac{0.0012932}{1 + 0.0036728 \times t\ (°C)} \times \frac{\rho\ (hPa)}{1013.25}$$

t : Air temperature (°C)

P : Air pressure (hPa)

When obtaining measurement results down to the third decimal place, 0.001 g/cm^3 is added to the measured value to compensate for the air density error.

Temperature of Liquid

When the density of a solid is measured, the density of the liquid changes with its temperature. Therefore, the digit at the second decimal place of the measured density value involves an error.

Obtain the density of a liquid by comparing its temperature with the values in Table 1 for distilled water or given in other reference documents for other liquids.

If you want to obtain the measured value of the density of a solid down to the third decimal place, use a thermometer with a tolerance of ±0.2°C.

Volume of Float

- The tolerance of the measured value of the volume of the float is ±0.01 cm^3. When the density is measured, the digit at the second decimal place of the measured density value involves an error.

- If you want to obtain the measured value of density down to the third decimal place, measure the volume of the float using distilled water.

$$V = \frac{A - B}{\rho - d} - 0.0035 \ (cm^3)$$

A : Weight of float in air (g)

B : Weight of float in water (g)

V : Volume of float (cm^3)

ρ : Density of distilled water at t°C (g/cm^3)

d : Buoyancy of air at t°C (g/cm^3)

0.0035 : Correction value for the wire of the density pan

Influence of Wire

- If the surface of the liquid rises 1 mm along the wire of the density pan (1 mm in diameter) when a sample is immersed in a liquid to measure the density of a solid, the buoyancy applied is about 0.8 mg. To minimize the rise in the liquid surface, select a sample with a volume that will not raise the liquid surface so high.

- When the wire (0.2 mm in diameter) to suspend the float is immersed in the liquid to measure the density of the liquid, a buoyancy of about 0.3 mg is exerted. However, this buoyancy can be ignored because it is divided by the volume of the float when the density of the liquid is obtained.

Surface Tension

- When the density of a solid is measured, a force of about 5 mg (surface tension) is applied to the pan between the wire (1 mm in diameter) of the pan and the surface of the liquid.

- The surface tension can be reduced to about 1 mg by adding a surface-active agent (for example, a water droplet preventive solution as used for developing photographs).

  Adding 0.1 ml (1.2 g/ cm^3 density) of a surface-active agent to 200 ml of water will increase the density of the water by about 0.1%.

- When the density of a liquid is measured, a force of about 1mg is exerted by the wire of 0.2 mm in diameter. However, this force can be ignored because it is divided by the volume of the float.

Bubbles

- The buoyancy of a bubble of 1 mm in diameter is about 0.5 mg. Stickiness of bubbles depends on the shape and material of a sample. Make measurements considering the characteristic of bubbles.

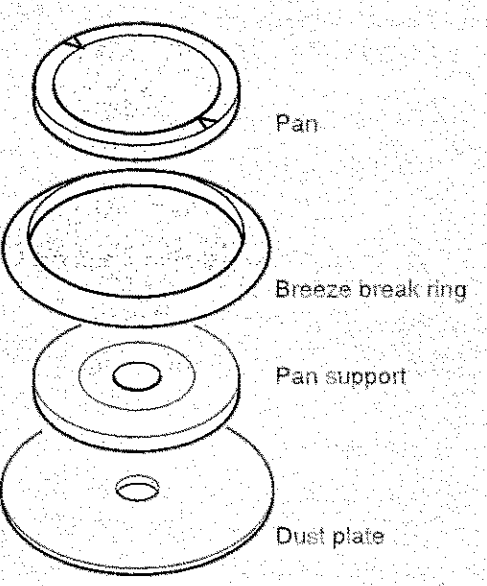
- When the density of a solid is measured, a surface-active agent may be added to reduce of the influence of bubbles.

4. Measuring the Density of a Solid

▶ Assemble the kit as described in the procedure below. Note that the assembly procedure depends on the model of the balance combined with the AD1653.

Assembling the Kit (FR Series)

1. Remove the pan, pan support, breeze break ring, and dust plate from the balance.



FR

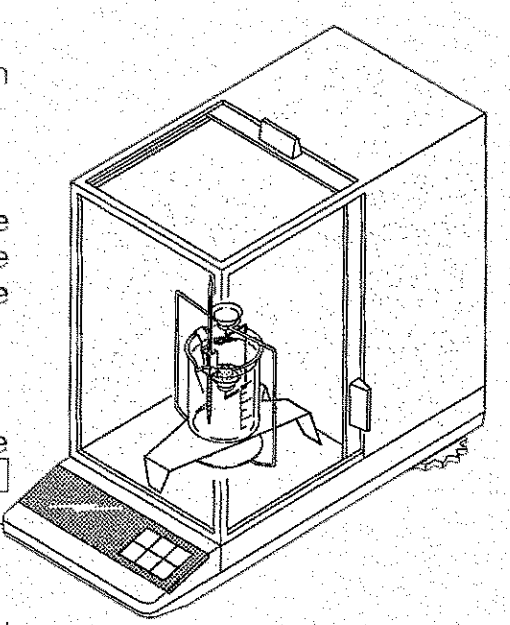
2. Set the density pan stand on the balance.

