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APPLICATION NOTE

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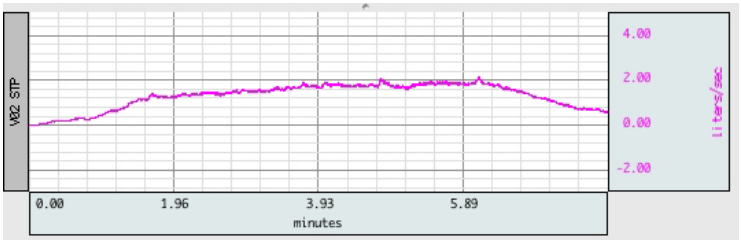
Application Note 252 Aerobic Capacity, Physical Fitness and VO_2 Maximum Measurement



Overview

Aerobic capacity is also known as maximal oxygen uptake or maximum oxygen consumption (VO_2 max). VO_2 max is the maximum capacity of a subject to transport (uptake) oxygen and utilize it during exercise. VO_2 max is an indication of the physical fitness of the subject.

VO_2 max can be expressed two ways:

1. Absolute: Liters of oxygen per minute (L/min)
2. Normalized: milliliters of oxygen per kilogram of subject bodyweight per minute (ml/kg/min)

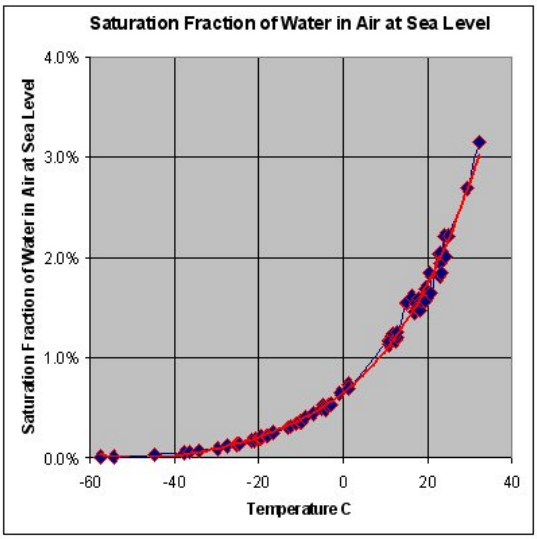
This application note illustrates the aerobic capacity measurement as indicated by VO_2 max.

Equipment

- MP160/150 data acquisition system (MP150WS Mac based system used for data shown in this application note)
- DA100C general-purpose Differential bridge amplifier
- TSD107B Pneumotach Air Flow Transducer (High Flow)
- O2100C Oxygen concentration measurement amplifier
- AFT25 Face Mask with T-valve
- AFT20 Gas Sampling Interface Kit
- 3 x AFT7 Smooth bore tubing (1 m)
- AFT15A 5-liter mixing chamber

Hardware Setup

1. Use AFT7 tubing to connect the AFT15A mixing chamber to the output port of the AFT25 face mask non-rebreathing “T” valve.
2. Use AFT7 tubing to connect the input port of the AFT25 face mask to the TSD107B Pneumotach.
3. Connect the TSD107B to the DA100C differential amplifier.
4. Use an additional section of AFT7 tubing to the output port of the AFT15A mixing chamber to eliminate the possibility of ambient air corrupting the oxygen concentration measurement.
5. Connect the O2100C to AFT15A mixing chamber with AFT20 gas sampling interface kit.
6. Connect one end of AFT7 tubing to the output port of the AFT15A mixing chamber and leave the other end open.



V02 Max Measurements & Assumptions

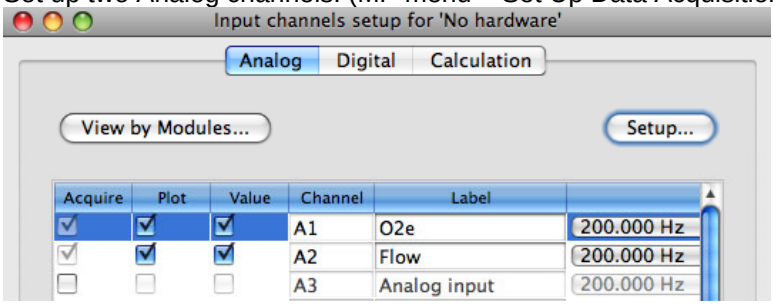
The following measurements and assumptions were made during the course of VO_2 max recording:

1. Measurement performed at ATP, then converted to STP.
2. Barometric pressure was 760 mmHg (1 atmosphere)
3. Room temperature was 72 deg F (22.22 deg C)
4. Saturation fraction of water in air at measurement site was 2%.
5. RER (respiratory exchange ratio) assumed to be unity during entire test.

