

When the determination is made by weighing, the buoyancy of air is disregarded, which may introduce an error of 1 unit in the 3<sup>rd</sup> decimal place. When using a density meter, the buoyancy of air has no influence.

*Oscillating transducer density meter.* The apparatus consists of:

- a U-shaped tube, usually of borosilicate glass, which contains the liquid to be examined;
- a magneto-electrical or piezo-electrical excitation system that causes the tube to oscillate as a cantilever oscillator at a characteristic frequency depending on the density of the liquid to be examined;
- a means of measuring the oscillation period ( $T$ ), which may be converted by the apparatus to give a direct reading of density, or used to calculate density using the constants  $A$  and  $B$  described below.

The resonant frequency ( $f$ ) is a function of the spring constant ( $c$ ) and the mass ( $m$ ) of the system:

$$f^2 = \frac{1}{T^2} = \frac{c}{m} \times \frac{1}{4\pi^2}$$

Hence:

$$T^2 = \left( \frac{M}{c} + \frac{\rho \times V}{c} \right) \times 4\pi^2$$

$M$  = mass of the tube,

$V$  = inner volume of the tube.

Introduction of 2 constants  $A = c / (4\pi^2 \times V)$  and  $B = M/V$ , leads to the classical equation for the oscillating transducer:

$$\rho = A \times T^2 - B$$

The constants  $A$  and  $B$  are determined by operating the instrument with the U-tube filled with 2 different samples of known density, for example, degassed *water R* and air. Control measurements are made daily using degassed *water R*. The results displayed for the control measurement using degassed *water R* shall not deviate from the reference value ( $\rho_{20} = 0.998203 \text{ g cm}^{-3}$ ,  $d_{20}^{20} = 1.000000$ ) by more than its specified error. For example, an instrument specified to  $\pm 0.0001 \text{ g cm}^{-3}$  shall display  $0.9982 \pm 0.0001 \text{ g cm}^{-3}$  in order to be suitable for further measurement. Otherwise a re-adjustment is necessary. Calibration with certified reference materials is carried out regularly. Measurements are made using the same procedure as for calibration. The liquid to be examined is equilibrated in a thermostat at 20 °C before introduction into the tube, if necessary, to avoid the formation of bubbles and to reduce the time required for measurement.

Factors affecting accuracy include:

- temperature uniformity throughout the tube,
- non-linearity over a range of density,
- parasitic resonant effects,
- viscosity, whereby solutions with a higher viscosity than the calibrant have a density that is apparently higher than the true value.

The effects of non-linearity and viscosity may be avoided by using calibrants that have density and viscosity close to those of the liquid to be examined ( $\pm 5$  per cent for density,  $\pm 50$  per cent for viscosity). The density meter may have functions for automatic viscosity correction and for correction of errors arising from temperature changes and non-linearity.

Precision is a function of the repeatability and stability of the oscillator frequency, which is dependent on the stability of the volume, mass and spring constant of the cell.

Density meters are able to achieve measurements with an error of the order of  $1 \times 10^{-3} \text{ g cm}^{-3}$  to  $1 \times 10^{-5} \text{ g cm}^{-3}$  and a repeatability of  $1 \times 10^{-4} \text{ g cm}^{-3}$  to  $1 \times 10^{-6} \text{ g cm}^{-3}$ .

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## 2.2.6. REFRACTIVE INDEX

The refractive index of a medium with reference to air is equal to the ratio of the sine of the angle of incidence of a beam of light in air to the sine of the angle of refraction of the refracted beam in the given medium.

Unless otherwise prescribed, the refractive index is measured at  $20 \pm 0.5$  °C, with reference to the wavelength of the D-line of sodium ( $\lambda = 589.3 \text{ nm}$ ); the symbol is then  $n_D^{20}$ .

Refractometers normally determine the critical angle. In such apparatus the essential part is a prism of known refractive index in contact with the liquid to be examined.

Calibrate the apparatus using certified reference materials.

When white light is used, the refractometer is provided with a compensating system. The apparatus gives readings accurate to at least the third decimal place and is provided with a means of operation at the temperature prescribed. The thermometer is graduated at intervals of 0.5 °C or less.

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## 2.2.7. OPTICAL ROTATION

Optical rotation is the property displayed by chiral substances of rotating the plane of polarisation of polarised light.

Optical rotation is considered to be positive (+) for dextrorotatory substances (i.e. those that rotate the plane of polarisation in a clockwise direction) and negative (–) for laevorotatory substances.

The specific optical rotation  $[\alpha_m]_{\lambda}^t$  is the rotation, expressed in radians (rad), measured at the temperature  $t$  and at the wavelength  $\lambda$  given by a 1 m thickness of liquid or a solution containing 1 kg/m<sup>3</sup> of optically active substance. For practical reasons the specific optical rotation  $[\alpha_m]_{\lambda}^t$  is normally expressed in milliradians metre squared per kilogram ( $\text{mrad m}^2 \text{ kg}^{-1}$ ).

The Pharmacopoeia adopts the following conventional definitions.

The *angle of optical rotation* of a neat liquid is the angle of rotation  $\alpha$ , expressed in degrees (°), of the plane of polarisation at the wavelength of the D-line of sodium ( $\lambda = 589.3 \text{ nm}$ ) measured at 20 °C using a layer of 1 dm; for a solution, the method of preparation is prescribed in the monograph.

The *specific optical rotation*  $[\alpha]_D^{20}$  of a liquid is the angle of rotation  $\alpha$ , expressed in degrees (°), of the plane of polarisation at the wavelength of the D-line of sodium ( $\lambda = 589.3 \text{ nm}$ ) measured at 20 °C in the liquid substance to be examined, calculated with reference to a layer of 1 dm and divided by the density expressed in grams per cubic centimetre.

The *specific optical rotation*  $[\alpha]_D^{20}$  of a substance in solution is the angle of rotation  $\alpha$ , expressed in degrees (°), of the plane of polarisation at the wavelength of the D-line of sodium ( $\lambda = 589.3 \text{ nm}$ ) measured at 20 °C in a solution of the substance to be examined and calculated with reference