3. Set the beaker stand so that it does not touch the density pan stand.

4. Attach the thermometer clamp to the beaker and insert the thermometer in the thermometer clamp holes.

5. Pour a liquid (distilled water, etc.)—whose specific gravity is known—into the beaker and place the beaker on the beaker stand.

6. Place the density pan on the density pan stand.



7. Adjust the amount of the liquid so that the sample is about 10 mm below the surface of the liquid with the sample placed on the lower pan (in the liquid).

8. When the value displayed on the balance becomes stable, press the RE-ZERO key to reset the displayed value to zero.

Preparations for measurement are now complete. Please continue with the measurements in section 5 or 6.

Assembling the Kit (HA Series)

▶ Position the doors of the HA for convenient use.

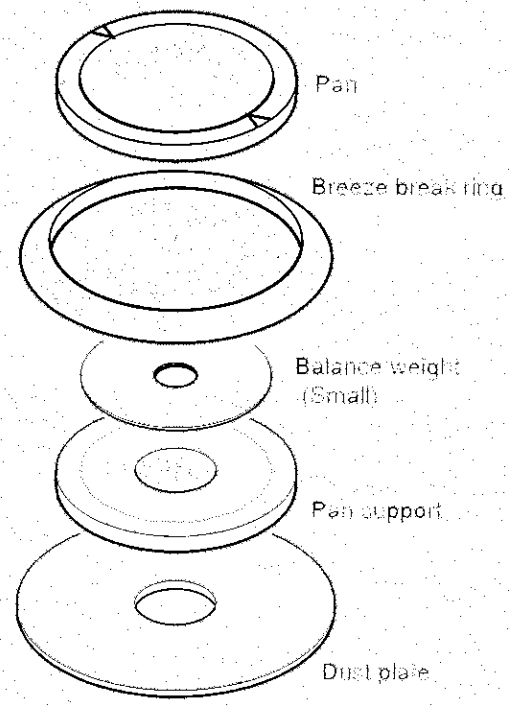
1. Remove the pan, balance weight, pan support, breeze break ring, and dust plate from the balance.

2. Set the density pan stand on the balance.

3. When you use HA-202M, place the small balance weight supplied with the kit on the density pan stand.

4. Set the beaker stand so that it does not touch the density pan stand.

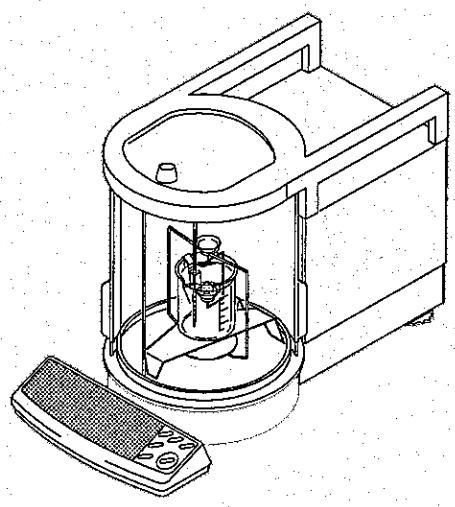
5. Attach the thermometer clamp to the beaker and insert the thermometer in the thermometer clamp holes.



HA

6. Pour a liquid (distilled water, etc.) — whose specific gravity is known — into the beaker and place the beaker on the beaker stand.

7. Place the density pan on the density pan stand.



8. Adjust the amount of the liquid so that the sample is about 10 mm below the surface of the liquid with the sample placed on the lower pan (in the liquid).

9. When the value displayed on the balance becomes stable, press the RE-ZERO key to reset the displayed value to zero.

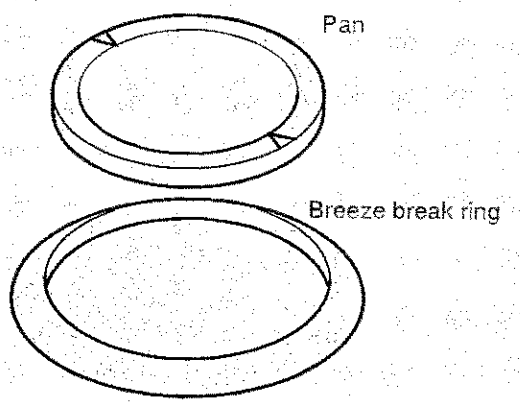
Preparations for measurement are now complete. Please continue with the measurements in section 5 or 6.

