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# Atmospheric Conditions Affect CO<sub>2</sub> Measurement Accuracy

All popular carbon dioxide measurement techniques fundamentally measure the number of CO<sub>2</sub> molecules in a certain fixed volume. This is also the case with the newest Non-Dispersive InfraRed (NDIR) techniques, e.g. Vaisala's CARBOCAP® sensor.

The customer preferred output for CO<sub>2</sub> measurement is volume/volume, usually expressed in %-vol or ppm<sub>vol</sub>. So a CO<sub>2</sub> measurement instrument must be adjusted to output volume/volume from the measured weight/volume. This is done by calibrating and adjusting the unit against a known CO<sub>2</sub> gas concentration and by considering the compressibility of gas. The compressibility is accounted for by correcting the volume concentration of the calibration gas by the ambient atmospheric pressure and temperature. See formula 1.

$$CVC = UCR \times \frac{1013 \times (t + 273)}{298 \times p}$$

Formula 1. Correcting gas concentration for atmospheric conditions.

CVC = corrected volume concentration (ppm or % CO<sub>2</sub>)  
UCR = uncorrected reading  
p = ambient pressure (hPa)  
t = ambient temperature (°C)

Thus, the calibration will result in the instrument outputting the best accuracy in the most common measurement conditions (exact output at 1013 hPa



A cutaway of Vaisala's CARBOCAP® CO<sub>2</sub> sensor: (1) an InfraRed source, (2) an F-P filter and (3) an IR detector.

pressure and +25 °C temperature). If the actual measurement environment differs very much from this, a small error will be introduced in the output. For example, if we are measuring at 1013 hPa and +35 °C, the output will be 3 % lower than the actual CO<sub>2</sub> concentration. Similarly, during a low pressure weather front with an atmospheric pressure of 980 hPa and at a temperature of +25 °C, the error will be -3 %. Formula (1) can also be used to

calculate the error in different operating conditions.

The measurement error induced by different atmospheric conditions is so small under normal use that it does not need to be compensated for. But in certain extreme conditions, e.g. in high altitudes, the error may be impractically large for some applications. If this is the case, the unit can be recalibrated in the typical atmospheric conditions of operation, to ensure greater accuracy. ■