

## BTPS Correction for Flow and Volume

BTPS Correction is used to convert flow and volume measured at ambient conditions to the conditions within the lungs. Ambient conditions are called ATP (ambient temperature, pressure); the conditions within the lungs are called BTPS (body temperature, pressure, water vapor saturated).

The BTPS correction differs between inspiration and expiration:

- Expiration:** Expiratory flow is water vapor saturated, and almost at body temperature. The small temperature difference between the lung temperature and the temperature of the gas within the flow sensor is usually corrected with a fixed BTPS correction factor of 2%.
- Inspiration:** Inspiratory flow is measured at ambient conditions and has to be converted to lung conditions. In this case the conversion is performed using the BTPS formula shown below. Correction factors are usually in the range of 8 to 12% (see below).

The following formula is used to compute the BTPS correction factor:

$$\frac{V_{BTPS}}{V_{ATP}} = \frac{T_{body}}{T_{amb}} \cdot \frac{P_{amb} - P_{H_2O}(T_{amb}, H_{amb})}{P_{amb} - P_{H_2O}(T_{body}, H_{body})}$$

Where  $V_{BTPS}$  represents the volume at BTPS conditions,  $V_{ATP}$  the volume at ATP conditions,  $P_{amb}$  the ambient pressure,  $P_{H_2O}$  the water vapor saturation pressure,  $T_{amb}$  and  $T_{body}$  ambient and body temperature (in Kelvin),  $H_{amb}$  and  $H_{body}$  ambient and body humidity.

The BTPS correction factor is computed using the following information provided by the user, or measured by sensors: Ambient temperature, ambient humidity and altitude. If an ambient pressure sensor is not available, altitude information is converted to an approximate pressure value using the following formula:

$$P_{amb} = P_0 \cdot \left(1 - \frac{0.0065 \cdot h}{288}\right)^{5.255}$$

The pressure  $P_{amb}$  at altitude  $h$  is computed using the reference pressure  $P_0$  (1013 hPa) and the altitude  $h$  in meters. The following table lists some examples of BTPS correction factors. Please note that a BTPS correction factor of 1.12 corresponds to a correction of 12%.

Ambient Temperature in °C	Ambient Pressure in hPa	Ambient Humidity in %	Body Temperature in °C	BTPS correction factor	Remarks
20	1013	50%	37	<b>1.115</b>	Normal conditions at sea level
20	898	50%	37	<b>1.123</b>	Normal conditions at 1000 m
20	1013	30%	37	<b>1.121</b>	Low humidity at sea level
37	1013	50%	37	<b>1.033</b>	High temperature
37	1013	100%	37	<b>1.000</b>	High temperature and humidity
20	616	20%	37	<b>1.170</b>	Altitude of 4000 m

It can well be seen that the correction factor is approx. 12% for normal conditions. An altitude change of 1000 m changes the BTPS correction factor only by 0.7%. If temperature (and humidity) are high the correction factor decreases. If inspired temperature and humidity correspond to lung conditions no correction has to be applied (correction factor 1.0). At high altitudes, low temperature and low humidity the correction factor can be very high, as in the example shown above 17%.