Assembling the Kit (HX-100)

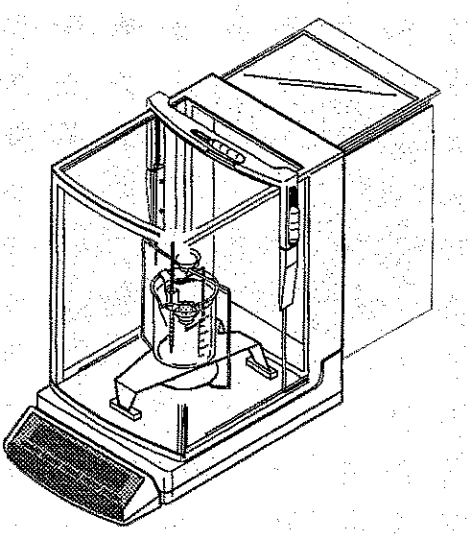
Use the HX-100 with its top glass opened.

1. Remove the pan and breeze break ring from the balance.
2. Attach an HX attachment to the pan boss of the balance.
3. Set the density pan stand on the balance.
4. Set the beaker stand so that it does not touch the density pan stand. Set the beaker stand spacers under the beaker stand legs so that the legs fit into the grooves of the spacers.
5. Attach the thermometer clamp to the beaker and insert the thermometer in the thermometer clamp holes.
6. Pour a liquid (distilled water, etc.) — whose specific gravity is known — into the beaker and place the beaker on the beaker stand.
7. Place the density pan on the density pan stand.
8. Adjust the amount of the liquid so that the sample is about 10 mm below the surface of the liquid with the sample placed on the lower pan (in the liquid).
9. When the value displayed on the balance becomes stable, press the RE-ZERO key to reset the displayed value to zero.

Preparations for measurement are now complete. Please continue with the measurements in section 5 or 6.



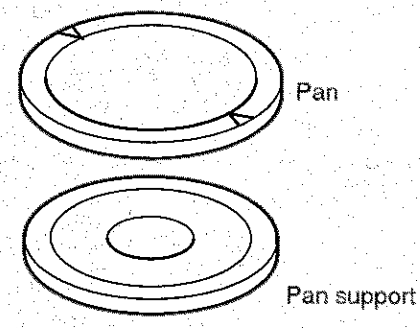
HX-100



Assembling the Kit (FX-300/FA-200)

Use the FX-300 or FA-200 with the optional top glass open, if it is attached.

1. Remove the pan and pan support from the balance.



FX-300
FA-200

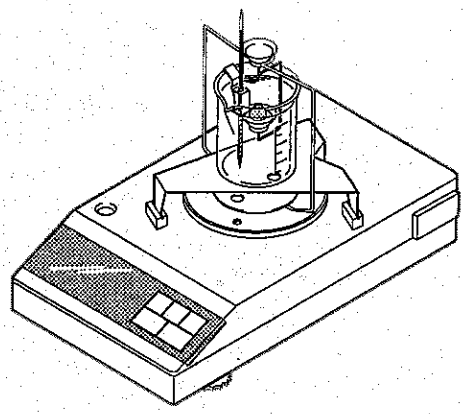
2. Attach an FX attachment to the pan boss.

3. Set the density pan stand on the balance.

4. Set the beaker stand so that it does not touch the density pan stand. Set the beaker stand spacers under the beaker stand legs so that the legs fit into the grooves of the spacers.

5. Attach the thermometer clamp to the beaker and insert the thermometer in the thermometer clamp holes.

6. Pour a liquid (distilled water, etc.) — whose specific gravity is known — into the beaker and place the beaker on the beaker stand.



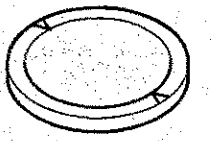
7. Place the density pan on the density pan stand.

8. Adjust the amount of the liquid so that the sample is about 10 mm below the surface of the liquid with the sample placed on the lower pan (in the liquid).

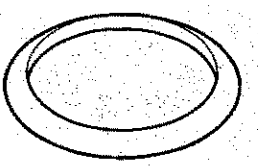
9. When the value displayed on the balance becomes stable, press the [RE-ZERO] key to reset the displayed value to zero.

Preparations for measurement are now complete. Please continue with the measurements in section 5 or 6.

