

# **GX-A/GF-A Series Options**

## **INSTRUCTION MANUAL**

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**GXA-13     Density Determination Kit**



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# 1. Introduction

Thank you for your A&D purchase! This is the instruction manual for the density determination kit.

The density determination kit can be easily used to measure the density of solid or liquid when it is combined with the following electronic balances.

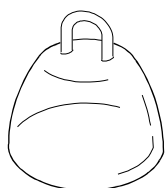
GX-203A, GX-303A, GX-403A, GX-603A, GX-1003A, GX-1603A,  
GF-203A, GF-303A, GF-403A, GF-603A, GF-1003A, GF-1603A

Before using the density determination kit, please read this instruction manual thoroughly.

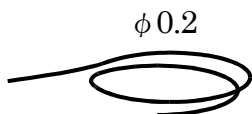
## 1.1. Precautions

- 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, therefore we cannot guarantee them to be 100 % accurate.
- 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.
- The balance is 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 room temperature and perform measurement in a stable environment.
- The breeze break provided with the balance cannot be used with the density determination kit. To perform an accurate density measurement, use the glass breeze break available as an option (GXA-10).

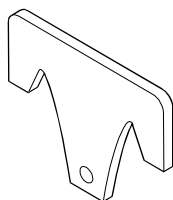
## 2. Packing List



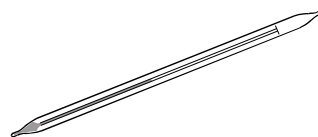
Float



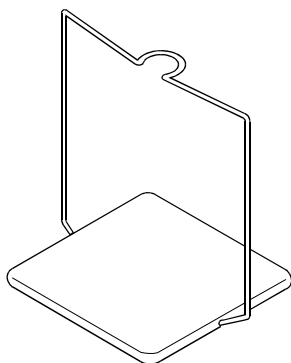
Wire



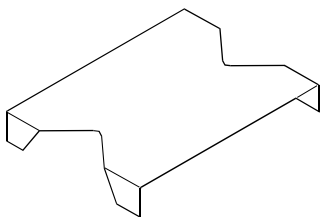
Float hook



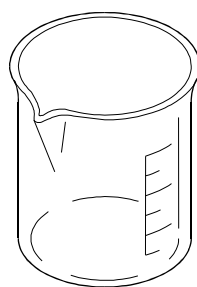
Thermometer



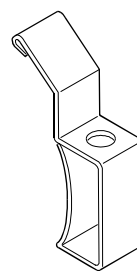
Density pan stand



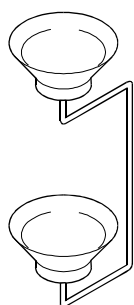
Beaker stand



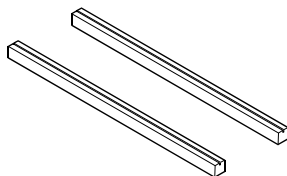
Beaker



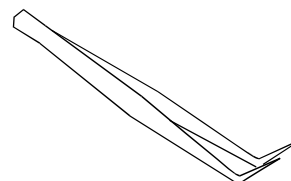
Thermometer clamp



Density pan

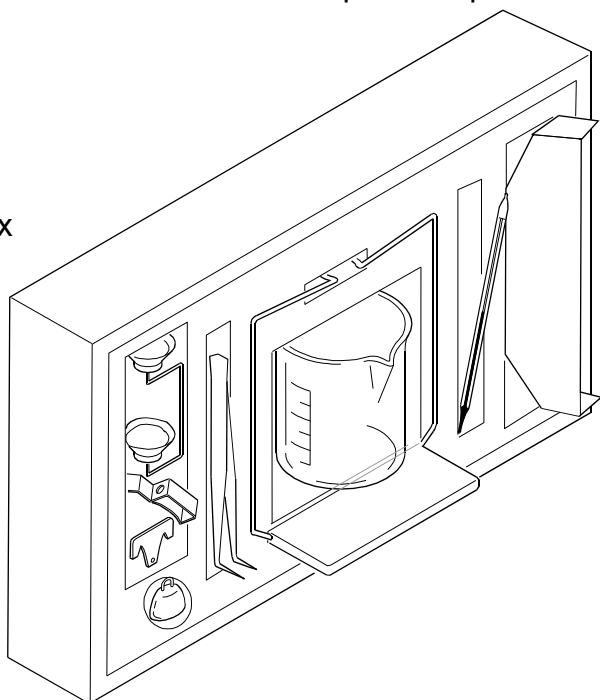


Beaker stand spacer 2 pieces



Tweezers

Kit box



## 3. Density Measurement Principle

### 3.1. Density

- Density means the amount of mass of a sample per unit volume. ( Unit [g/cm<sup>3</sup>] and others )

$$\rho = \frac{M}{V} \quad \rho: \text{ Density [g/cm}^3\text{]} \quad M: \text{ Mass [g]} \quad V: \text{ Volume [cm}^3\text{]}$$

### 3.2. Specific Gravity

- Specific gravity means 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.

$$\rho = \frac{M}{V \cdot \rho_4} \quad \rho: \text{ Specific gravity [ No unit ]} \quad M: \text{ Mass [g]} \quad V: \text{ Volume [cm}^3\text{]} \\ \rho_4: \text{ Density of water at 4 [}^\circ\text{C], 0.99997 [g/cm}^3\text{]} \doteq 1.000 \text{ [g/cm}^3\text{]}$$

### 3.3. Density Measurement Principle

- The GXA-13 combined with an authorized balance can measure the density of a sample based on the Archimedes' principle.

#### Archimedes' Principle of Density Measurement

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

### 3.4. Density of a Solid

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

$$\rho = \frac{A}{A - B} \times \rho_0 \quad \rho: \text{ Density of sample [g/cm}^3\text{]} \quad A: \text{ Sample weight in air [g]} \\ \rho_0: \text{ Density of liquid [g/cm}^3\text{]} \quad B: \text{ Sample weight in liquid [g]}$$

### 3.5. Density of a Liquid

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

$$\rho = \frac{A - B}{V} + d \quad \rho: \text{ Density of liquid [g/cm}^3\text{]} \quad A: \text{ Weight of the float in air [g]} \\ V: \text{ Volume of the float [cm}^3\text{]} \quad B: \text{ Weight of the float in liquid [g]} \\ d: \text{ Density of air ( approximately 0.001 [g/cm}^3\text{] )}$$

## 4. Error Factors

- There are several error factors that may affect the accuracy of a density measurement.

### 4.1. Buoyancy of Air

- When the liquid density 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:

$$d = \frac{0.0012932}{1+0.0036728 \times t} \times \frac{P}{1013.25}$$

d: Air density [g/cm<sup>3</sup>]      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 an error in air density.

### 4.2. Temperature of a Liquid

- When taking a density measurement using a liquid, the density measurement will change depending on the temperature. Obtain the density of a liquid by comparing its temperature with the values in “[Table 1 Temperature and Density of Water](#)” for distilled water or provided in other reference documents for other liquids.