6. Subject for data used for this application note was male, 29 years old, 84 kg (185 lbs).

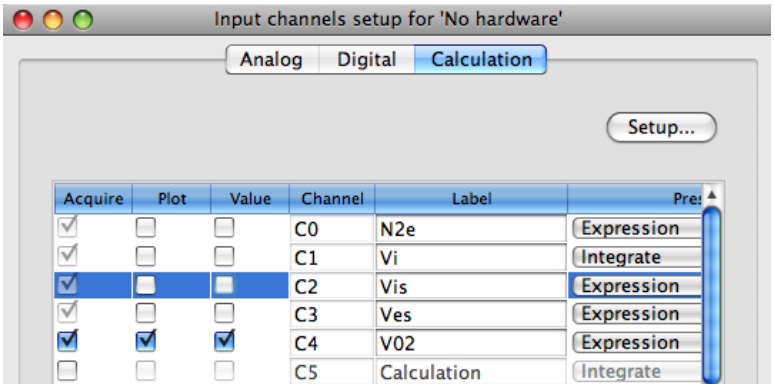
Software Setup

1. Set up two Analog channels. (MP menu > Set Up Data Acquisition > Channels.)

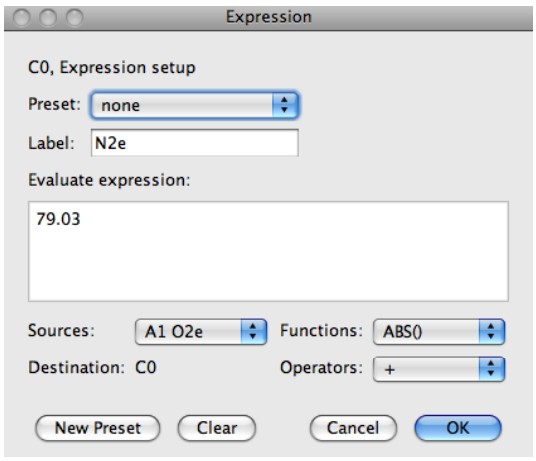


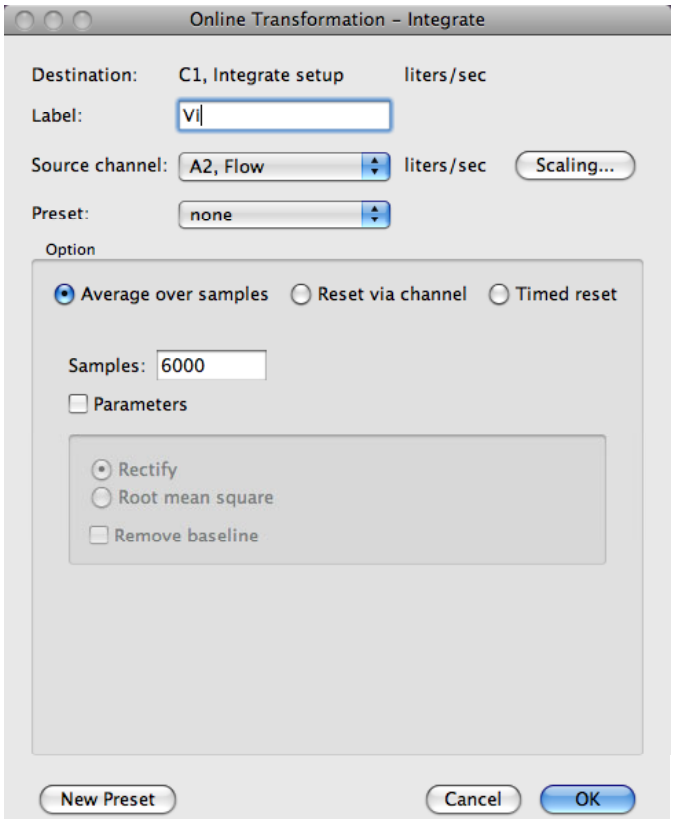
   a. O2e
   b. Flow

2. Set up five Calculation channels.



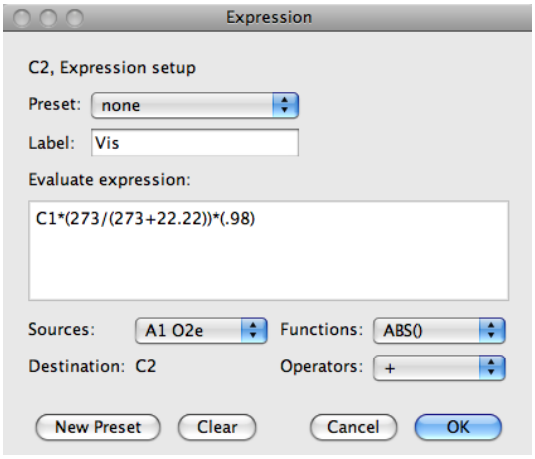
   a. N2e on calculation channel C0: Expression with source A1 set to 79.03
   b. Vi on calculation channel C1: Integrate with source A2 set to Average over samples for 6000 samples

