

Equations

Oxygen Consumption, Carbon Dioxide Production, and Methane Production

The following four equations are used to calculate oxygen consumption (VO_2), carbon dioxide production (VCO_2) and methane production (VCH_4). The oxygen consumption is calculated by taking the difference between the input oxygen flow and the output oxygen flow. Similarly, the carbon dioxide production is calculated by taking the difference between the output and input carbon dioxide flows. The methane production is calculated by taking the difference between the output and input methane flows. Note that the methane information is only applicable if a methane sensor is present. This equation requires the input ventilation rate (V_i) which is calculated using the Haldane transform. The nitrogen fractions needed in the Haldane transform are simply the balance of the input or output samples. The resultant consumption and production values have the units of milliliters per hour (ml/hr). Standard conversion factors are included in the calculation to result with the units selected in the Software Configuration.

$$VO_2 = V_i O_{2i} - V_o O_{2o}$$

V_i and V_o are the input and output ventilation rates (LPM)
 O_{2i} and O_{2o} are oxygen fractions at the input and output

$$VCO_2 = V_o CO_{2o} - V_i CO_{2i}$$

V_i and V_o are the input and output ventilation rates (LPM)
 CO_{2i} and CO_{2o} are carbon dioxide fractions at the input and output

$$VCH_4 = V_o CH_{4o} - V_i CH_{4i}$$

V_i and V_o are the input and output ventilation rates (LPM)
 CH_{4i} and CH_{4o} are methane fractions at the input and output

$$V_o = V_i \times \frac{N_i}{N_o}$$

N_i and N_o are nitrogen fractions at the input and output

$$N_x = 1 - O_2 - CO_2 - CH_4$$

N_x is the nitrogen fraction of the sample
 O_2 is the observed oxygen fraction of the sample
 CO_2 is the observed carbon dioxide fraction of the sample
 CH_4 is the observed methane fraction of the sample

Respiratory Exchange Ratio

The respiratory exchange ratio (RER) is simply the ratio between the carbon dioxide production and the oxygen consumption. This value is a ratio and thus does not have a unit. The RER ratio is calculated before any units conversion, weight normalization, or effective mass correction.

$$RER = \frac{VCO_2}{VO_2}$$

Heat

Oxymax will calculate heat with one of two methods. Both methods calculate the heat before the application of any normalization or correction and, thus, reflect the exact heat of the subject. The method termed Internal will derive a calorific value (CV) based on the observed respiratory exchange ratio. This calorific value is then used with the observed oxygen consumption (VO_2) to calculate heat. The equations are:

$$\text{Heat} = CV \times VO_2$$

$$CV = 3.815 + 1.232 \times RER$$

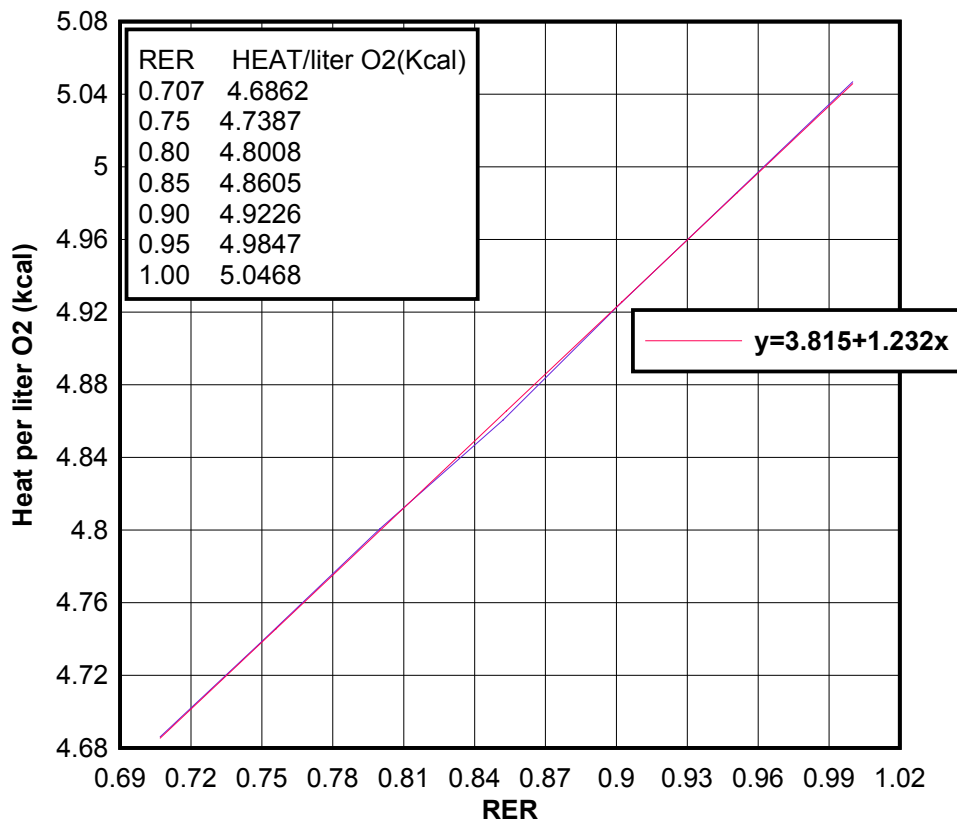
The constants are derived from the following data:

