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Application Note 150 Application Example using the O2100C Module

Technical Use Notes

The O2100C module can be used to perform real-time oxygen concentration monitoring. The O2100C module may be used to perform analysis of expired air during the course of a pulmonary function or exercise physiology test. This application note will focus on the use of the O2100C module for estimating oxygen consumption (VO_2).

When performing a test of this kind, many factors exist to confound the measurement. For example, it may be reasonable to think that the volume of expired air is always the same as inspired air, but this is only true when the volume of carbon dioxide expired is equal to the amount of oxygen consumed. In other words, the inspired and expired volumes are equal only when the Respiratory Exchange Ratio (RER) equals one. The Respiratory Exchange Ratio is defined as VCO_2 divided by VO_2. (V is Volume.) For purposes of simplicity, this application note will assume that RER = 1.

An additional factor affecting oxygen consumption measurement is the response time of the O2100C module. Nominally, the step response time of the O2100C module is 500 msec for 100 ml/min flow rate. For breath rates exceeding 42 BPM (using the formula: Tr = 0.35 / Fh), the O2100C will begin to attenuate its response to oxygen changes.

When measuring O_2 concentration changes during the course of a breathing cycle without the use of a mixing chamber, the response time of the CO2100C module is critical. It is possible, for certain applications (i.e. breath-by-breath analysis,) to improve the response time by increasing the sampling flow rate of the O2100C module.

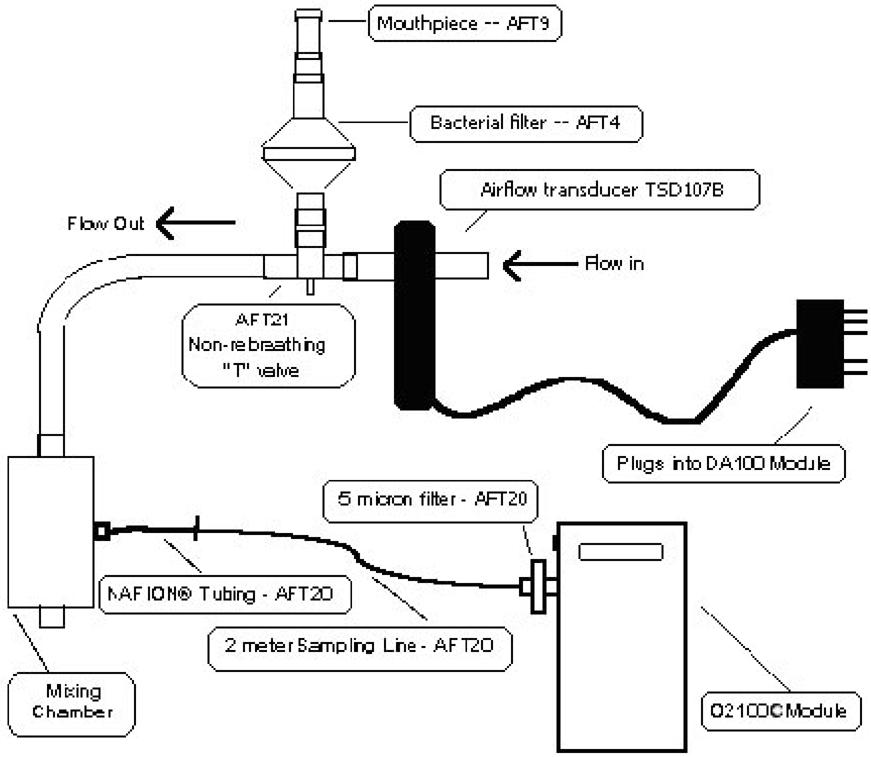
Naturally, when using a mixing chamber to average O_2 concentration over a few breaths, there is no performance degradation when measuring O_2 concentration changes for arbitrarily high breathing rates. Accordingly, a mixing chamber is typically recommended for quick, accurate and easy metabolic analysis.

The O2100C module is normally used in conjunction with an MP system. The O2100C connects to the monitored gas flow via the AFT20 Gas Sampling Interface Kit. The AFT20 kit is used to connect the O2100C module to a mixing chamber (typically 5 liters) which is on the output end of a non-rebreathing ñTòvalve (like the AFT21). The input end of the ñTòvalve connects to a Pneumotach (airflow) transducer, like the TSD107B.