### 4.3. Volume of Float

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

### 4.4. Influence of Wire

- When a solid sample is placed on the density pan for measurement, which is immersed in a liquid, the liquid surface position rises. At this time, the wire (φ1 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 approx. 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, or perform a mathematical correction.
- When measuring the density of a liquid, the float–suspending wire (φ2 mm) immersed in the liquid affects the measurement. Immersing the wire by 10 mm exerts a buoyancy of approx. 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.

## 4.5. Surface Tension

- When the density of a solid is measured, a force of approx. 5 mg (surface tension) is applied to the density pan, between the wire ( $\phi 1$  mm) of the density pan and the surface of the liquid.
- The surface tension can be reduced to approx. 1 mg by adding a surfactant (for example, a water droplet preventive solution as used for developing photographs). Adding 0.1 mL (1.2 [g/cm<sup>3</sup>] density) of a surfactant to 200 mL of water will increase the density of the water by approx. 0.0001 [g/cm<sup>3</sup>].
- When the density of a liquid is measured, a force of about 1 mg 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.

## 4.6. Bubbles

- The buoyancy of a bubble of 1 mm in diameter is approx. 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, we recommend adding a surfactant to reduce the influence of surface tension and bubbles.



# 5. Measuring the Density of a Solid

## 5.1. Assembling the Kit

Step 1. Remove the weighing pan and breeze break from the balance.

Step 2. Put the density pan stand on the pan support.

Step 3. Place the spacer under the legs of the beaker stand so that the legs fit to the ditch of the spacer.

Put the beaker stand on the balance as such that it will not touch the density pan stand.

Step 4. Attach the thermometer clamp to beaker. Insert the thermometer into the clamp.

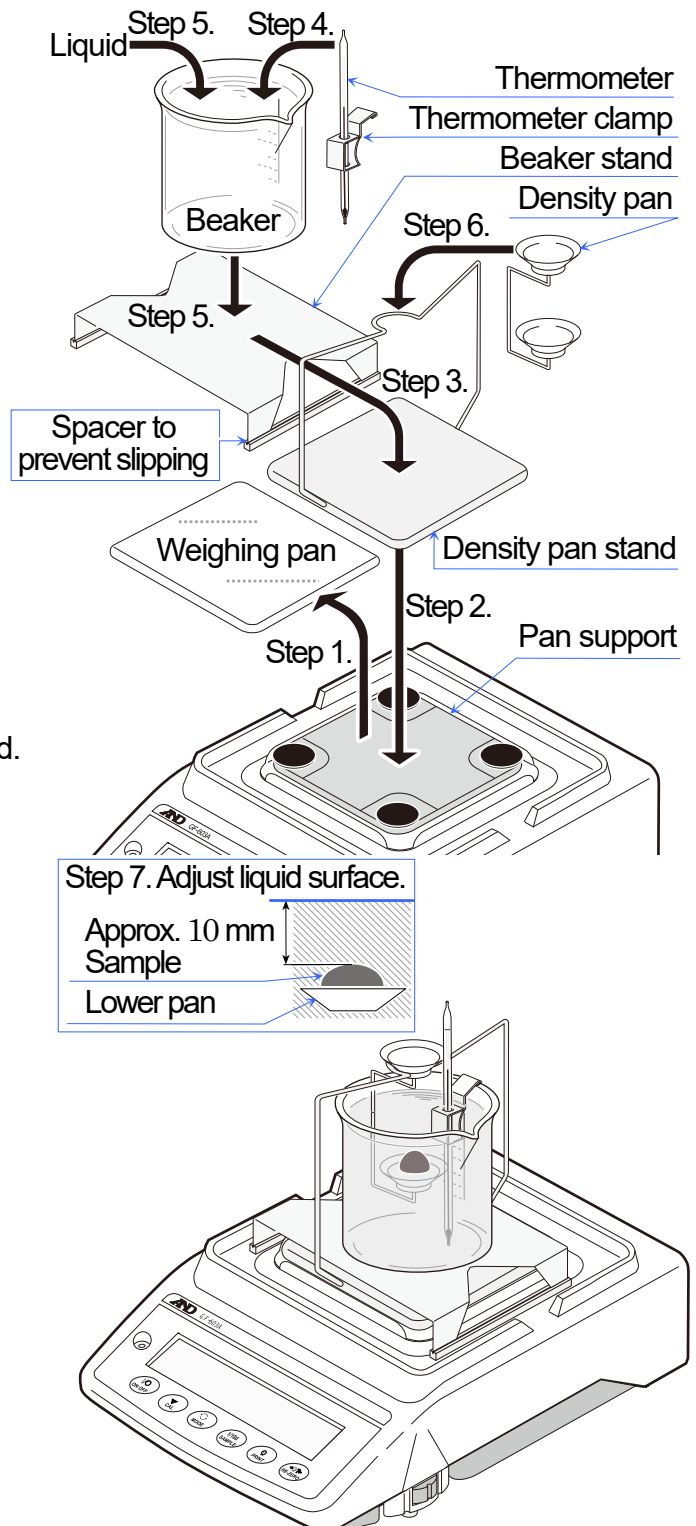
Step 5. Pour a liquid (distilled water, etc.), whose specific gravity is known, into the beaker. Put the beaker on the beaker stand.

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

Step 7. Adjust the amount of the liquid so that sample is approximately 10 mm under the surface of the liquid when the sample is put on the lower pan of the density pan in the liquid.

Step 8. Press the **RE-ZERO** key to display zero after the weighed value stabilized. All preparations are complete.

# If the weighing value is unstable due to breeze and vibration, etc., increase the parameter of "Condition (  $\zeta_{OND}$  )" in the function table or use the breeze break.



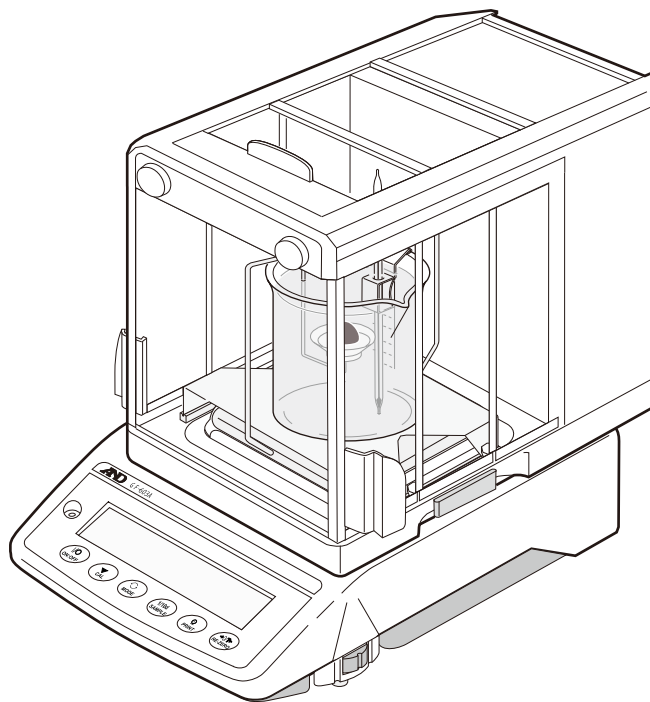
### 5.1.1. Assembling the Kit Using Glass Breeze Break (GXA-10)

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Step 1. Remove the weighing pan from the balance.

