

# GX-13

Density Determination Kit

For GX-200/300/400/600/800/1000

GF-200/300/400/600/800/1000

INSTRUCTION MANUAL



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# Welcome!

Thank You for Your A&D Purchase!

This is the Instruction Manual for the Density Determination Kit.

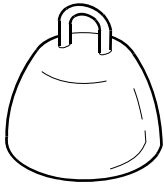
The Density Determination Kit, when combined with our electronic balance (GX-200, GX-300, GX-400, GX-600, GX-800, GX-1000, GF-200, GF-300, GF-400, GF-600, GF-800, GF-1000), allows the density of a solid or liquid to be measured easily.

Before using the Density Determination Kit, please read this manual thoroughly.

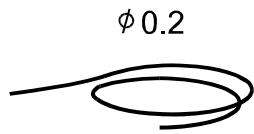
## Best Measurement Conditions

- This density determination 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 density determination kit for measuring the density of chemically active substances.
- After using the density determination kit, clean all surfaces to remove rust and oxides.
- A balance is a precision instrument, so avoid shocks or excessive loads.
- To improve measuring accuracy, allow the temperature of liquid (water) and sample (solid) to equalize to the ambient temperature and perform measurement in a stable environment.
- The breeze break provided with the balance can not be used with the density determination kit. To perform an accurate density measurement, use the glass breeze break available as an option (GX-10).

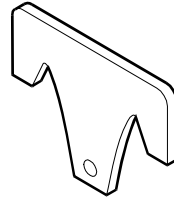
# 1. The Kit Includes



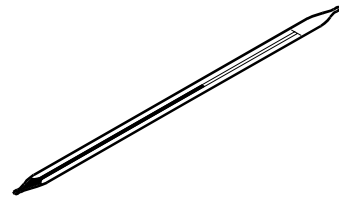
Float



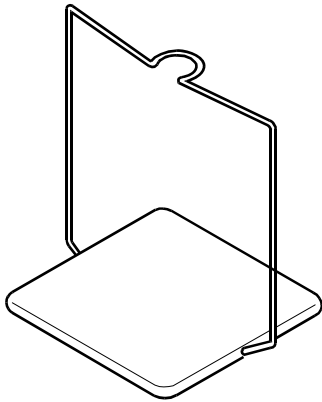
Wire



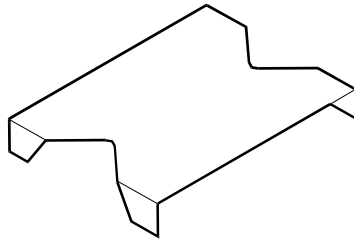
Float hook



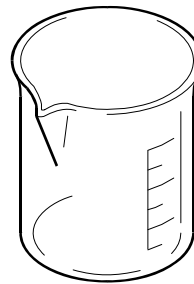
Thermometer



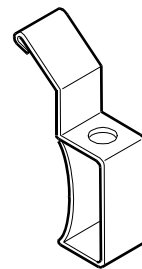
Density pan stand



Beaker stand



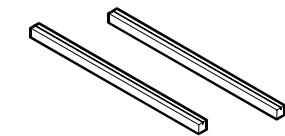
Beaker



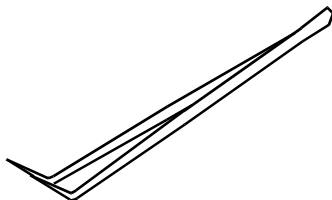
Thermometer clamp



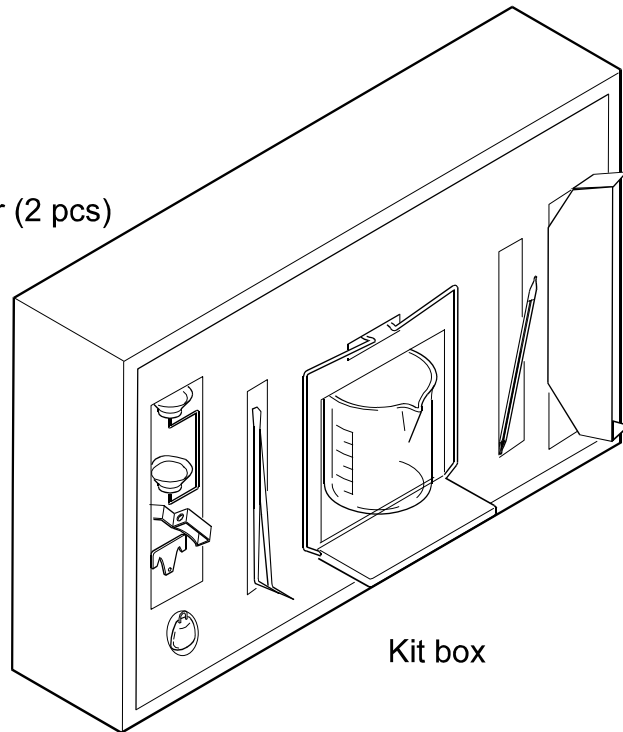
Density pan



Beaker stand spacer (2 pcs)



Tweezers



Kit box

## 2. Principle of Density Measurement

### Density

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

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

$\rho$  : 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 1013.25 hPa.