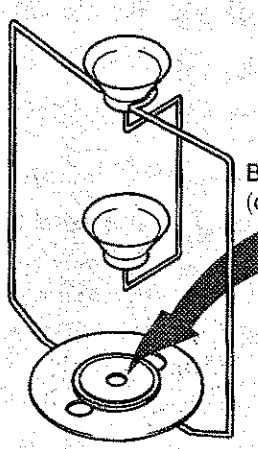
Assembling the Kit (HR - 60/120/200)



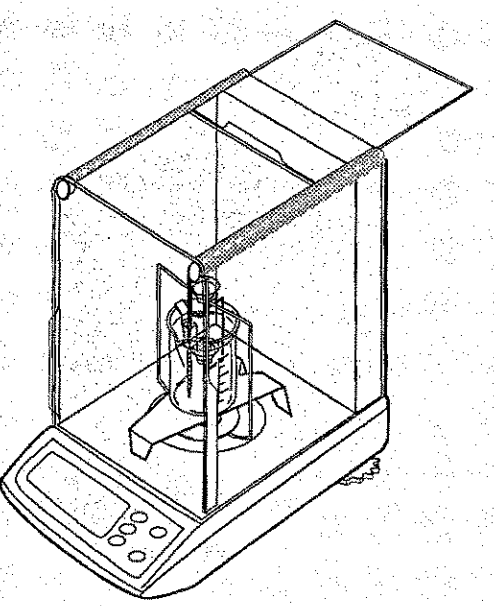
Pan



Breeze break ring



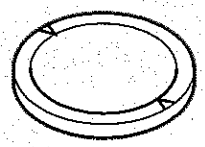
Balance weights
(one large, one small)



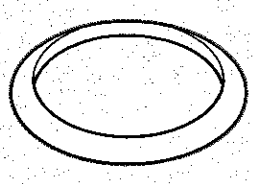
1. Remove the pan and breeze break ring from the balance.
2. Set the density pan stand on the balance. Place the balance weights (one large and one small) supplied with the kit on the density pan stand.
3. Set the beaker stand so that it does not touch the density pan stand
4. Attach the thermometer clamp to the beaker and insert the thermometer in the thermometer clamp holes.
5. Pour a liquid (distilled water, etc.)—whose specific gravity is known—into the beaker and place the beaker on the beaker stand.
6. Place the density pan on the density pan stand.
7. Adjust the amount of the liquid so that the sample is about 10 mm below the surface of the liquid with the sample placed on the lower pan (in the liquid).
8. When the value displayed on the balance is stable, press the [RE-ZERO] key to reset the displayed value to zero.
9. Please calibrate the balance when the balance displays [-E] or [-------] .

Preparations for measurement are now complete. Please continue with the measurements in section 5 or 6.

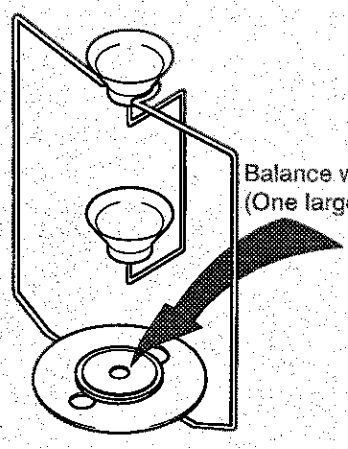
Assembling the Kit (GR Series)



Pan

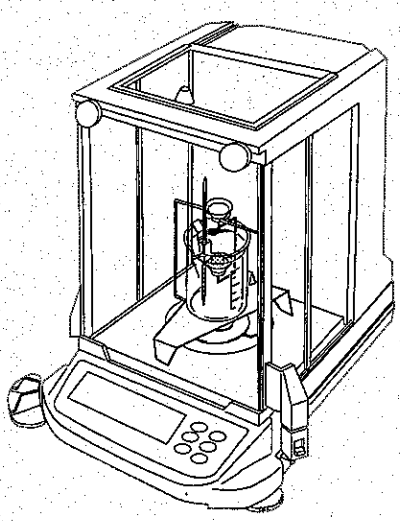


Breeze break ring



Balance weights
(One large , one small)

1. Remove the pan and breeze break ring from the balance.
2. Set the density pan stand on the balance. Place the balance weights (one large and one small) supplied with the kit on the density pan stand.
3. Set the beaker stand so that it does not touch the density pan stand.
4. Attach the thermometer clamp to the beaker and insert the thermometer in the thermometer clamp holes.
5. Pour a liquid (distilled water, etc.) — whose specific gravity is known — into the beaker and place the beaker on the beaker stand.
6. Place the density pan on the density pan stand.
7. Adjust the amount of the liquid so that the sample is about 10 mm below the surface of the liquid with the sample placed on the lower pan (in the liquid).