Step 2. Place the breeze break on the balance and perform the procedures from step 2 to step 8 in "5.1. Assembling the Kit".  
All preparations are complete.

# If the weighing value is unstable due to breeze and vibration, etc., increase the parameter of "Condition ( [  $\sigma$  ] )" in the function table or use the breeze break.



## 5.2. Measuring the Density of a Solid

- The density of a solid can be obtained by averaging the measured values.  
Display example is GX-603A.

Step 1. Start the measurement after the water temperature becomes stable.

Step 2. Press the **RE-ZERO** key to display zero.

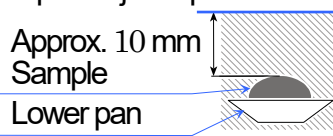
Step 3. Put sample on the upper pan of the density pan and record the measurement value **A** in air.

Step 4. After removing the sample from the upper pan of the density pan, press the **RE-ZERO** key to display zero.

Step 5. Put sample on the lower pan of the density pan and record measurement value **B** in liquid.

- # Adjust the amount of the liquid so that sample is approximately 10 mm under the liquid surface when the sample is put on lower pan in the liquid.

Step 5. Adjust liquid surface.



Step 6. Obtain the water density using the water temperature and "Table-1, temperature and density of water". Acquire liquid density using the following formula substituted the measured value.

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

$\rho$  : Calculated sample density [g/cm<sup>3</sup>]  
 $\rho_0$  : Water density [g/cm<sup>3</sup>]  
**A** : Measurement value in air [g]  
**B** : Measurement value in water [g]

Example of recording sheet and calculation (3 significant figures).

|                                   |                              |                                     |                           |                   |       |
|-----------------------------------|------------------------------|-------------------------------------|---------------------------|-------------------|-------|
| Measurement value in air <b>A</b> | 4.810 [g]                    | Measurement value in water <b>B</b> | 4.215 [g]                 | Water temperature | 26 °C |
| Water density $\rho_0$            | 0.99678 [g/cm <sup>3</sup> ] | Calculated sample density $\rho$    | 8.06 [g/cm <sup>3</sup> ] |                   |       |

$$\frac{4.810}{4.810 - 4.215} \times 0.99678 = 8.06 \text{ [g/cm}^3\text{]}$$

### 5.2.1. Density of Water

- At sea level (1 atmosphere pressure), the density of water reaches a maximum at 3.98 [°C].

Table 1, Temperature and Density of Water

Unit: g/cm<sup>3</sup>

| °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 |

## 6. Measuring the Density of a Liquid

### 6.1. Assembling the Kit

- Assemble the kit as described in the procedure below.

Step 1. Refer to “5.1. Assembling the Kit” up to assembling the beaker stand.

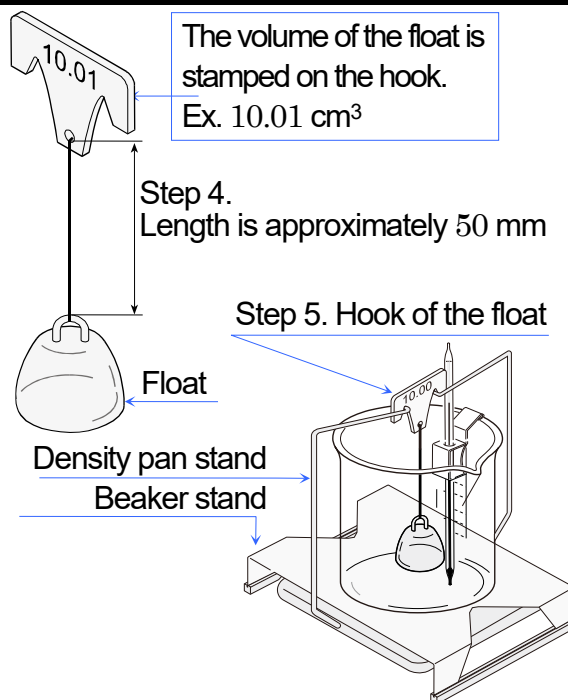
Step 2. Attach the thermometer clamp to beaker. Insert the thermometer through this clamp.

Step 3. Put the beaker on the beaker stand.

Step 4. Connect the float and hook using stainless wire whose length is approximately 50 mm.

Step 5. Hang the hook to density pan stand. Check that it does not hit the beaker, and lower the float.

Step 6. This completes the preparations before measurement.



### 6.2. Measuring the Density of a Liquid

- The density of a liquid can be obtained by the following procedure. Display example is GX-603A.

Step 1. Press the **RE-ZERO** key to set the displayed value to zero.

Step 2. Place the float, and then record its weight in the air. Let the measured value be A.

Step 3. To measure density of the liquid, pour it into the beaker.

- # Adjust the amount of the liquid so that the sample is approximately 10 mm under the liquid surface when the sample is hung in the liquid.

Step 4. When the display stabilizes, and then record its weight of the float in the liquid. Let the measured value be B.

Step 5. Use the following equations to obtain the density of the liquid.

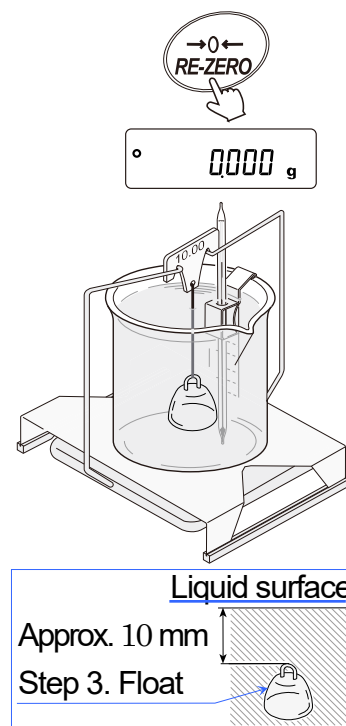
$$\rho = \frac{A - B}{V} + d$$

$\rho$  : Calculated density of liquid [g/cm<sup>3</sup>]  
 $A$  : Weight of float in air [g]  
 $B$  : Weight of float in liquid [g]  
 $V$  : Volume of float (stamped on the hook) [cm<sup>3</sup>]  
 $d$  : Density of air (Approximately 0.001 [g/cm<sup>3</sup>])

Example of recording sheet and calculation (3 significant figures).

|                                   |         |                          |                       |                                     |  |
|-----------------------------------|---------|--------------------------|-----------------------|-------------------------------------|--|
| Measurement value<br><b>A - B</b> | 9.970 g | Volume of float <b>V</b> | 10.01 cm <sup>3</sup> | Density of air <b>d</b>             | 1.184x10 <sup>-3</sup> g/cm <sup>3</sup> |
| Temperature                       | 25 °C   | Atmospheric pressure     | 1013.25 hPa           | Calculated density of liquid $\rho$ | 0.997 g/cm <sup>3</sup>                  |

$$\frac{9.970}{10.01} + 0.001 = 0.997 \text{ [g/cm}^3\text{]}$$



## 7. Density Measurement Using the GX-A/GF-A Balance

- The GX-A / GF-A balances are equipped with a density function (specific gravity mode). When this density determination kit GXA-13 is used with density function of the following balances, the density of a solid and liquid can be measured.