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

$S$  : Specific gravity

$M$  : Mass

$V$  : Volume

$\rho_4$  : Density of water at 4°C (0.99997 g/cm<sup>3</sup>  $\cong$  1.000 g/cm<sup>3</sup>)

### Archimedes' Principle of Density Measurement

#### Archimedes' Principle

A body immersed in a liquid is subject to an upward force equal to the weight of the liquid it displaces. The upward force is buoyancy.

The GX-13 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.

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

- $\rho$  : Density of sample
- A : Weight in air
- B : Weight in liquid
- $\rho_0$  : Density of liquid

## Density of a Liquid

A float with a known volume is used. The density of a liquid can be obtained according to the weight in air, weight in liquid, and volume of a float.

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

- $\rho$  : Density of liquid
- A : Weight of float in air
- B : Weight of float in liquid
- V : Volume of float
- d : Density of air (about 0.001 g/cm<sup>3</sup>)

## 3. Error Factors

- There are several things that can affect 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<sup>3</sup>, is exerted in proportion to the volume of the liquid.

- The buoyancy in air per 1 cm<sup>3</sup> is found by:

$$d \text{ ( g/cm}^3\text{)} = \frac{0.0012932}{1 + 0.0036728 \times t \text{ (}^\circ\text{C)}} \times \frac{P \text{ ( hPa)}}{1013.2}$$

t : Air temperature ( °C )  
P : Air pressure ( hPa )

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

### Temperature of a Liquid

- When the density of a solid is measured, the density of the liquid changes with its temperature.
- 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.

### Volume of Float

- The tolerance of the measured value of the volume of the float is ±0.01 cm<sup>3</sup>.



## Influence of Wire

- When a solid sample is placed on the density pan, which is immersed in a liquid, for a density measurement, the liquid surface position rises. At this time, the wire ( $\phi$  1 mm) connecting the upper and lower pans is subject to the buoyancy whose magnitude is equal to the weight of the raised liquid. 1-mm raise of the liquid surface exerts a buoyancy of about 0.8 mg to the wire. To minimize a measurement error caused by the buoyancy, adjust the sample size so that it will not raise the liquid surface so much, or perform a mathematical correction.
- When measuring the density of a liquid, the float-suspending wire ( $\phi$  2 mm) immersed in the liquid affects the measurement. Immersing the wire by 10 mm exerts a buoyancy of about 0.3 mg to the wire. 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 ( $1.2 \text{ g/cm}^3$  density) of a surface-active agent to 200 ml of water will increase the density of the water by about  $0.0001 \text{ g/cm}^3$ .
- 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