Because the O2100C module is connected to the mixing chamber, the module will sense the changes in oxygen concentration occurring as the subject breathes. Furthermore, because the TSD 107B is placed in the ñFlow Inòline, the total volume of inspired air can be calculated on a breath-by-breath basis. Finally, because both the oxygen concentration and total volume of expired air is known (assuming RER = 1), it is possible to estimate the approximate amount of oxygen consumed by the subject during the course of breathing.

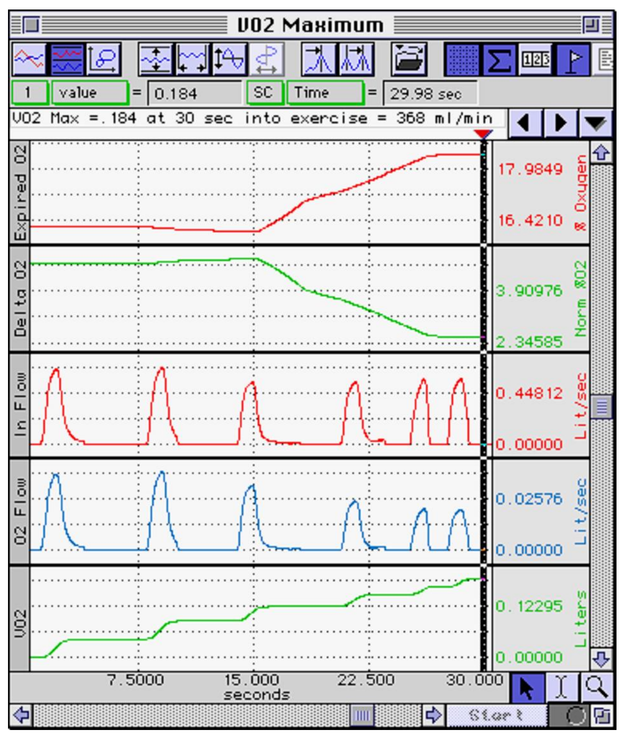
Like all gas sampling equipment, the module measures the partial pressure of oxygen in its internal sample cell, and is therefore sensitive to changes in ambient pressure. When connecting the module sampling line to the mixing chamber, ambient pressure influences on the oxygen reading are minimal.

The following diagram illustrates a typical connection for the O2100C module to the AFT21 and TSD107B. The subject breathes through the mouthpiece (AFT9) which attaches to the non-rebreathing ñTòvalve (AFT21) via a bacteria filter (AFT4). When the subject inspires, air is drawn into the AFT21, through the TSD107B airflow transducer, as shown by the ñFlow Inòarrow. When the subject expires, air is forced out through the mixing chamber.



CO2100C Connection to Mixing Chamber, AFT21 and TSD107B

The following graph illustrates data collected using the previously defined setup procedure. The waveforms shown are calculated and derived by Acq*Knowledge* in real time. The waveform descriptions are as follows:



Waveform 1 – Expired O_2

This waveform is the O2100C module output. The O2100C module samples the O_2 concentration directly from the mixing chamber.

Waveform 2 – Delta O_2

This waveform is the O_2 concentration in the mixing chamber subtracted from the O_2 concentration in the ambient environment (O_2 = 20.93%). This waveform is the concentration consumed.

Waveform 3 – Inspired Flow

This waveform is generated by the TSD107B, which is connected to a DA100C module. This waveform is the total inspired air flow. Please note that this application note assumes inspired air flow to be equal to expired air flow (RER = 1).

Waveform 4 – O_2 Flow

This waveform is the mathematical result of multiplying the expired air flow measured by the TSD107B (Waveform 3) by the oxygen concentration (Waveform 2). Accordingly, this waveform is the oxygen flow consumed by the subject. Note how the flow signal drops as the normalized oxygen concentration level drops.

Waveform 5 – VO_2

This waveform is the integral of the oxygen flow consumed by the subject. The integral of the oxygen flow is the amount of oxygen consumed up to a particular point in time. In this case, VO_2 equaled 184 ml after 30 seconds of exercise, which extends to an estimate of 368 ml/min oxygen consumption.

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