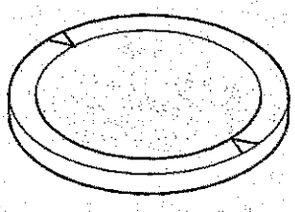


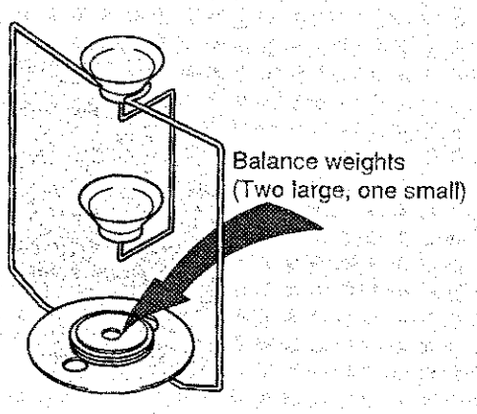
8. When the value displayed on the balance is stable, press the [RE-ZERO] key to reset the displayed value to zero.
9. Please calibrate the balance when the balance displays [-E] or [- - - - - - -].

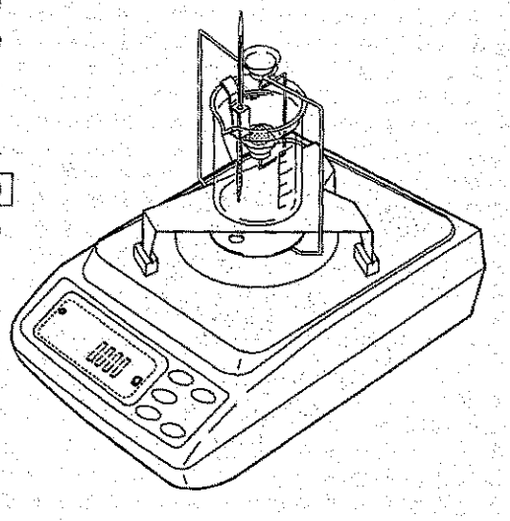
Preparations for measurement are now complete. Please continue with the measurements in section 5 or 6.

Assembling the Kit (HF-200/300/400)

1. Remove the pan from the balance.
2. Place the density pan stand on the balance.
3. Place the balance weights (two large and one small) supplied with the kit on the density pan stand as shown.
4. Set the beaker stand so that it does not touch the density pan stand. Set the beaker stand spacers under the beaker stand legs so that the legs fit into the grooves of the spacers.
5. Attach the thermometer clamp to the beaker and insert the thermometer in the thermometer clamp holes.
6. Pour a liquid (distilled water, etc.) — whose specific gravity is known — into the beaker and place the beaker on the beaker stand.
7. Place the density pan on the density pan stand.
8. Adjust the amount of the liquid so that the sample is about 10 mm below the surface of the liquid with the sample placed on the lower pan (in the liquid).
9. When the value displayed on the balance is stable, press the [RE-ZERO] key to reset the displayed value to zero.
10. Please calibrate the balance when the balance displays [-E] or [- - - - - - -].





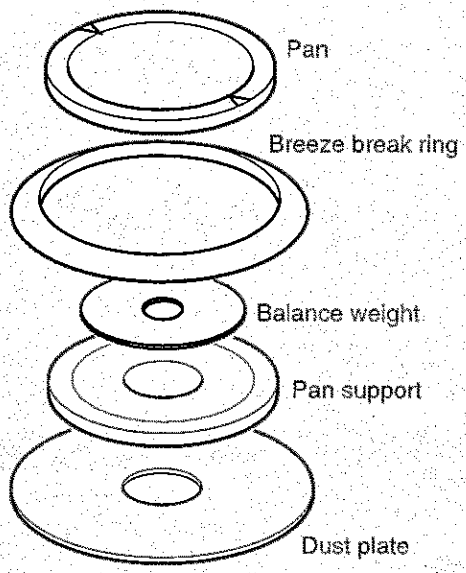


Preparations for measurement are now complete. Please continue with the measurements in section 5 or 6.

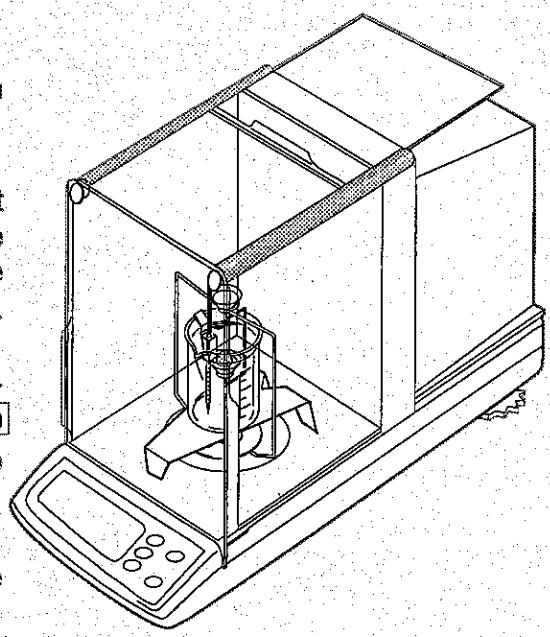
Assembling the Kit (HM Series/HR-202/HR-300)