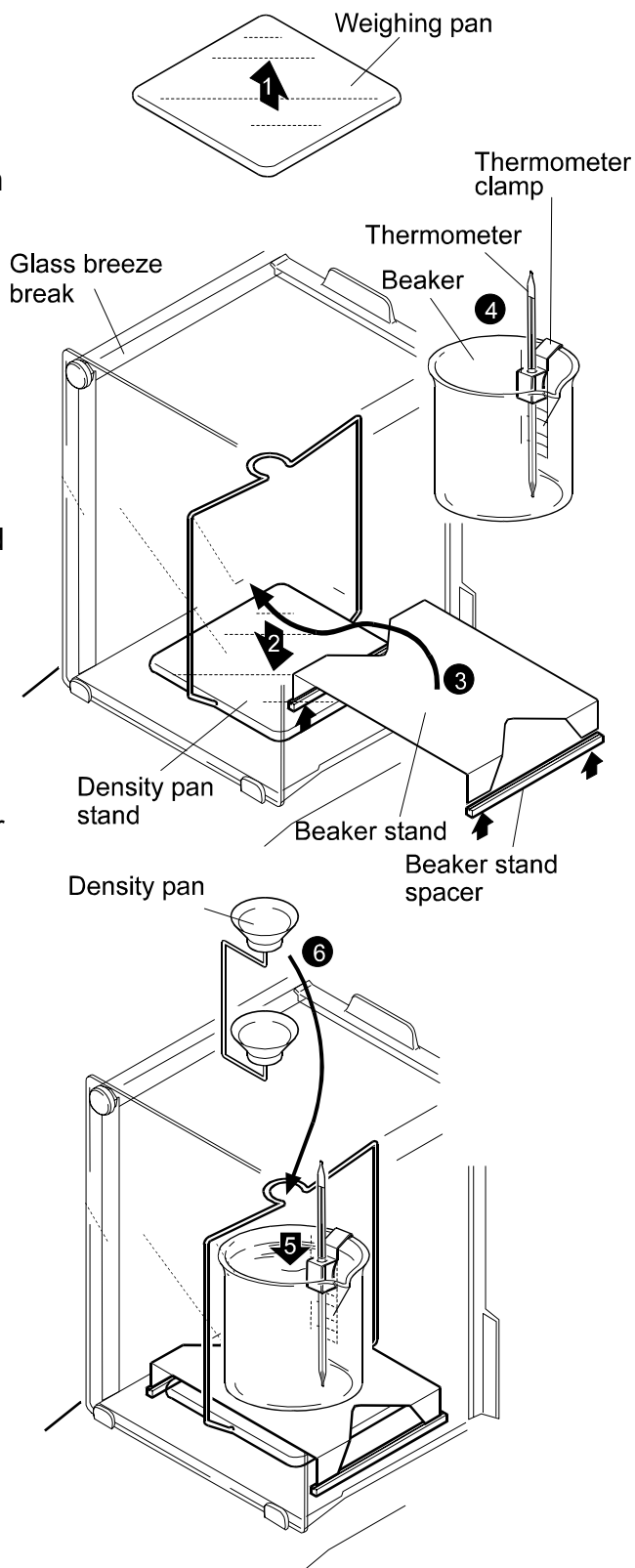
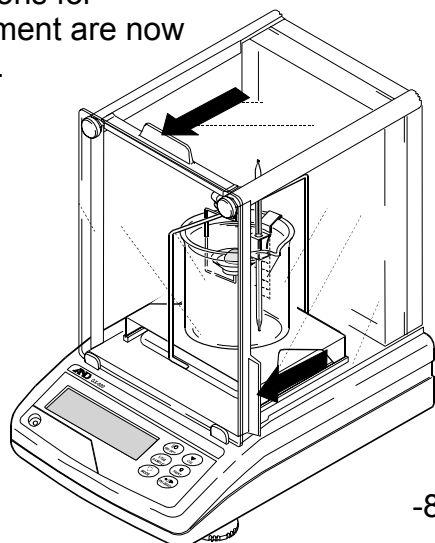
- The buoyancy of a bubble of 1 mm in diameter is about 0.5 mg. Stickiness of bubbles depends on the shape and material of a sample. Make measurements considering the characteristic of bubbles.
- When the density of a solid is measured, a surface-active agent may be added to reduce the influence of surface tension and bubbles.

## 4. Measuring the Density of a Solid

### Assembling the Kit (On the balance with a glass breeze break installed)

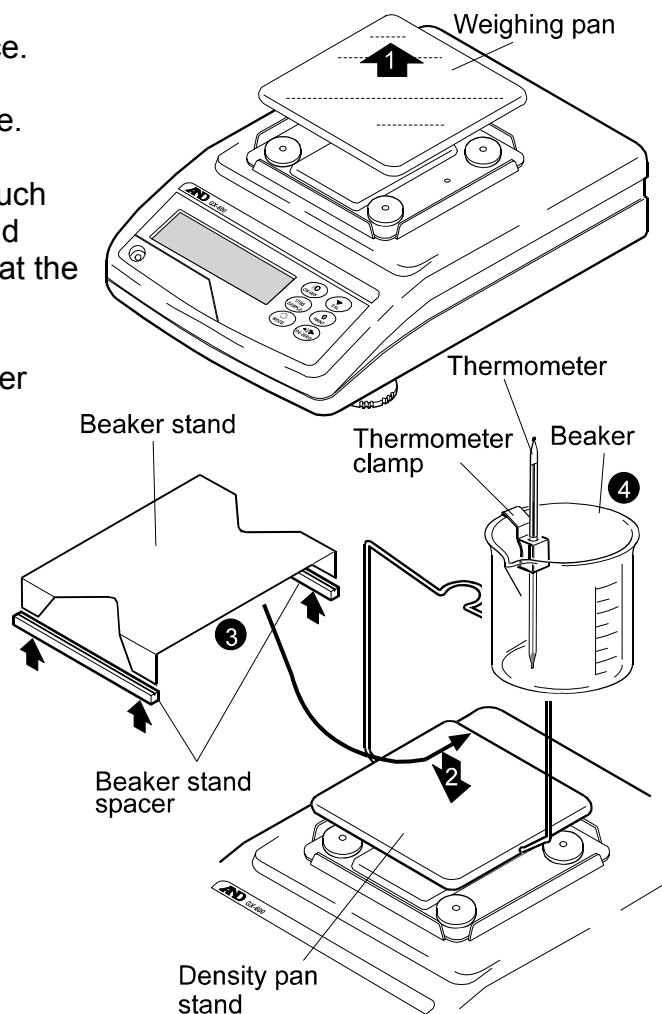
- (1) Remove the weighing pan from the balance.
- (2) Set the density pan stand on the balance.
- (3) Set the beaker stand so that it does not touch the density pan stand. Set the beaker stand spacers under the beaker stand legs so that the legs fit into the grooves of the spacers.
- (4) Attach the thermometer 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.