GX-203A, GX-303A, GX-403A, GX-603A, GX-1003A, GX-1603A,  
GF-203A, GF-303A, GF-403A, GF-603A, GF-1003A, GF-1603A

### Caution

- The density function (  $d5_{Fnc}$  ) of the balance cannot be selected when using factory settings.

The density function of the balance does not display in the function table when the specific gravity (  $SpG$  ) of the weighing unit (  $Unit$  ) is inactive. To use the specific gravity of the weighing unit, register "specific gravity" of "weighing unit" in the "function table" at first, and then select the specific gravity (  $SpG$  ) of the weighing unit using the **MODE** key in weighing mode.

- When the liquid density input (  $Ld_{in}$  ) is active, the liquid density input (  $Ld_{in}$  ) or density of solid (  $d5$  ) is displayed. Refer to the instruction manual of balance for operation method of the "function table".
- The measurement value of density (specific gravity) is fixed to 3 decimal places.



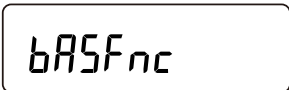

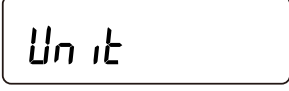

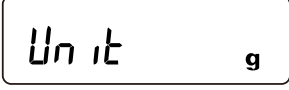

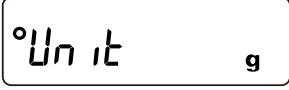
## 7.1. Preparation Before Measurement (Settings of the Function Table)

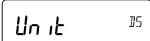

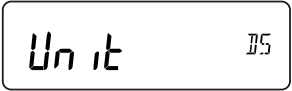


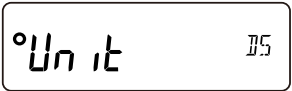


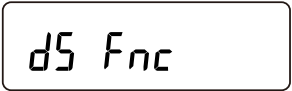







Set the function table of the balance before the density function (specific gravity mode) is used.

### Enabling the Unit of Specific Gravity ( $\overset{\circ}{\text{SG}}$ )

Register the specific gravity (  $\overset{\circ}{\text{SG}}$  ) of the weighing unit (  ).

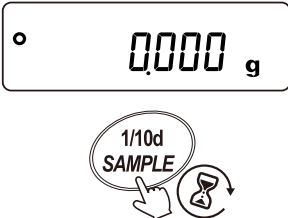
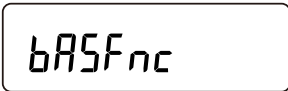

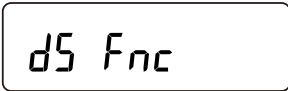


The following is an example of registering units in the order of **g** (grams)  $\rightarrow$   $\overset{\circ}{\text{SG}}$  ( Specific Gravity ).

| Step | Description   | Display and Key Operation   |
|------|---|---|
| 1.   | Press and hold (for about 2 seconds) the <input type="text" value="SAMPLE"/> key in weighing mode.<br><input type="text" value="bASFnC"/> of the function table is displayed. | <br><br>Press and hold<br>(for about 2 seconds)<br> |
| 2.   | Press the <input type="text" value="SAMPLE"/> key several times to display the weighing unit <input type="text" value="Unit"/> .  | <br>Press several times<br>   |
| 3.   | Press the <input type="text" value="PRINT"/> key to display <input type="text" value="Unit"/> g.  | <br>  |
| 4.   | Press the <input type="text" value="RE-ZERO"/> key to specify the unit and display the unit specification mark "◦".   | <br>  |

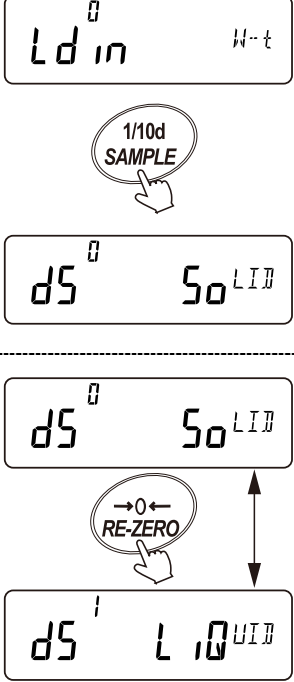
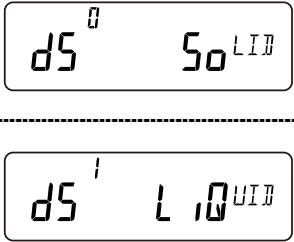
| Step | Description   | Display and Key Operation   |
|------|---|---|
| 5.   | Press the <b>SAMPLE</b> several times to display  .   | <br>Press several times<br>   |
| 6.   | Press the <b>RE-ZERO</b> key to specify the unit and display the unit specification mark “  ”.   | <br>  |
| 7.   | Press the <b>PRINT</b> key to register the specified unit.  | <br>   |
| 8.   | Press the <b>CAL</b> key to return to weighing display.   | <br><br> |
| 9.   | <p>Each time you press the <b>MODE</b> key, the units will switch in the specified order.<br/>Order from <b>g</b> to <b>g<sub>sol</sub></b> *.</p> <p>* In the specific gravity mode, the unit is <b>g<sub>sol</sub></b> when calculating the density.</p> <p>The display unit is <b>g</b> when measuring weight in air (<b>d - A</b> shows at the top left and the “” mark blinks) and when measuring weight in water (<b>d - B</b> shows at the top left, “” mark shows).</p> | <br><br> |

## Selecting Substance ( Solid or Liquid )

- Select a substance which is either solid or liquid. It can be specified at “substance selection (  $d5$  )” of “density function (  $d5 Fnc$  )” in the function table.

| Step | Description   | Display and Key Operation   |
|------|---|---|
| 10.  | Press and hold (for about 2 seconds) the <b>SAMPLE</b> key while the scale is in weighing mode.<br>$bASFnC$ of the function table is displayed. |  <p>Press and hold (for about 2 seconds)</p>  |
| 11.  | Press the <b>SAMPLE</b> key several times to display the “density function ( $d5 Fnc$ )”.   |  <p>Press several times</p>               |
| 12.  | Press the <b>PRINT</b> key to enter the item.   |     |











| Step | Description   | Display and Key Operation   |
|------|---|---|
| 13.  | <p>Select substance using the following keys.</p> <p><b>SAMPLE</b> key</p> <p>Used to select "substance selection ( <math>d5</math> )".</p> <p><b>RE-ZERO</b> key</p> <p>Selects either "solid density measurement ( <math>\square</math> )" or "liquid density measurement ( <math>l</math> )".</p>  |   |
| 14.  | <p>Description of settings is as follows.</p> <p>"Solid ( <math>\square</math> )"</p> <p>Proceeds to "7.2. Measuring Solid Density (Specific Gravity), Function Table <math>d5 \square</math> " after step 18.</p> <p>"Liquid ( <math>l</math> )"</p> <p>Proceeds to "7.4. Measuring Liquid Density (Specific Gravity), Function Table <math>d5 l</math> " after step 18.</p> |  |