1. Remove the pan, balance weight, pan support, breeze break ring and dust plate.
2. Place the density pan stand on the balance.
3. When you use HM-202 and HR-202, place the small balance weight supplied with the kit on the density pan stand.
4. Set the beaker stand so that it does not touch the density pan stand.
5. Attach the thermometer clamp to the beaker and insert the thermometer in the thermometer clamp holes.
6. Pour a liquid (distilled water, etc.) — whose specific gravity is known — into the beaker and place the beaker on the beaker stand.
7. Set the density pan on the density pan stand.
8. Adjust the amount of the liquid so that the sample is about 10 mm below the surface of the liquid with the sample placed on the lower pan (in the liquid).
9. When the value displayed on the balance is stable, press the RE-ZERO Key to reset the displayed value to zero.
10. Please calibrate the balance when the balance displays [-E] or [- - - - - - -].

Preparations for measurement are now complete. Please continue with the measurements in section 5 or 6.



HM Series



Zero Calibration

1. Turn off the display after connecting the AC adaptor, supplying electric power.
   Confirm that there is nothing on the weighing pan.

2. Press the [ON:OFF] key to turn on the balance.

   If the balance displays [E] or [- - - - - - -] , you must perform zero-point-calibration.

3. Press the [RE-ZERO] key.

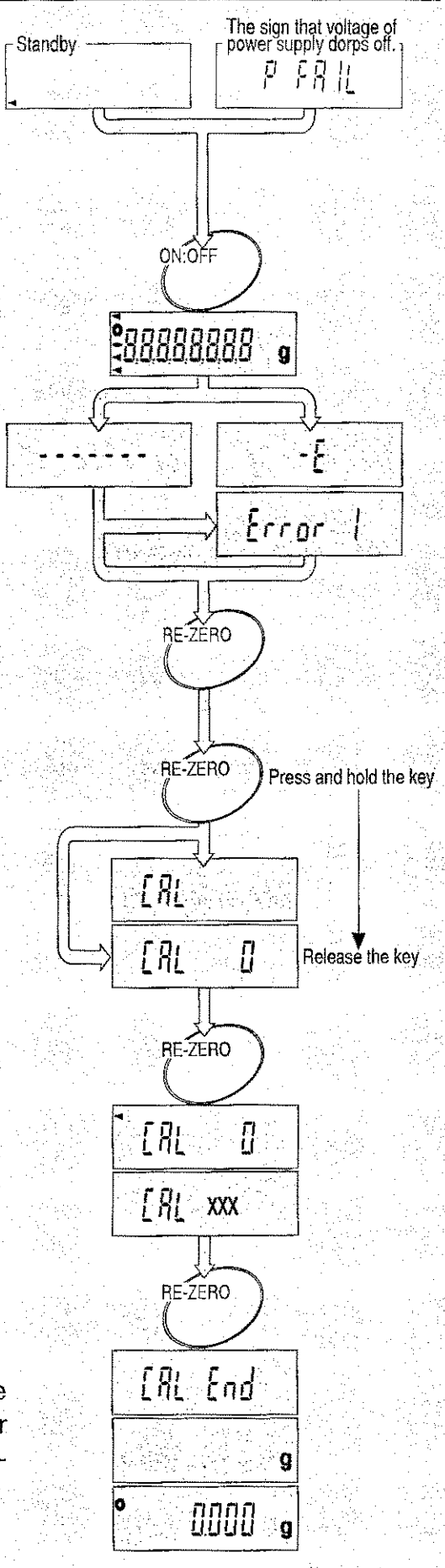
4. Press and hold the [RE-ZERO] key until the balance displays [CAL] . The balance enters calibration mode.

5. Press the [RE-ZERO] key. The balance measures zero point.

   Avoid environmental conditions that could cause errors during calibration.

6. Press the [RE-ZERO] key.
   The zero-point-calibration is finished, the balance returns normal weighing mode.

Please perform Zero-Calibration, if the balance displays [E] or [- - - - - - -] ,when you start the measurement.