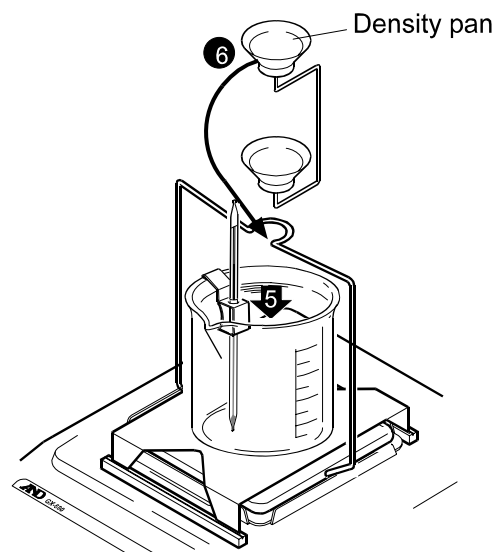
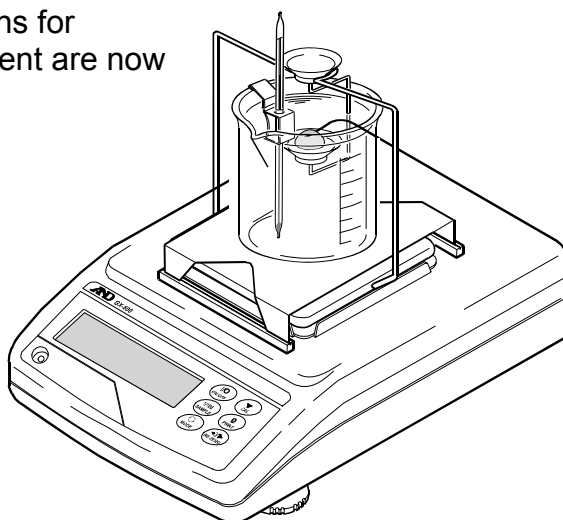


## Assembling the Kit (On the balance without a glass breeze break installed)

- (1) Remove the weighing pan from the balance.
- (2) Place the density pan stand on the balance.
- (3) 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.
- (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.



### Note

If the glass breeze break is not available and the display is hard to stabilize, set “Condition (Cond)” of “Environment/Display” (bASFnC) in the function table to a greater value.

## Measuring the Density of a Solid

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

(1) Start the measurement when the water temperature becomes stable.