## Selecting Input Method of Liquid Density Used for Solid Density Measurement (Specific Gravity)

- When measuring the density (specific gravity) of a liquid (function table  $d5 \quad l$ ), the “liquid density input (  $Ld \quad in$  )” setting is irrelevant, so proceed to step 17.

| Step | Description   | Display and Key Operation |
|------|---|---------------------------|
| 15.  | The density of a liquid can be registered using the following keys.   |                           |
|      | <p><b>SAMPLE</b> key</p> <p>Used to select the “liquid density input ( <math>Ld \quad in</math> )”.</p>   |                           |
|      | <p><b>RE-ZERO</b> key</p> <p>Specifies either “Density input of liquid using water temperature ( <math>\square</math> )” or “Direct density input of liquid ( <math>l</math> )”.</p>  |                           |
| 16.  | Description of settings is as follows.  |                           |
|      | <p>“Water temperature input ( <math>\square</math> )”</p> <p>Proceeds from step 7 of “7.2. Measuring Solid Density (Specific Gravity), Function Table <math>d5 \quad \square</math>” to “Method To Input The Water Temperature ( <math>Ld \quad in \quad \square</math> )” of “7.3. Specifying Liquid Density”.</p> |                           |
|      | <p>“Direct density input ( <math>l</math> )”</p> <p>Proceeds from step 7 of “7.2. Measuring Solid Density (Specific Gravity), Function Table <math>d5 \quad \square</math>” to “Method To Input The Density Directly ( <math>Ld \quad in \quad l</math> )” of “7.3. Specifying Liquid Density”.</p>                 |                           |

| Step | Description   | Display and Key Operation   |
|------|---|---|
| 17.  | Press the <b>PRINT</b> key to store the settings.   | <br>  |
| 18.  | All preparations are complete.<br>Press the <b>CAL</b> key to enter the weighing mode to start measurement.   | <br><br>   |
| 19.  | Press the <b>MODE</b> key to display the specific gravity mode units.<br>Go to “7.2. Measuring Solid Density (Specific Gravity), Function Table <i>d5 0</i> ” or “7.4. Measuring Liquid Density (Specific Gravity), Function Table <i>d5 1</i> ”. | <br><br>Measuring Solid Density<br>( <i>d5 0</i> )<br>or<br><br>Measuring Liquid Density<br>( <i>d5 1</i> ) |

### Reference

- The density function (specific gravity) uses “density function ( *d5 Fnc* )” of the function table.

| Class   | Item                                 | Parameter  | Description                                       |
|---|--------------------------------------|------------|---|
| <i>d5 Fnc</i><br>Density function<br>(Specific gravity) | <i>Ld in</i><br>Liquid density input | ■ <i>0</i> | Density input of a liquid using water temperature |
|   |                                      | <i>1</i>   | Direct density input of a liquid                  |
|   | <i>d5</i><br>Substance selection     | ■ <i>0</i> | Density measurement of a solid                    |
|   |                                      | <i>1</i>   | Density measurement of a liquid                   |

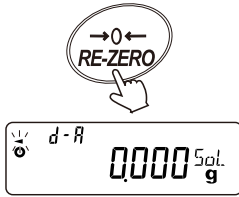
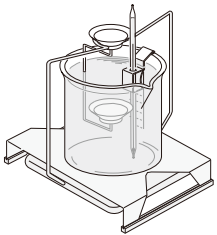
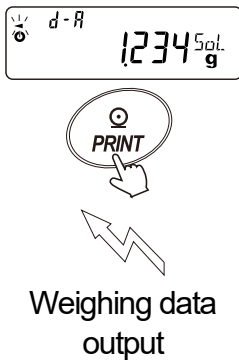
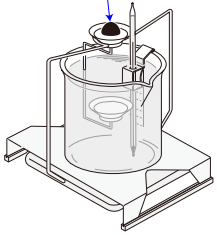
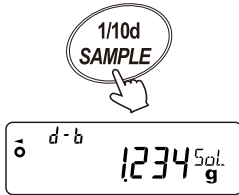
- indicates factory settings.

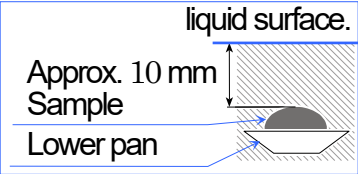

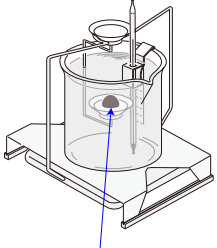
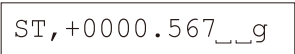
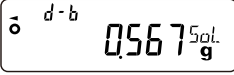


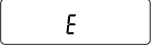

## 7.2. Measuring Solid Density (Specific Gravity), Function Table $d_5$



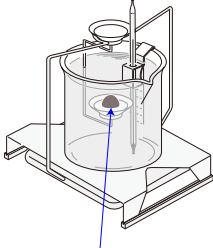

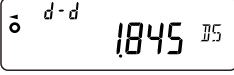





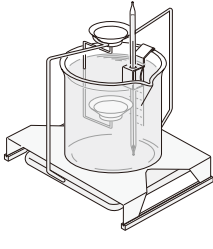

### Cautions

- When the temperature or type of liquid changes, register again the density of the liquid using “7.3. Specifying Liquid Density”.
- The measurement value of the density function (specific gravity mode) is fixed to 4 decimal places. The minimum division cannot be changed using the **[SAMPLE]** key.
- The procedure of the density (specific gravity) measurement is to weigh the sample in air, to weigh the sample in liquid and to display calculated density of the sample.

### Procedure

| Step | Description  | Display and Key Operation  | Weighing Operation   |
|------|--|--|--|
| 1.   | <p><b>Weighing mode for in air</b></p> <p>Preparation for measurement in air.<br/>( <math>d - A</math> shows and <math>\frac{1}{10}d</math> blinks )</p> <p>Press the <b>[RE-ZERO]</b> key to display zero with nothing is put on the upper pan and lower pan.</p>   |    |                             |
| 2.   | <p>Put the sample on the upper pan and wait until the weighing value is stable. If necessary, press the <b>[PRINT]</b> key to output the weight of the sample.</p> <p>Example output: Weight in air<br/>A&amp;D standard format (factory setting)</p> <p><code>ST,+0001.234_ _g</code></p> <p>_ is a space</p> |   | <p>Sample in the air</p>  |
| 3.   | <p>Press the <b>[SAMPLE]</b> key to record weight in air and proceed to the weighing mode for liquid ( <math>d - b</math> shows and <math>\triangleleft</math> shows ).</p> <p><b>Cautions</b></p> <p>The <b>[SAMPLE]</b> key is inactive when weighing value is overload <b>[E]</b> .</p>                     |  |  |