Table 3.2 Analysis of the oxidation of mixtures of carbohydrate and fat.¹
(Converted from the table of Lusk, 1928)

RER	% of total O2 consumed by:		% of total heat produced by:		Heat per liter of O2	
	Carbohydrate	fat	Carbohydrate	fat	(kJ)	(kcal)
0.707	0	100.0	0	100.0	19.62	4.6862
0.75	14.7	85.3	15.6	84.4	19.84	4.7387
0.80	31.7	68.3	33.4	66.6	20.10	4.8008
0.85	48.8	51.2	50.7	49.3	20.35	4.8605
0.90	65.9	34.1	67.5	32.5	20.61	4.9226
0.95	82.9	17.1	84.0	16.0	20.87	4.9847
1.00	100.0	0	100.0	0	21.13	5.0468

HEAT per liter of O2 vs. RER

Table 3.2 Analysis of the oxidation of mixtures of carbohydrate and fat.
(Converted from the table of Lusk,1928)



¹ From "Animal and Human Calorimetry" by McLean and Tobin, Cambridge Univ. Press 1987, ISBN 0-521-30905-0

A least squares linear fit to the data provides the formula $\text{Heat}(\text{kcal/liter of O}_2) = 3.815 + 1.232 \cdot \text{RER}$. Multiplication by VO_2 in liters/unit time yields a heat value in kcal/unit time.

Example calculation: assume $\text{VO}_2 = 4000 \text{ ml/hr/kg}$ for a 25 gram mouse and $\text{RER} = 0.85$.
 $\text{Heat (kcal/hr)} = (3.815 + 1.232 * 0.85) * 4000 \text{ ml/hr/kg} * 1\text{L}/1000 \text{ ml} * 1\text{kg}/1000\text{g} * 25 \text{ g} = 0.486 \text{ kcal/hr}$

The other method, termed User Defined, allows the user to enter calorific values (CV_x) relating to the oxygen consumption (VO_2) the carbon dioxide production (VCO_2), and the methane production (VCH_4). Note that the methane term drops out if a methane sensor is not present. Each of the calorific values is entered in the form Kcal/Liter of the respective gas. The equation used is:

$$\text{Heat} = \text{CV}_1 \times \text{VO}_2 + \text{CV}_2 \times \text{VCO}_2 + \text{CV}_3 \times \text{VCH}_4$$

Body Weight Normalization and Effective Mass Correction

VO_2 , VCO_2 , and VCH_4 values are normalized with respect to the animal body weight and corrected according to an effective mass value. A value of 1.0 will eliminate any effective mass correction.

$$\text{Normalized } V_{xx} = V_{xx} / [(\text{weight}(\text{g}) / \text{mass unit})^{\text{effective mass}}$$

Eg. $V_{xx} = 50 \text{ ml/hr}$, $\text{weight} = 25 \text{ grams}$, $\text{mass unit} = \text{KG}$, $\text{effective mass factor} = .75$
 $V_{xx} = 50 / (25/1000)^{0.75} = 795.27 \text{ ml/KG/hr}$