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

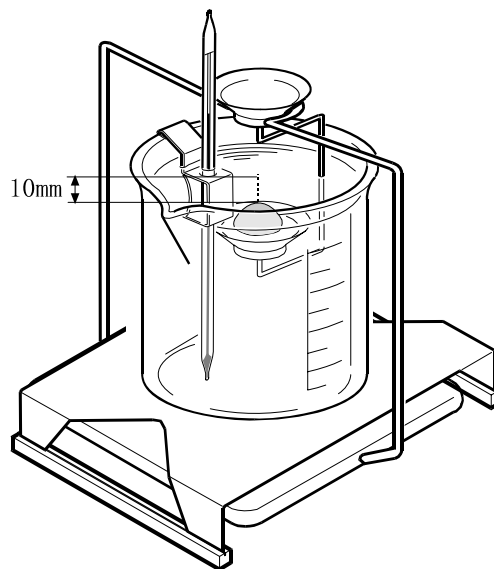
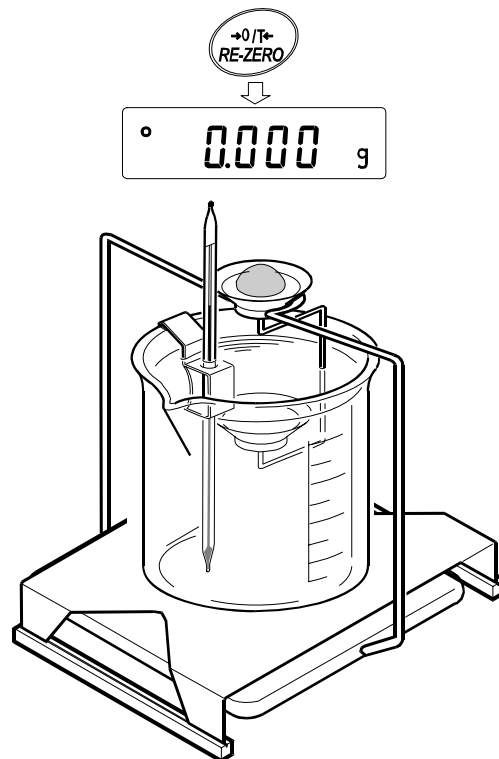
(3) Place the sample on the upper pan and record its weight in air (A).

(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).

**Note : 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).



Weight in air A (g)	Weight in liquid B (g)	Water temperature (°C)	$\frac{(\text{Weight in air A})}{ \text{Weight in liquid B} } \times (\text{Density of water})$ (g/cm <sup>3</sup> )
4.810	0.595	26	8.06 (Calculated value)
		Density of water (g/cm <sup>3</sup> )	
		0.99678	

(7) The density will be found by:

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

Where

$\rho$  : Density of sample (g/cm<sup>3</sup>)

A : Weight in air (g)

B : Weight in liquid (g)

$\rho_0$  : Density of water (g/cm<sup>3</sup>)

Table 1 Density of water

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

Temp. (°C)	+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	0.99970	0.99961	0.99949	0.99938	0.99924	0.99910	0.99894	0.99877	0.99860	0.99841
20	0.99820	0.99799	0.99777	0.99754	0.99730	0.99704	0.99678	0.99651	0.99623	0.99594
30	0.99565	0.99534	0.99503	0.99470	0.99437	0.99403	0.99368	0.99333	0.99297	0.99259
40	0.99222	0.99183	0.99144	0.99104	0.99063	0.99021	0.98979	0.98936	0.98893	0.98849
50	0.98804	0.98758	0.98712	0.98665	0.98618	0.98570	0.98521	0.98471	0.98422	0.98371
60	0.98320	0.98268	0.98216	0.98163	0.98110	0.98055	0.98001	0.97946	0.97890	0.97834
70	0.97777	0.97720	0.97662	0.97603	0.97544	0.97485	0.97425	0.97364	0.97303	0.97242
80	0.97180	0.97117	0.97054	0.96991	0.96927	0.96862	0.96797	0.96731	0.96665	0.96600
90	0.96532	0.96465	0.96397	0.96328	0.96259	0.96190	0.96120	0.96050	0.95979	0.95906

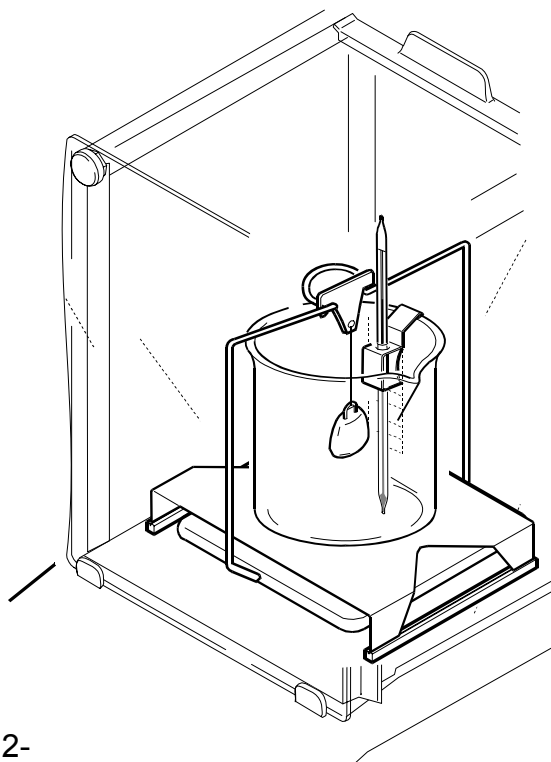
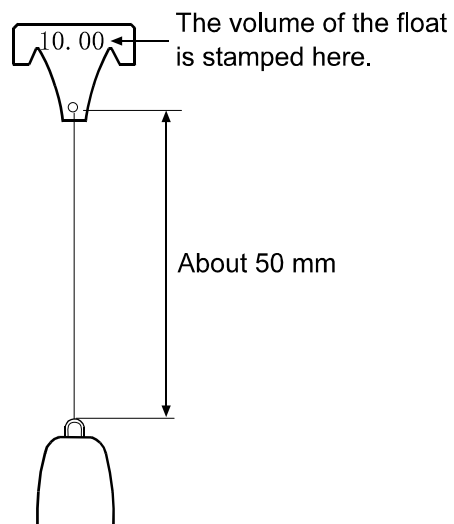
## 5. Measuring the Density of a Liquid

