

## B. GENERAL TESTS

### Specific Gravity

Specific Gravity means the ratio of the mass of a sample to that of an equal volume of a standard substance. In this test, the specific gravity ( $d_t^t$ ) means the ratio of the weight of the sample at  $t'$  to that of an equal volume of distilled water at  $t$ . When the specific gravity only is given, unless otherwise specified, it means the ratio of the weight ( $d_{20}^{20}$ ) of the sample at 20 to that of an equal volume of distilled water at 20. Unless otherwise specified, the measurement is performed by Method 1, Method 2, or Method 4. When the figure specified is accompanied with "about," Method 3 is also applicable.

**Method 1. Measurement by Pycnometer** A pycnometer is a bottle with a capacity of usually 10 ml to 100 ml, having a ground-glass stopper fitted with a thermometer, and a side inlet-tube with a marked line and a ground-glass cap.

Weigh accurately a pycnometer, previously cleaned and dried, and note the weight  $W$ . Remove the stopper and the cap, fill the pycnometer with the sample, keeping at a temperature 1 - 3 lower than the specified temperature ( $t'$ ), and stopper, preventing bubble formation. Raise the temperature gradually, when the thermometer shows the specified temperature, remove the portion of the sample above the mark from the side tube, and stopper the side tube. Wipe the outside surface thoroughly, weigh accurately, and note the weight  $W_1$ . Perform the same procedure, using the same pycnometer containing distilled water, note the weight  $W_2$  at the specified temperature ( $t$ ). Calculate the specific gravity ( $d_t^t$ ) by the formula

$$d_t^t = \frac{W_1 - W}{W_2 - W}$$

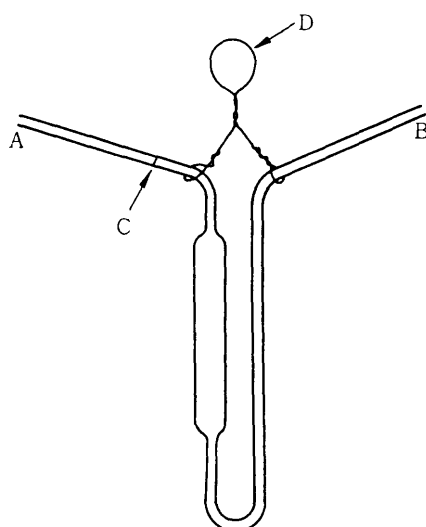
**Method 2. Measurement by Sprengel-Ostwald Pycnometer** The Sprengel-Ostwald pycnometer (Figure) usually has a capacity of 1 to 10 ml, with thick-walled fine tubes at both ends. On one of the fine tube (A), there is a marked line (C). When weighing, attach platinum wire (or aluminum wire, etc.) D so that the pycnometer is hung with the wire on the hook of the chemical balance.

Weigh accurately the pycnometer, previously cleaned and dried, and note weight  $W$ . Immerse fine tube B without marked line in the sample kept at a temperature 3 - 5 lower than the specified temperature. Attach a rubber tube or a ground-glass tube to the end of A, and gently suck up the sample until the forefront comes up above marked line C, preventing bubble formation. Immerse the pycnometer in a

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water bath kept at the specified temperature ( $t'$ ) for 15 minutes, and then, by attaching a piece of filter paper to the end of B, adjust the front of the sample to marked line C. After taking the pycnometer out of the water bath and wiping its outside well, weigh accurately its weight ( $W_1$ ). By use of the same pycnometer, perform the same determination with distilled water. Weigh accurately the pycnometer containing distilled water at the specified temperature ( $t$ ), and note weight  $W_2$ . Calculate the specific gravity ( $d_t^{t'}$ ) by the formula

$$d_t^{t'} = \frac{W_1 - W}{W_2 - W}$$



**Method 3. Measurement by Hydrometer** Use a hydrometer for the specified temperature with the required precision. Before using, clean with ethanol or ether.

Shake the sample well. After the bubbles disappear, place the hydrometer in the sample. When the hydrometer comes to a standstill at the specified temperature, read the specific gravity at the upper brim of the meniscus. When using a hydrometer with specific instructions, make a reading in accordance with the instruction.

### **Method 4. Measurement by Oscillator-Type Density Meter**

Measurement with an oscillator-type density meter is designed to determine the specific gravity of a liquid or gaseous sample from the density of the sample obtained by measuring the intrinsic vibration period ( $T$  (s)), of a cell filled with the sample. The specific gravity is determined from the mass of reference substances. When a cell containing a sample is vibrated, it undergoes a vibration with an intrinsic vibration period ( $T$ ) in proportion to the mass of the sample. If the volume of the vibrating part of the sample cell is fixed, the relation of the square of intrinsic oscillation period and density of the sample shall be

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linear. Before measuring a sample density, the respective intrinsic oscillation periods,  $T_{s1}$  and  $T_{s2}$ , for two reference substances (density:  $\rho_{s1}$ ,  $\rho_{s2}$ ) must be measured at a specified temperature ( $t'$ ), and the cell constant  $K_{t'}$  ( $\text{g}\cdot\text{cm}^{-3}\text{s}^{-2}$ ) must be determined by the formula

$$K_{t'} = \frac{\rho_{s1} - \rho_{s2}}{T_{s1}^2 - T_{s2}^2}$$

Usually, water and dried air are used as reference substances. Here the density of water at  $t'$  °C,  $\rho_{s1}$ , is obtained from the attached table, and that of dried air  $\rho_{s2}$  is calculated by the formula

$$\rho_{s2} = 0.0012932 \times \{273.15/(273.15 + t')\} \times (p/101.325),$$

where the pressure of dried air is at  $p$  kPa.