| Step | Description   | Display and Key Operation   | Weighing Operation  |
|------|---|---|---|
| 4.   | <p><b>Weighing mode for in liquid</b></p> <p>To measure the density of the liquid, pour it into the beaker and sink the float.</p> <p>( <math>d-b</math> shows, <math>\leftarrow</math> shows ).</p> <p>Adjust the amount of the liquid so that the float is approximately 10 mm under the liquid surface when float is hung in the liquid.</p>  |   |  <p>Sample in the liquid</p> |
| 5.   | <p>Press the <b>PRINT</b> key to output the weighing value.</p> <p>Example output: Weight in air<br/>A&amp;D standard format (factory setting)</p>  <p>__ is a space</p>   |    <p>Weighing data output</p> |   |
| 6.   | <p>Press the <b>SAMPLE</b> key to record the weight in the liquid and proceed to the liquid density input mode ( <math>d-[-</math> shows and <math>\leftarrow</math> shows).</p> <p><b>Cautions</b></p> <p>The <b>SAMPLE</b> key is inactive when weighing value is overload  .</p>  |   |   |

| Step | Description  | Display and Key Operation  | Weighing Operation  |
|------|--|--|---|
| 7.   | <p><b>Liquid density input mode</b></p> <p>Input the density of the liquid.<br/> Refer to “<a href="#">Method To Input The Water Temperature ( L d in 0 )</a>” (page 23) or “<a href="#">Method To Input The Density Directly ( L d in 1 )</a>” (page 24) in “7.3. Specifying Liquid Density”.</p>   |  <p>Input the Water Temperature ( L d in 0 )</p> <p>or</p>  <p>Input the Density Directly ( L d in 1 )</p>             |  <p>Sample in the liquid</p> |
| 8.   | <p>Press the <b>PRINT</b> key to proceed to the density display of a solid. ( <math>d-d</math> shows and <math>\blacktriangleleft</math> shows)</p>  |     |   |
| 9.   | <p><b>Solid density display mode</b></p> <p>If necessary, while the density of the sample is displayed, press the PRINT key to output the density.<br/> The unit of density (specific gravity) is <math>DS</math>.</p> <p>Example output: Density (specific gravity)<br/> A&amp;D standard format (factory setting)</p> <div style="border: 1px solid black; padding: 2px; width: fit-content;">ST, +0001.845_DS</div> <p><math>\_</math> is a space</p> |    <p>Weighing data output</p> |   |
| 10.  | <p>If another sample is to be measured, press the <b>SAMPLE</b> key and proceed to step 1 of “<a href="#">Weighing mode for in air</a>” ( <math>d-R</math> shows and <math>\blacktriangleleft</math> blinks ).</p>   |    |                            |
| 11.  | <p>When the temperature or type of a liquid being measured changes, if necessary, register again the density of the liquid according to step 7 of “<a href="#">Liquid density input mode</a>”.</p>   | <p>Refer to “<a href="#">Liquid density input mode</a>” in step 7.</p>   |   |
| 12.  | <p>If the <b>MODE</b> key is pressed, the display is changes to another weighing mode.</p>   |    |   |

## 7.3. Specifying Liquid Density

- Select the density input method of a liquid when the solid density is measured.

The “liquid density input (  $Ld_{in}$  )” has “[Method To Input The Water Temperature \(  \$Ld\_{in} \text{ } \square\$  \)](#)” (page 23) and “[Method To Input The Density Directly \(  \$Ld\_{in} \text{ } |\$  \)](#)” (page 24).

### Method To Input The Water Temperature ( $Ld_{in} \text{ } \square$ )

This step is an additional explanation of step 7 “[Liquid density input mode](#)” (page 22).

The current setting of water temperature is displayed. (Factory setting is 25.0 °C.)

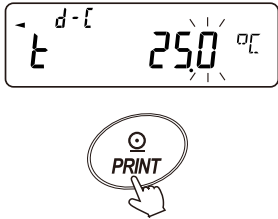
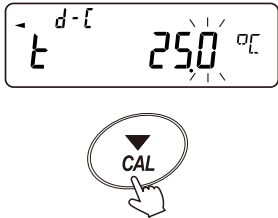
Refer to [Table 1](#) in “[5.2.1. Density of Water](#)” regarding the relation between temperature and density of water.

Register the water temperature using the following keys.

The setting range of temperature is 0.0 to 99.9 °C in 0.1 °C interval.



| Step | Description  | Display and Key Operation |
|------|--|---------------------------|
| 1.   | <p><b>RE-ZERO</b> key</p> <p>Increases number of blinking digit. (+ key)<br/>(Number next 9 is 0.)</p> | <br><br>                  |
|      | <p><b>MODE</b> key</p> <p>Decreases number of blinking digit. (- key)<br/>(Number next 0 is 9.)</p>    | <br><br>                  |
|      | <p><b>SAMPLE</b> key</p> <p>Moves blinking digit.</p>  | <br><br>                  |

| Step | Description   | Display and Key Operation   |
|------|---|---|
| 1.   | <p><b>PRINT</b> key</p> <p>Stores the current setting and proceeds to the density display.<br/>(Go to Step 9. “Solid density display mode”) (page 22)</p> |  |
|      | <p><b>CAL</b> key</p> <p> Cancels the setting and proceeds to the density display.<br/>(Go to Step 9. “Solid density display mode”) (page 22)</p>         |  |

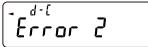
### Method To Input The Density Directly ( $Ld_{in}$ )

This step is an additional explanation of step 7 “Liquid density input mode” (page 22).

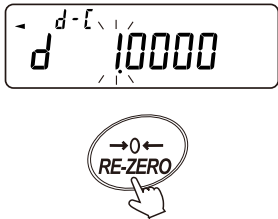

The current setting of density of water is displayed. (Factory setting is 1.0000 g/cm<sup>3</sup>.)

Register density of water using the following keys.

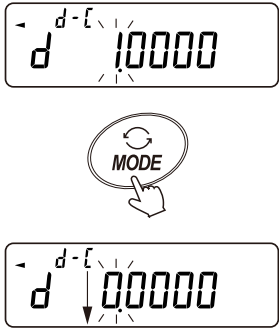
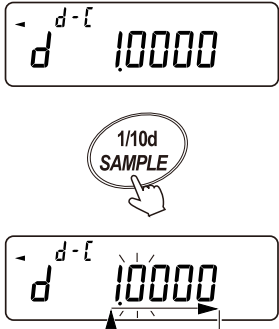
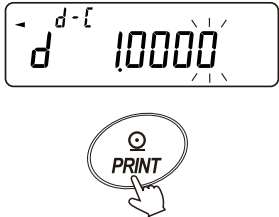
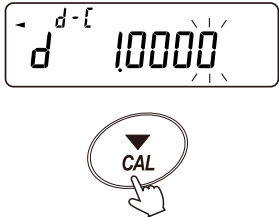
The setting range of density is 0.0000 to 1.9999 g/cm<sup>3</sup>.

