2.1.2 Barometry

Barometric units

The pascal (Pa) is the name given to the SI unit of pressure, the newton per square metre. Following the 8th Congress of the World Meteorological Organization the hectopascal (hPa) became, on 1 January 1986, the preferred unit for the measurement of pressure for meteorological purposes. Many barometers in current use, however, bear millibar (mbar), conventional millimetre of mercury (mmHg) or conventional inch of mercury (inHg) scales.

1 hPa = 1 mbar = 100 Pa
1 mmHg = 133.322 4 Pa
1 inHg = 3 386.39 Pa

Note: the reference condition known as a standard atmosphere (atm) is defined as 101 325 Pa, which is equal to 760 mmHg to within 1 part in 7 million. It should not now be used as a unit of pressure, but only to define a standard reference environment.

General-purpose mercurial barometers conforming with BS 2520:1983 *Barometer Conventions and Tables, their application and use* are manufactured to measure pressures directly (except for a calibration correction) when they are subjected to *standard conditions*, that is a temperature of 0 °C and an acceleration due to gravity of 9.806 65 ms^{-2}. In practice, conditions are usually different and it is therefore necessary to take account of the local value of gravity and the barometer’s temperature when its vernier is set. Tabulated corrections are given in BS 2520:1983 but they may be calculated from a knowledge of local gravitational acceleration, the barometer’s vernier reading and its temperature.

Calculation of pressure from Fortin barometer readings

$$\text{Pressure} = \frac{g}{9.806\ 65}\left[R + c - R\left(\frac{(\beta - \alpha)t}{(1 + \beta t)}\right)\right]$$

where *R* is the barometer reading

c is its calibration correction (see note 1 below)
g is the acceleration due to gravity at the point of observation in m s^{-2} (see note 2 below)
β is the coefficient of expansion of mercury (taken to be 0.000 181 8/°C)
α is the coefficient of linear expansion of the scale (taken to be 0.000 018 4/°C for brass)
t is the temperature of the barometer in °C

At normal room temperatures the correction for instruments with brass scales approximates closely to the simpler expression:

$$\text{Pressure} = \frac{g}{9.806\ 65}\left[R + c - 0.000\ 163Rt\right]$$

Calculation of pressure from Kew pattern barometer readings

$$\text{Pressure} = \frac{g}{9.806\ 65}\left[R + c - R\left(\frac{(\beta - \alpha)t}{(1 + \beta t)}\right) - \frac{V}{A} f\,(\beta - 0.000\ 030)t\right]$$

where the symbols are as above and

$\frac{V}{A}$ is a geometrical factor in millimetre units which should be inscribed on the barometer;

f is a unit conversion factor: 1.333 for a hPa or mbar scale,
1.000 for a mmHg scale,
0.039 37 for an inHg scale.

The value of 0.000 030/°C in the equation represents an expansion coefficient which allows for a steel cistern and the glass tube. At normal room temperatures the correction for instruments with brass scales approximates closely to the simpler expression:

$$\text{Pressure} = \frac{g}{9.806\,65}\left[R + c - 0.000\,163\,Rt - 0.000\,152\frac{V}{A}\,\text{ft}\right]$$

Note 1: Although both Fortin and Kew pattern barometers are fundamental in operation, calibration is necessary to evaluate any corrections arising from capillarity effects, scale errors, inadequate reference vacuum, etc.
Note 2: The value of g may be calculated in terms of geographical latitude and height above sea level using the formula in section 2.7.5.

Calculation of pressure at different heights

A mercury barometer measures atmospheric pressure at the level of its lower mercury surface. Should a pressure value at a different level be required, an allowance has to be made for the hydrostatic pressure exerted by the intervening vertical air column. To correct for small height differences, such as from floor to floor in a laboratory, the pressure at height H metres *above* the barometer's lower mercury surface is given by

$$P_H = P - \rho_a gH/U$$

where P is the pressure at the barometer's lower surface
ρ_a is the density of the intervening vertical air column in kg/m^3 (see section 2.1.1)
U is a factor which converts the height correction term from pascals to the pressure units used.

Note: This expression is only correct for small height differences and provided there are no other causes of pressure differential such as wind or air conditioning fans.

Capillary depression

Capillary forces tend to depress the surface of mercury columns by an amount which depends on the column diameter, the surface tension and the angle of contact between the mercury surface and the boundary wall. Barometer manufacturers usually make an allowance for this effect by off-setting the scale (under standard conditions, the mercury surface in an 8mm diameter tube can be depressed by up to about 1 mm). Long-term changes in capillary depression do occur, however; this is usually because the angle of contact and the surface tension change as the mercury surface becomes contaminated. Changes in capillary depression are most easily detected by calibrating the barometer against a more accurate instrument.

Barometers used as primary instruments should either have their readings corrected for capillary depression (Gould and Vickers, 1952) or be of sufficient diameter to render the correction negligible (with a 40mm diameter tube, the capillary depression is about 0.000 1 mm).

Reference

F. A. Gould and T. Vickers (1952) *J. Sci. Instrum.*, **29**, 85–7.

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