- Assemble the kit as described in the procedure below.

### Assembling the Kit

- (1) Follow the assembly procedure described in "4. Measuring the Density of a Solid", 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.

(2) Pour the liquid whose density is to be measured into the beaker.  
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, record the displayed value without its minus sign. (This value is A in the formula below.)

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

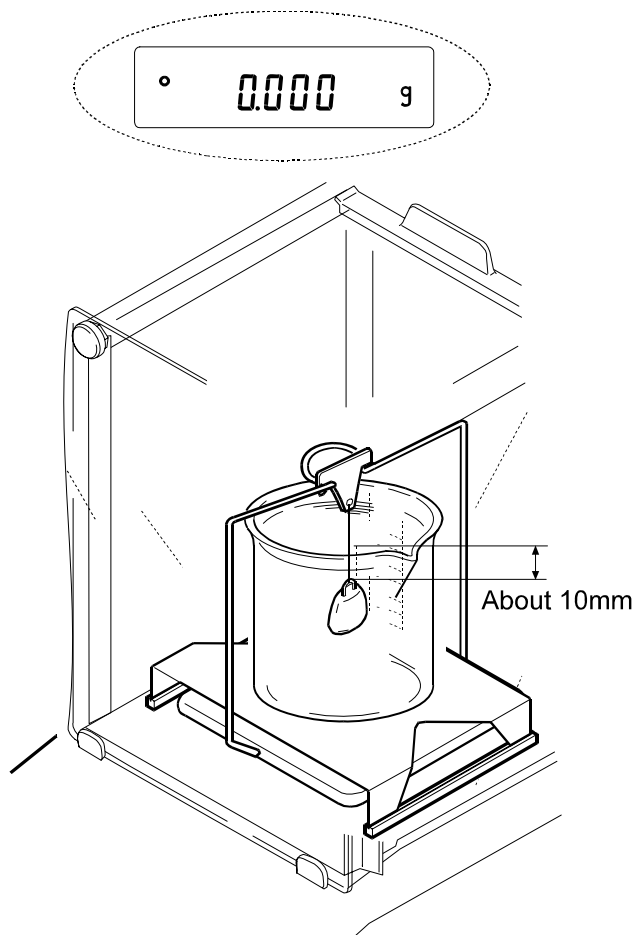
$$\rho = \frac{A}{V} + d$$

$\rho$  : Density of liquid (g/cm<sup>3</sup>)

A : Buoyancy of float (g)

V : Volume of float (cm<sup>3</sup>)

d : Density of air (g/cm<sup>3</sup>)



Example: If the measured value (A) is 9.970 g, the volume of the float (V) (stamped on the float hook) is 10.01 cm<sup>3</sup>, the density of air (d) is 0.001 g/cm<sup>3</sup> and the temperature indicated by the thermometer is 25°C, then we have:

$$\frac{9.970}{10.01} + 0.001 = 0.997 \text{ g/cm}^3 (25^\circ\text{C})$$

# 6. Measurement Using the Density Mode of the GX/GF Series Balance

The GX/GF series balance is equipped with a density mode. It calculates the density of a solid using the weight of a sample in air and the weight in liquid.

- The density mode was not selected for use when the balance was shipped from the factory. To use the mode, change the function table and activate the density mode.
- Two ways to set the density of a liquid are available:  
by entering the water temperature or by entering the density directly.

## Formula to obtain the density

The density can be obtained by the following formula.

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

Where

- $\rho$  : Density of sample
- A : Weight in air
- B : Weight in liquid
- $\rho_0$  : Density of liquid

## Changing the function table

### ● Selecting the density mode

The density mode is available as one of the weighing units. To use the mode, select it in the function table.