If the input becomes out of range, the balance displays  and returns to the input display.



| Step | Description  | Display and Key Operation  |
|------|--|--|
| 1.   | <p><b>RE-ZERO</b> key</p> <p>Increases number of blinking digit. (+ key)<br/>(Number next 9 is 0.)</p> | <br> |




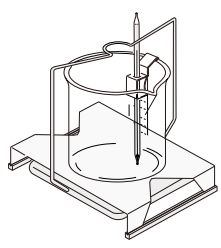
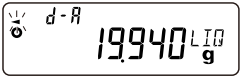


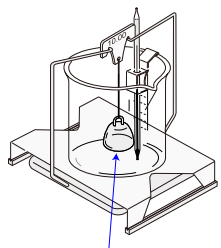

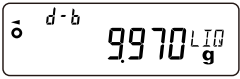


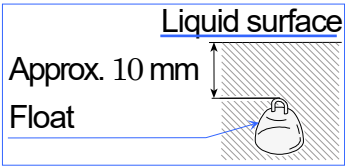
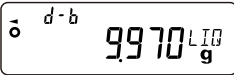
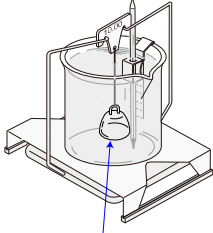
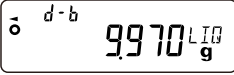




| Step | Description   | Display and Key Operation   |
|------|---|---|
| 1.   | <p><b>MODE</b> key</p> <p>Decreases number of blinking digit. (- key)<br/>(Number next 0 is 9.)</p>   |  <p>The diagram shows two states of the display. The top state shows 'd' followed by '10000' with a vertical bar over the first zero. An arrow points to the 'MODE' key. The bottom state shows 'd' followed by '00000' with a vertical bar over the first zero. An arrow points to the 'MODE' key.</p>      |
|      | <p><b>SAMPLE</b> key</p> <p>Moves blinking digit.</p>   |  <p>The diagram shows two states of the display. The top state shows 'd' followed by '10000' with a vertical bar over the first zero. An arrow points to the 'SAMPLE' key. The bottom state shows 'd' followed by '10000' with a vertical bar over the second zero. An arrow points to the 'SAMPLE' key.</p> |
|      | <p><b>PRINT</b> key</p> <p>Stores the current setting and proceeds to the density display.<br/>(Go to Step 9. “Solid density display mode”) (page 22)</p> |  <p>The diagram shows two states of the display. The top state shows 'd' followed by '10000' with a vertical bar over the first zero. An arrow points to the 'PRINT' key. The bottom state shows 'd' followed by '10000' with a vertical bar over the second zero. An arrow points to the 'PRINT' key.</p> |
|      | <p><b>CAL</b> key</p> <p> Cancels the setting and proceeds to the density display.<br/>(Go to Step 9. “Solid density display mode”) (page 22)</p>         |  <p>The diagram shows two states of the display. The top state shows 'd' followed by '10000' with a vertical bar over the first zero. An arrow points to the 'CAL' key. The bottom state shows 'd' followed by '10000' with a vertical bar over the second zero. An arrow points to the 'CAL' key.</p>     |

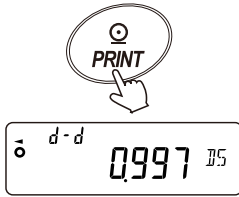
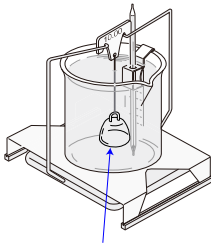
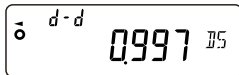
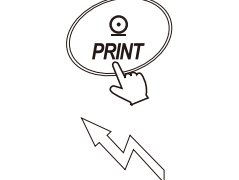
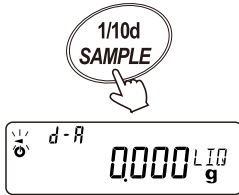
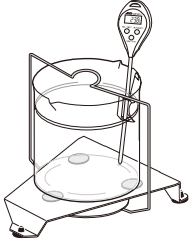

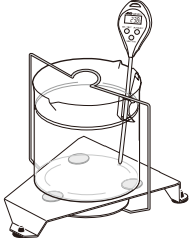
## 7.4. Measuring Liquid Density (Specific Gravity), Function Table d5 1

- The measurement value of density (specific gravity) is fixed to 3 decimal places. Minimum division cannot be changed using the **SAMPLE** key. The procedure of the density (specific gravity) measurement is to weigh the float in air, to weigh the float in liquid and to display calculated density of the float. Each status and indications are as follows :

### Procedure

| Step | Description   | Display and Key Operation   | Weighing Operation   |
|------|---|---|--|
| 1.   | <p><b>Weighing mode for in air</b></p> <p>Preparation for a measurement in air.<br/>( <math>d-R</math> shows ,  blinks )</p> <p>Press the <b>RE-ZERO</b> key to display zero with nothing placed on the density pan stand.</p>   | <br>  |                       |
| 2.   | <p>Put the float on the upper pan and wait until the weighing value is stable. If necessary, press the <b>PRINT</b> key to output the weight of the sample..</p> <p>Example output: Weight in air<br/>A&amp;D standard format (factory setting)</p> <div style="border: 1px solid black; padding: 2px; display: inline-block;">ST,+0019.940_ _g</div> <p>_ is a space</p> | <br><br><br>Weighing data output | <br>float in the air |
| 3.   | <p>Press the <b>SAMPLE</b> key to record weight in air and proceed to the weighing mode for liquid<br/>( <math>d-b</math> shows and <math>\blacktriangleleft</math> shows ).</p> <p><b>Cautions</b></p> <p>The <b>SAMPLE</b> key is inactive when weighing value is overload <b>E</b> .</p>   | <br>  |  |

| Step | Description   | Display and Key Operation  | Weighing Operation   |
|------|---|--|--|
| 4.   | <p><b>Weighing mode for in liquid</b></p> <p>To measure the density of the liquid, pour it into the beaker and sink the float.</p> <p>( <math>d-b</math> shows, <math>\blacktriangleleft</math> shows ).</p> <p>Adjust the amount of the liquid so that the float is approximately 10 mm under the liquid surface when float is hung in the liquid.</p>  |    |  <p>float in liquid</p> |
| 5.   | <p>Wait until the weighing value is stable. To output the weighing value, press the <b>PRINT</b> key.</p> <p>Example output: Weight in liquid<br/>A&amp;D standard format (factory setting)</p> <div style="border: 1px solid black; padding: 2px; display: inline-block;">ST, +0009.970_ _g</div> <p>_ is a space</p>  |    <p>Weighing data output</p> |  |
| 6.   | <p>Press the <b>SAMPLE</b> key to record the weight in the liquid and proceed to the float volume input mode ( <math>d-[\ ]</math> shows and <math>\blacktriangleleft</math> shows ).</p> <p><b>Cautions</b></p> <p>The <b>SAMPLE</b> key is inactive when weighing value is overload <b>E</b> .</p>  |   <p>volume input mode</p>   |  |
| 7.   | <p><b>Float volume input mode</b></p> <p>Input the volume of the float.<br/>Refer to “7.5. Specifying Volume of Float” and input the volume of the float.</p>   | <p>Refer to “7.5. Specifying Volume of Float”.</p>   |  |

| Step | Description  | Display and Key Operation   | Weighing Operation   |
|------|--|---|--|
| 8.   | Press the <b>PRINT</b> key to proceed to the density display ( $d-d$ shows and $\leftarrow$ shows ).   |   | <br>float in liquid |
| 9.   | <p><b>Liquid density display mode</b></p> <p>If necessary, while the calculated density of the liquid is displayed, press the <b>PRINT</b> key to output the density.</p> <p>The unit of density (specific gravity) is 15.</p> <p>Example output: density (specific gravity)<br/>A&amp;D standard format (factory setting)</p> <pre>ST, +0000.997_DS</pre> <p>_ is a space</p> |   <p>Weighing data output</p> | float in liquid  |
| 10.  | <p>If another sample is to be measured, press the <b>SAMPLE</b> key and proceed to step 1 of “Weighing mode for in air”</p> <p>( <math>d-R</math> shows and <math>\leftarrow</math> blinks ).</p>  |   |                   |
| 11.  | If the <b>MODE</b> key is pressed, the display is changes to another weighing mode.  |   |                   |

## 7.5. Specifying Volume of Float

This step is an additional explanation of step 7 “[Float volume input mode](#)” (page 27).