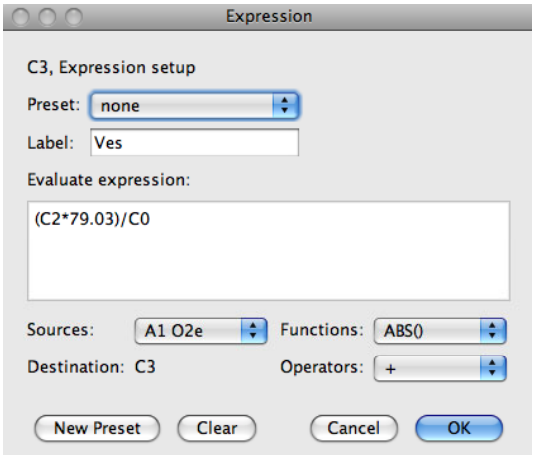




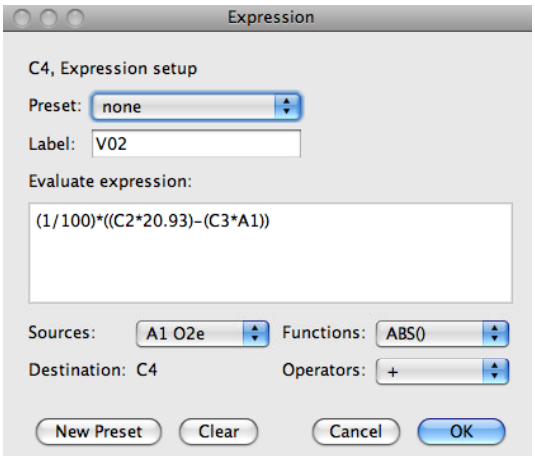
   c. Vis on calculation channel C2: Expression with source A1 set to C1*(273/(273+22.22))*(.98)

d. Ves on calculation channel C3: Expression with source A1 set to (C2*79.03)/C0





e. V02 on calculation channel C4: Expression with source A1 set to (1/100)*((C2*20.93)-(C3*A1)



Recording

1. Click “Start” in the Acq*Knowledge* software.
2. After the desired time interval, click “Stop” in the Acq*Knowledge* software.
   - For this application note, VO_2 measurement was performed for nearly 8 minutes.

Results

VO_2 max	ATP	STP
Absolute	4.72 Liters in one minute	4.37 liters in one minute
Normalized	56.2 mL per Kg per min	52 mL per Kg per min

Analysis

The top waveform on the following graph is the concentration of oxygen measured (using the O2100C via AFT20 Gas Sampling Interface Kit) inside the AFT15A mixing chamber.

Measurements were made at ATP (Ambient Temperature and Pressure). For ATP measurements, allowance must be made for the concentration of water vapor in the atmosphere. The factor 0.98 accounts for this volume. When the total volume of air inspired by subject is calculated by integrating the flow signal, this volume also includes the volume of water vapor. Multiplying by 0.98 (for the ambient measurements made) eliminates this errant factor from the measurement.