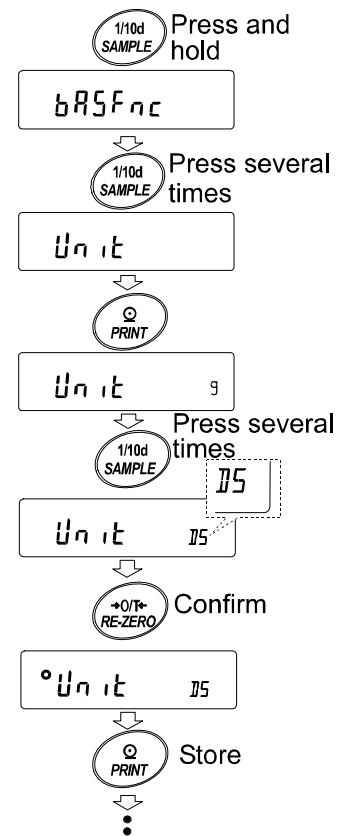
### Operation

- (1) Press and hold the **SAMPLE** key to display **bRSFnC**.
- (2) Press the **SAMPLE** key several times to display **Unit**.
- (3) Press the **PRINT** key.
- (4) Press the **SAMPLE** key several times to display **Unit 15**, press the **RE-ZERO** key to confirm. (displays **°Unit 15**)

To select weighting units (modes) other than the density mode, follow the same procedure described above:

Press the **SAMPLE** key to select a unit and press the **RE-ZERO** key to confirm.

- (5) Press the **PRINT** key to store. The balance displays **End** and then displays **id**.
- (6) Press the **CAL** key to enter the density mode.





## ● Selecting a way to set the density of a liquid

Select the liquid density input method from the function table below. The function table is available only when the density mode is selected.

### Operation

(1) Press and hold the **SAMPLE** key to display **bRSFnC**.

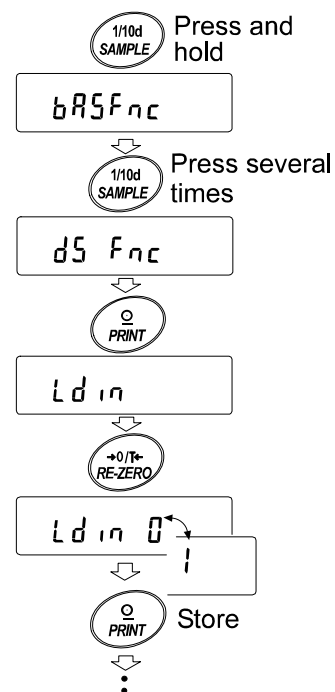
(2) Press the **SAMPLE** key several times to display **dS FnC**.

(3) Press the **PRINT** key to display **Ld in**.

(4) Press the **RE-ZERO** key to select **Ld in 0** or **Ld in 1**.

(5) Press the **PRINT** key to store. The balance displays **End** and then displays **Unit**.

(6) Press the **CAL** key to enter the density mode.



Class	Item	Parameter	Description
<i>dS FnC</i>	<i>Ld in</i>	0	Water temperature
Density function	Liquid density input	1	Liquid density

0 = Factory setting

**Note** : “*dS FnC*” appears after “*S iF*”.

### Setting the density of a liquid

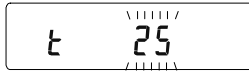
1. Press the **MODE** key as necessary to select the density mode. When the processing indicator blinks with the unit “g” displayed, it indicates that the density mode is selected.
2. In the density mode, press and hold the **MODE** key to enter the mode to set the liquid density.

### Note

In the normal weighing mode, the same procedure will activate the automatic response adjustment. This function is not available in the density mode.

### Entering the water temperature ( $Ld in \bar{0}$ )

In the density mode, press and hold the **MODE** key until the water temperature currently set (unit: °C, factory setting : 25°C) is displayed. Use the following keys to change the value.



- RE-ZERO** key      To increase the temperature by one degree. (0-99)
- MODE** key        To decrease the temperature by one degree. (0-99)
- PRINT** key        To store the change, display **End** and return to the density mode.
- CAL** key          To cancel the change and return to the density mode.

The relation between the water temperature and density is shown below.