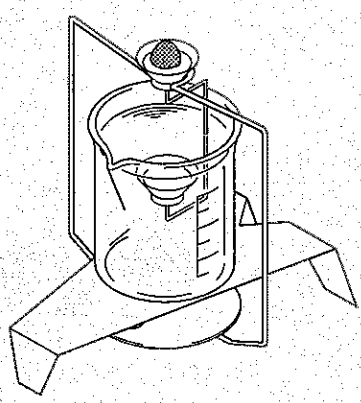
Measuring the Density of a Solid

▶ The density of a solid is obtained by averaging the measured values.

1. Start the measurement when water temperature becomes stable.

(Ex: Display of HA)

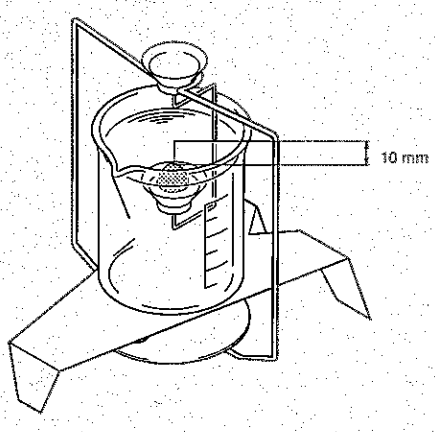
2. Press the RE-ZERO key to reset the displayed value to zero.



3. Place the sample on the upper pan and record its weight in air (A).

4. Press the RE-ZERO key to reset the displayed value to zero.

5. Place the sample on the lower pan and record its weight in water (B).



Adjust the amount of water so that the sample is about 10 mm below the surface of the water.

6. Obtain the density of the water according to the temperature of water. (See Table 1).

Example of Recording Sheet

Weight in air A [g]	Weight in liquid B [g]	Water temperature [°C]	$\frac{\text{(Weight in air A)}}{\lvert\text{Weight in liquid B}\rvert\ [g/cm^3]} \times$ (Density of water)
4.8102	0.5946	26	8.06 (Calculated value)
		Density of water [g/cm³]	
		0.99678	

Weight in air A [g]	Weight in liquid B [g]	Water temperature[°C]	Atmosphere (hpa)	$\frac{\text{Weight in air A [g]}}{\lvert\text{Weight in liquid B [g]}\rvert} \times \left(\text{Density of water} - \text{Density of air}\right) + \text{Density of air}$ [g/cm³]
4.8102	0.5946	26	1013	8.055 (Calculated value)
		Density of water [g/cm³]	Density of air [g/cm³]	
		0.99678	0.0012	

7 The density will be found by:

• Three significant digits

$$\rho = \frac{A}{|B|} \times \rho_0$$

• Four or more significant digits

$$\rho = \frac{A}{|B|} \times (\rho_0 - d) + d$$

Where

ρ : Density of sample [g/cm^3]

A : Weight in air [g]

B : Weight in liquid [g]

ρ_0 : Density of water [g/cm^3]

d : Density of air [g/cm3]

Table 1 Density of water

At sea level (1 atmosphere), the density of water reaches the maximum at 3.98°C. (Unit: g/cm^3).

Tempera-ture	0	1	2	3	4	5	6	7	8	9
0	0. 99984	0. 99990	0. 99994	0. 99996	0. 99997	0. 99996	0. 99994	0. 99990	0. 99985	0. 99978
10	99970	99961	99949	99938	99924	99910	99894	99877	99860	99841
20	99820	99799	99777	99754	99730	99704	99678	99651	99623	99594
30	99565	99534	99503	99470	99437	99403	99368	99333	99297	99259

5. Measuring the Density of a Liquid

▶ Assemble the kit as described in the procedure below.

Assembling the Kit

1. Follow the assembly procedure for the balance used up to the setting of the beaker stand.

2. Attach the thermometer clamp to the beaker and insert the thermometer in the thermometer clamp holes.

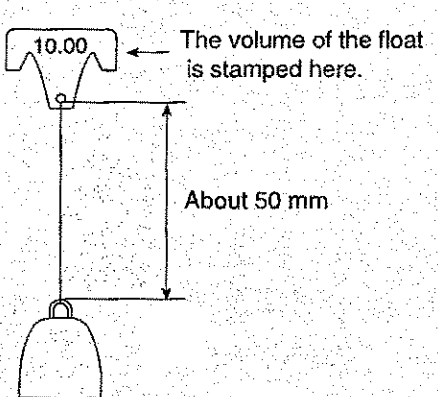
3. Place the beaker on the beaker stand.

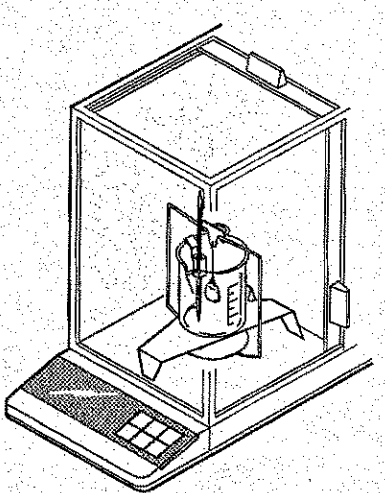
4. Connect the float to the float hook with a wire. The length of wire must be about 50 mm.