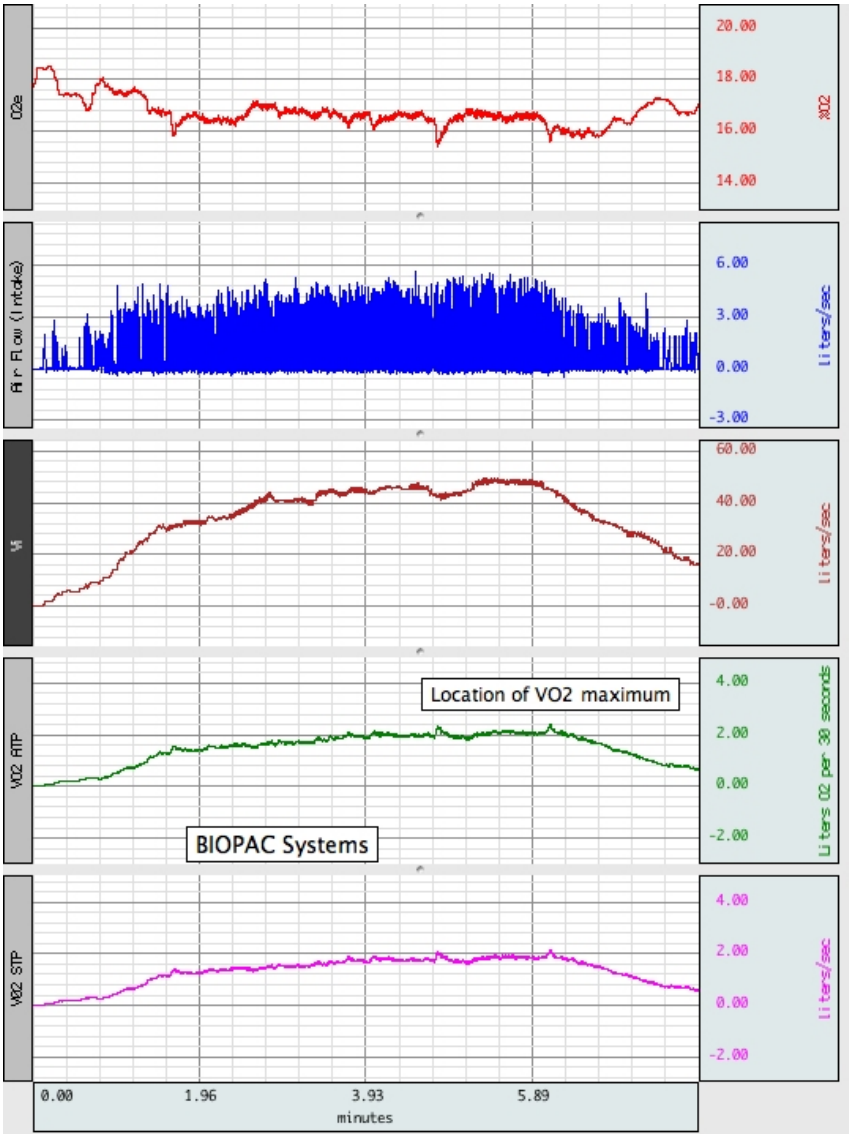
The VO_2 max signal peaked at 6.1 minutes into the recording. This value was 2.36 liters. VO_2 max over a 30 second integration interval was 2.36 liters of oxygen. Prorated to 60 seconds, this would be 4.72 liters of oxygen.

Body weight of male subject is 84 kg.

VO_2 max = 4.72 liters of oxygen per min / 84 Kg = 56.2 mL/min of O_2 per Kg of body weight

To convert the subject’s measurement to STP (Standard Temperature and Pressure), from ATP, multiply value of 56.2 mL per Kg per min by “0.925” giving a STP measurement of 52 mL/min per Kg.

- The conversion factor of 0.925 is derived from the gas law reference 273 / (273 + 22.22).



In the subject's age group, "superior" cardiovascular fitness would be indicated by VO_2 max equal to or greater than 52.4 mL/min per Kg, so the subject looks to have a rather high VO_2 measurement relative to his age group.

Normative data for VO_2max (values in ml/kg/min)

Gender	Age	Very Poor	Poor	Fair	Good	Excellent	Superior
Female	13-19	<25.0	25.0 - 30.9	31.0 - 34.9	35.0 - 38.9	39.0 - 41.9	>41.9
	20-29	<23.6	23.6 - 28.9	29.0 - 32.9	33.0 - 36.9	37.0 - 41.0	>41.0
	30-39	<22.8	22.8 - 26.9	27.0 - 31.4	31.5 - 35.6	35.7 - 40.0	>40.0
	40-49	<21.0	21.0 - 24.4	24.5 - 28.9	29.0 - 32.8	32.9 - 36.9	>36.9
	50-59	<20.2	20.2 - 22.7	22.8 - 26.9	27.0 - 31.4	31.5 - 35.7	>35.7
	60+	<17.5	17.5 - 20.1	20.2 - 24.4	24.5 - 30.2	30.3 - 31.4	>31.4
Male	13-19	<35.0	35.0 - 38.3	38.4 - 45.1	45.2 - 50.9	51.0 - 55.9	>55.9
	20-29	<33.0	33.0 - 36.4	36.5 - 42.4	42.5 - 46.4	46.5 - 52.4	>52.4
	30-39	<31.5	31.5 - 35.4	35.5 - 40.9	41.0 - 44.9	45.0 - 49.4	>49.4
	40-49	<30.2	30.2 - 33.5	33.6 - 38.9	39.0 - 43.7	43.8 - 48.0	>48.0
	50-59	<26.1	26.1 - 30.9	31.0 - 35.7	35.8 - 40.9	41.0 - 45.3	>45.3
	60+	<20.5	20.5 - 26.0	26.1 - 32.2	32.3 - 36.4	36.5 - 44.2	>44.2

Table Reference: The Physical Fitness Specialist Certification Manual, The Cooper Institute for Aerobics Research, Dallas TX, revised 1997 printed in Advance Fitness Assessment & Exercise Prescription, 3rd Edition, Vivian H. Heyward, 1998. p48.