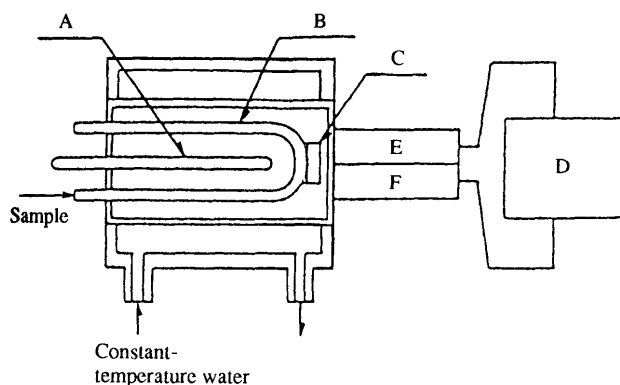
Next, introduce the sample into a sample cell of a cell constant ( $K_{t'}$ ) and measure the intrinsic vibration period ( $T_T$ ) of the sample under the same operating conditions as used for the reference substances. Then, determine the density of the sample ( $\rho_{t'}$ ) using the intrinsic oscillation period ( $T_{s1}$ ) and the density of water ( $\rho_{s1}$ ) at a specified temperature ( $t'$  °C) by the formula

$$\rho_{t'} = \rho_{s1} + K_{t'} (T_T^2 - T_{s1}^2).$$

Then, determine the specific gravity of a sample ( $d_{t'}$ ) against water at a temperature ( $t'$  °C) using the density of water ( $\rho_{s1}$ ) at a temperature ( $t'$  °C) indicated in the table by the formula

$$d_{t'} = \rho_{t'} / \rho_{s1}.$$

**Apparatus** An oscillator-type density meter is usually composed of a U-shaped glass tube cell of about 1 ml volume, the end of which is fixed to the vibration plate, an oscillator which applies an initial vibration to the cell, a detector to measuring the intrinsic vibration period, and a temperature controlling system. The apparatus is illustrated in the figure.



- A : Thermometer
- B : Sample cell
- C : Vibration plate
- D : Amplifier
- E : Detector
- F : Vibrator

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### Procedure

Adjust previously the sample cell, water, and the sample to a specified temperature ( $t^{\circ}\text{C}$ ). Wash the sample cell with water or an appropriate solvent, and dry it thoroughly with a flow of dried air. Stop the flow of dried air, confirm that the temperature is at the specified value, and then measure the intrinsic oscillation period  $T_{s2}$  given by the dried air. Separately, measure the atmospheric pressure ( $p$  kPa) at the place of determination. Next, introduce water into the sample cell and measure the intrinsic oscillation period ( $T_{s1}$ ) for water. Determine the cell constant ( $K_t$ ) of the sample, using the intrinsic oscillation period and the atmospheric pressure for each of water and dried air by above-mentioned formula.

Next, introduce a sample into the glass cell, confirm that the specified temperature is kept, and measure the intrinsic oscillation period  $T_T$  for the sample. Obtain the density of the sample ( $\rho_T$ ), using the intrinsic oscillation periods for water and the sample, the density of water ( $\rho_{s1}$ ), and the cell constant ( $K_t$ ). If necessary, calculate the specific gravity of the sample ( $d^t_t$ ) against water at a temperature ( $t^{\circ}\text{C}$ ), using the density of water ( $\rho_{s1}$ ) given in the table above.

In this measurement, avoid the occurrence of bubble formation in the sample cell, when introducing the sample or water into the cell.

Temperature	Density g/cm <sup>3</sup>	Temperature	Density g/cm <sup>3</sup>	Temperature	Density g/cm <sup>3</sup>	Temperature	Density g/cm <sup>3</sup>
0	0.99984	10	0.99970	20	0.99820	30	0.99565
1	0.99990	11	0.99961	21	0.99799	31	0.99534
2	0.99994	12	0.99950	22	0.99777	32	0.99503
3	0.99996	13	0.99938	23	0.99754	33	0.99470
4	0.99997	14	0.99924	24	0.99730	34	0.99437
5	0.99996	15	0.99910	25	0.99704	35	0.99403
6	0.99994	16	0.99894	26	0.99678	36	0.99368
7	0.99990	17	0.99877	27	0.99651	37	0.99333
8	0.99985	18	0.99860	28	0.99623	38	0.99297
9	0.99978	19	0.99841	29	0.99594	39	0.99259