5. Hook the float hook on the density pan stand.

6. When the value displayed on the balance becomes stable, press the RE-ZERO key to reset the displayed value to zero.

Preparations for measurement are now complete.





Measuring the Density of a Liquid

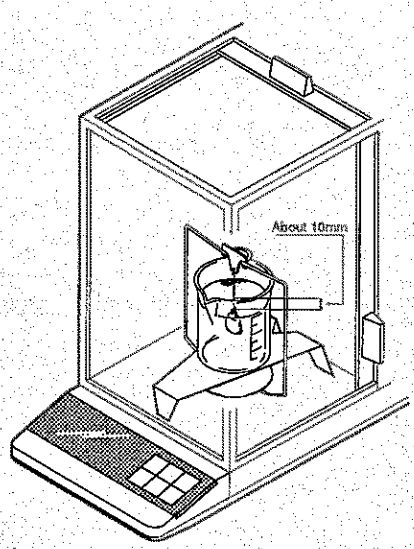
Measure the density of a liquid by the following procedure:

1. Press the RE-ZERO key with the float hanging.

0.0000 g

2. Pour the liquid whose density is to be measured.

   Adjust the amount of the liquid so that the float is about 10 mm below the surface of the liquid.



3. When the display becomes stable, note down the displayed value without its minus sign. (Suppose that this value is A.)

4. The density of the liquid can be found by substituting the measured value in the following equation:

$$\rho = \frac{A}{V} + d$$

ρ : Density of liquid [g/cm^3]
A : Buoyancy of float (g)
V : Volume of float (cm^3)
d : Density of air [g/cm^3]

Example: If the measured value (A) is 9.9704 g, the volume of the float (V) (stamped on the float hook) is 10.01 cm^3, the density of air (d) is 0.001 g/cm^3 and the temperature indicated by the thermometer is 25°C, then we have:

$$\frac{9.9704}{10.01} + 0.001 = 0.997 \text{ g/cm}^3 \text{ (25°C)}$$

6. Frequently Asked Questions

Q: I'd like to measure the density of a resin pellet or sheet, which floats in water. Is it possible?

A: Use a liquid that has a lower density than water and does not dissolve the sample, such as methanol (density 0.798) or kerosene (density 0.80). The density of the liquid used is measured using the float provided with the kit.

Q: Can a sample containing bubbles be measured?

A: The density of a sample with bubbles contained can be measured as it is. But as time passes, the bubbles disappear and the apparent density may change.
A sample, which floats on water due to the low density, can not be measured.

Q: The measurement repeatability may be affected by the water's surface tension. What can I do about this?

A: A few drops of a surface-active agent (for example, a mild detergent for washing dishes) added to the water reduces the influence of surface tension. A few drops of a surface-active agent will affect the liquid density only a very small amount.
When methanol is used in place of water, the influence of surface tension is small, even without a surface-active agent.

Q: When tap water is used, bubbles are gradually generated on the sample surface and a measurement error occurs. What can I do about this?

A: Tap water contains dissolved gases such as oxygen and carbon dioxide. When tap water is used, the released dissolved gases generate bubbles. It is recommended that pure water or distilled water, which contains few dissolved gases, be used.

Q: I try to measure a high water repellent material such as rubber but bubbles stick to the sample. What can I do about this?

A: Before measurement, soak the sample in the water with an appropriate amount of surface-active agent added. Doing this increases the sample surface hydrophilicity and bubbles may hardly stick to the sample surface.

Q: Up to what size of sample can be measured?

A: Considering the density pan size, the maximum size of the sample that can be measured is as follows:

Diameter	25 mm
Height	30 mm
Mass	100 g

Q: Can I measure the density of a liquid with a high viscosity?

A: A liquid with a viscosity up to 500 mPa(s can be measured. If the viscosity exceeds this value, the float takes excessive time to sink and a measurement error occurs.
Measuring adhesives is not recommended because the adhesive sample may be difficult to remove from the float.

Q: When a semi-micro balance is used, is accuracy improved?

A: Surface tension affects the measurement value in the range approximately between 0.2 mg and 1.0 mg. In a measurement using the 0.1 mg range, the magnitude of an error and the level of balance accuracy are almost the same.
In a measurement using the 0.01 mg range, the magnitude of an error greatly exceeds the level of balance accuracy. So, using a semi-micro balance is not recommended.