Temp. (°C)	+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	0.99970	0.99961	0.99949	0.99938	0.99924	0.99910	0.99894	0.99877	0.99860	0.99841
20	0.99820	0.99799	0.99777	0.99754	0.99730	0.99704	0.99678	0.99651	0.99623	0.99594
30	0.99565	0.99534	0.99503	0.99470	0.99437	0.99403	0.99368	0.99333	0.99297	0.99259
40	0.99222	0.99183	0.99144	0.99104	0.99063	0.99021	0.98979	0.98936	0.98893	0.98849
50	0.98804	0.98758	0.98712	0.98665	0.98618	0.98570	0.98521	0.98471	0.98422	0.98371
60	0.98320	0.98268	0.98216	0.98163	0.98110	0.98055	0.98001	0.97946	0.97890	0.97834
70	0.97777	0.97720	0.97662	0.97603	0.97544	0.97485	0.97425	0.97364	0.97303	0.97242
80	0.97180	0.97117	0.97054	0.96991	0.96927	0.96862	0.96797	0.96731	0.96665	0.96600
90	0.96532	0.96465	0.96397	0.96328	0.96259	0.96190	0.96120	0.96050	0.95979	0.95906

### Entering the density directly ( $Ld in \bar{1}$ )

In the density mode, press and hold the **MODE** key until the density currently set (unit : g / cm<sup>3</sup>, factory setting : 1.000g / cm<sup>3</sup>) is displayed. Use the following keys to change the value.



- RE-ZERO** key      To set the value of the digit selected.
- SAMPLE** key      To select the digit to change the value.
- PRINT** key        To store the change, display **End** and return to the density mode.
- CAL** key          To cancel the change and return to the density mode.

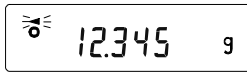
### Note

The range to set the density is 0.0000 to 1.9999 g / cm<sup>3</sup>

## Measuring the density

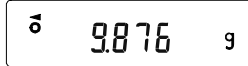
In the density measurement, the balance displays the weight of a sample in air, the weight in liquid and then the density.

- Measuring the weight of a sample in air.



The processing indicator blinks with the unit “g” displayed.

- Measuring the weight of a sample in liquid.



The processing indicator illuminates with the unit “g” displayed.

- Displaying the density.



The processing indicator illuminates with “DS” displayed.

To cycle through the above three, press the **SAMPLE** key.

## Note

The **SAMPLE** key can not be used to change the minimum weighing value. The density is displayed with three decimal places.

## Measuring procedure

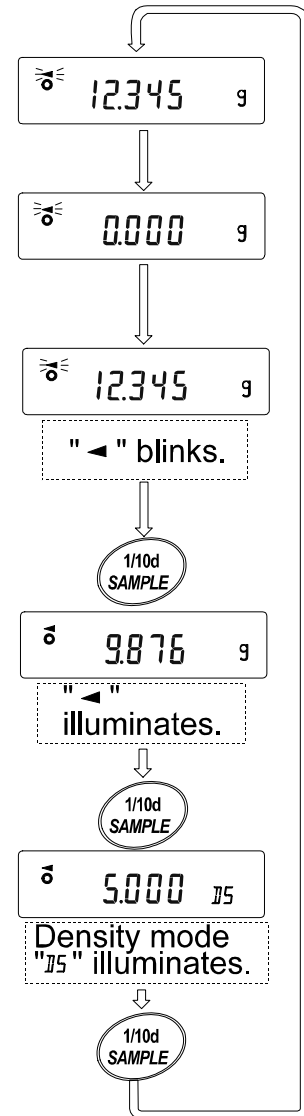
- (1) Confirm that the balance is in the mode to measure the weight of the sample in air. ("g" displayed and processing indicator blinking)
- (2) Confirm that the balance indicates zero. If it does not indicate zero, press the **RE-ZERO** to reset the displayed value to zero.
- (3) Place the sample on the upper pan (in air). When the value displayed on the balance becomes stable, press the **SAMPLE** key to confirm the value (the weight of the sample in air). The balance enters the mode to measure the weight of the sample in liquid ("g" displayed and processing indicator illuminated).

**Note : If a negative value or E (error) is displayed, the **SAMPLE** key is disabled.**

- (4) Remove the sample from the upper pan and place it on the lower pan (in liquid). When the value displayed on the balance becomes stable, press the **SAMPLE** key to confirm the value (the weight of the sample in liquid). The balance enters the mode to display the density ("g" disappears).

**Note : If E (error) is displayed, the **SAMPLE** key is disabled.**

- (5) To output or store the density, press the **PRINT** key. The density output unit is "DS". To measure the density of another sample, press the **SAMPLE** key to return to the mode to measure the weight in air and repeat the procedure described above.



## Note

**If the liquid temperature or the type of liquid is changed during measurement, reset the value of the liquid density as necessary. For details, refer to "Setting the density of a liquid".**

## 7. Frequently Asked Questions on Density Determination

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.