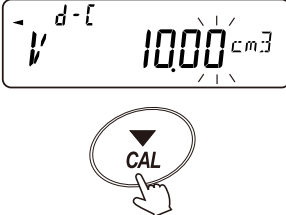
The current volume of the float is displayed. (Factory setting is 10.00 cm<sup>3</sup>.)

Register the volume using the following keys.

The setting range of volume is 0.01 to 99.99 cm<sup>3</sup> in 0.01 cm<sup>3</sup> interval.



| Step | Description  | Display and Key Operation |
|------|--|---------------------------|
| 1.   | <p><b>RE-ZERO</b> key</p> <p>Increases number of a blinking digit. (+ key)<br/>(Number next 9 is 0.)</p>   | <br><br>                  |
|      | <p><b>MODE</b> key</p> <p>Decreases number of a blinking digit. (- key)<br/>(Number next 0 is 9.)</p>  | <br><br>                  |
|      | <p><b>SAMPLE</b> key</p> <p>Moves a blinking digit.</p>  | <br><br>                  |
|      | <p><b>PRINT</b> key</p> <p>Stores the current setting and proceeds to the density display.<br/>(Go to Step 9. “<a href="#">Liquid density display mode</a>”) ( Page 28.)</p> | <br>                      |

| Step | Description   | Display and Key Operation   |
|------|---|---|
| 1.   | <p><span style="border: 1px solid black; padding: 2px;">CAL</span> key</p> <p>Cancels the setting and proceeds to the density display.<br/>           (Go to Step 9. <a href="#">“Liquid density display mode”</a>) ( Page 28.)</p> |  |

## 8. Frequently Asked Questions and Answers

**Question:**

I would like to measure the density of a resin pellet or sheet, which floats in water. Is this possible?

**Answer:**

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.

**Question:**

Can a sample containing bubbles be measured?

**Answer:**

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 this low density, cannot be measured.

**Question:**

The measurement repeatability may be affected by the water's surface tension.

What can I do about this?

**Answer:**

A few drops of a surfactant (for example, a mild detergent for washing dishes) added to the water reduces the influence of surface tension. A few drops of a surfactant 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 surfactant.

**Question:**

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

**Answer:**

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.

**Question:**

I try to measure a highly water resistant material such as rubber, but bubbles stick to the sample.

What can I do about this?

**Answer:**

Before measurement, soak the sample in the water with an appropriate amount of surfactant added. Doing this increases the sample surface hydrophilicity and bubbles may only stick to the sample surface in a very small amount.

**Question:**

Up to what size of sample can be measured?

**Answer:**

Considering the density pan size, the maximum size of the sample that can be measured is as follows: Diameter 25 mm                      Height 30 mm

**Question:**

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

**Answer:**

A liquid with a viscosity up to 500 [mPa x s] can be measured. If the viscosity exceeds this value, the float takes an excessive amount of 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.

**Question:**

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

**Answer:**

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. Therefore using a semi-micro balance is not recommended.









### **A&D Company, Limited**

3-23-14 Higashi-Ikebukuro, Toshima-ku, Tokyo 170-0013, JAPAN  
Telephone: [81] (3) 5391-6132 Fax: [81] (3) 5391-1566

### **A&D ENGINEERING, INC.**

47747 Warm Springs Blvd, Fremont, California 94539, U.S.A.  
Tel: [1] (800) 726-3364 Weighing Support:[1] (888) 726-5931 Inspection Support:[1] (855) 332-8815

### **A&D INSTRUMENTS LIMITED**

Unit 24/26 Blacklands Way, Abingdon Business Park, Abingdon, Oxfordshire OX14 1DY United Kingdom  
Telephone: [44] (1235) 550420 Fax: [44] (1235) 550485

### **A&D AUSTRALASIA PTY LTD**

32 Dew Street, Thebarton, South Australia 5031, AUSTRALIA  
Telephone: [61] (8) 8301-8100 Fax: [61] (8) 8352-7409

### **A&D KOREA Limited**

한국에이.엔.디(주)  
서울특별시 영등포구 국제금융로6길33 (여의도동) 맨하탄빌딩 817 우편 번호 07331  
( 817, Manhattan Bldg., 33. Gukjegeumyung-ro 6-gil, Yeongdeungpo-gu, Seoul, 07331 Korea )  
전화: [82] (2) 780-4101 팩스: [82] (2) 782-4264

### **ООО A&D RUS**

### **ООО "ЭЙ энд ДИ РУС"**

Почтовый адрес:121357, Российская Федерация, г.Москва, ул. Вереysкая, дом 17  
Юридический адрес: 117545, Российская Федерация, г. Москва, ул. Дорожная, д.3, корп.6, комн. 86  
( 121357, Russian Federation, Moscow, Vereyskaya Street 17 )  
тел.: [7] (495) 937-33-44 факс: [7] (495) 937-55-66

### **A&D Instruments India Private Limited**

### **ऐ&डी इन्स्ट्रुमेंट्स इण्डिया प्रा० लिमिटेड**

509, उद्योग विहार , फेस -5, गुडगांव - 122016, हरियाणा , भारत  
( 509, Udyog Vihar, Phase-V, Gurgaon - 122016, Haryana, India )  
फोन : [91] (124) 4715555 फैक्स : [91] (124) 4715599

### **A&D SCIENTECH TAIWAN LIMITED. A&D台灣分公司 艾安得股份有限公司**

台灣台北市中正區青島東路5號4樓  
( 4F No.5 Ching Tao East Road, Taipei Taiwan R.O.C. )  
Tel : [886](02) 2322-4722 Fax : [886](02) 2392-1794

### **A&D INSTRUMENTS (THAILAND) LIMITED**

### **บริษัท เอ แอนด์ ดี อินสตรูमेंท์ (ไทยแลนด์) จำกัด**

168/16 หมู่ที่ 1 ตำบลรังสิต อำเภอธัญบุรี จังหวัดปทุมธานี 12110 ประเทศไทย  
( 168/16 Moo 1, Rangsit, Thanyaburi, Pathumthani 12110 Thailand )  
Tel : [66] 20038911