Defence Research and Development Canada
Recherche et développement pour la défense Canada

DEFENCE R&D DÉFENSE

DRDC Toronto/HPP Metabolic Measurement Software V2.0

Users' Manual

Allan A. Keefe

Defence R&D Canada – Toronto
Technical Memorandum
DRDC Toronto TM 2002-038
August 2002

Canada

DRDC Toronto/HPP Metabolic Measurement Software V2.0

Users' Manual

Allan A. Keefe

Defence R&D Canada – Toronto

Technical Memorandum

DRDC Toronto TM 2002-038

August 2002

Author

Allan A. Keefe

Approved by

Dr. P. Shek

Head, Operational Medicine Section

Approved for release by

K.M. Sutton

Chair, Document Review and Library Committee

Abstract

As a result of changes in computer technology, an update to the DRDC Toronto/HPP Metabolic Measurement Software was deemed necessary. In addition to making this software compliant with the Windows™ 32-bit operating system, several enhancements were made to improve its usability and accuracy of measurements. These include; a 'wizard' to facilitate test set-up data entry, protection of data loss due to equipment failure, compensation for system lag, graphical display of data, and integration with Microsoft Excel™ for data exporting, saving and analysis. This document is a manual to assist the operator in the usage of this software.

Résumé

Par suite des changements qui se sont produits dans le domaine de la technologie informatique, une mise à niveau du logiciel DRDC Toronto/HPP Metabolic Measurement a été jugée nécessaire. En plus de faire en sorte que ce logiciel soit conforme au système d'exploitation 32-bits de WindowsTM , un grand nombre de modifications y ont été apportées pour améliorer sa convivialité et l'exactitude de ses mesures. Celles-ci incluent : un assistant qui facilite la saisie des données de préparation des essais, la protection contre la perte de données causée par une panne de matériel, une compensation pour le retard du système, l'affichage graphique des données et l'intégration à Microsoft ExcelTM pour permettre l'exportation, l'enregistrement et l'analyse des données. Ce document est un manuel de référence à l'intention de l'utilisateur de ce logiciel.

This page intentionally left blank.

Executive summary

Recently, the Human Performance and Protection (HPP) section of DRDC Toronto has been using the DRDC Toronto/HPP Metabolic Measurement Software (MMS) v1.0 for the measurement of metabolic parameters at rest and exercise. This software was written to provide a uniform user interface and customizable code across all metabolic measurement systems in the HPP inventory. A complete description of its function, reliability and validity may be found in a previous report (Keefe and Pope, 1997).

Since the inception of this software, Microsoft Windows™ has progressed from the 16-bit architecture of version 3.1, to its current 9x/2000, 32-bit operating system running on Pentium™ class processors. As a result, an update to the MMS software was necessary to maintain compatibility with current technology. In the process of this update, the opportunity was taken to make several enhancements to both the method of data collection and user interface.

Internally, the MMS v2.0 software compensates for the inherent system lag, or mismatch between flow measurement and gas analysis due to the volume of the collection tubing and mixing box. During each test, all metabolic measurements are saved to a temporary file, which may be retrieved in the event of computer or power failure. Visually, the user benefits from a simple wizard to facilitate entering test setup parameters, pop-up tool tips explain the function of the menus and buttons, and $\dot{V}O_2$ is graphically displayed in real-time, in either L•min-1 or mL•kg•min-1. At the end of each test, the user has the option to export the data directly to an Excel spreadsheet for printing, saving or analysis.

As a result of these enhancements, metabolic measurements may be made with greater ease and accuracy. This document is intended to be a user and technical manual detailing the operating function of the DRDC Toronto/HPP MMS v2.0.

Keefe, A.A. 2002. DRDC Toronto/HPP Metabolic Measurement Software v2.0. DRDC Toronto TM 2002-038. Defence R&D Canada – Toronto

Sommaire

Dernièrement, la section de la performance humaine et de la protection des personnes (HPP) de l'IMED a utilisé le logiciel DRDC Toronto/HPP Metabolic Measurement (MMS) v1.0 pour mesurer des caractéristiques métaboliques au repos et en exercice. Ce logiciel a été créé pour fournir une interface-utilisateur uniforme et des codes adaptables à tous les systèmes de mesure métabolique répertoriés par la HPP. Vous trouverez une description complète de ses fonctions, de sa fiabilité et de sa validité dans un rapport publié précédemment (Keefe et Pope, 1997).

Depuis la création de ce logiciel, Microsoft Windows™ est passé de l'architecture 16-bits de la version 3.1 au système actuel d'exploitation 9X/2000 de 32-bits utilisé avec des processeurs de type Pentium™. Par conséquent, une mise à niveau du logiciel MMS était nécessaire pour assurer sa compatibilité avec les technologies actuelles. Nous avons profité de cette mise à niveau pour apporter plusieurs modifications au mode de collecte de données et à l'interface-utilisateur.

À l'interne, le logiciel MMS v2.0 équilibre le retard inhérent au système, ou la non-concordance entre la mesure du débit et l'analyse des gaz attribuables au volume du tube de prélèvement et de la boîte de mélange. Pendant chaque test, toutes les mesures métaboliques sont enregistrées dans un fichier temporaire, qui peut être récupéré en cas de défaillance du système ou de panne de courant. Sur le plan visuel, l'utilisateur bénéficie d'un assistant facile à utiliser qui simplifie la saisie des paramètres de configuration des essais, d'info-bulles outils décrivant la fonction des menus et des boutons, et de l'affichage graphique du $\dot{V}O_2$ en temps réel, selon les formules L•min-1 ou mL•kg•min-1. À la fin de chaque essai, l'utilisateur a la possibilité d'exporter les données directement dans une feuille de calcul Excel pour les imprimer, les enregistrer ou les analyser.

Grâce à ces modifications, les mesures métaboliques peuvent être effectuées avec plus de facilité et de précision. Ce document se veut un manuel technique et un guide de l'utilisateur qui décrit en détails les fonctions d'exploitation du DRDC Toronto/HPP MMS v2.0

Keefe, A.A. 2002. DRDC Toronto/HPP Metabolic Measurement Software v2.0. DRDC Toronto TM 2002-038. Defence R&D Canada – Toronto

Table of contents

Abstract i

Résumé i

Executive summary iii

Sommaire iv

Table of contents v

List of figures vi

Acknowledgements vii

Introduction 1

Getting started 2

Main menu overview 3

- Check inputs 3
- Calibration 4
- Data entry wizard 7

Metabolic Test Screen 12

Menu Bar 13

- Metabolic Test Screen 15

Appendix A: Pin Out tables 17

Appendix B: Hardware schematics 18

Appendix C: Metabolic calculations 19

References 21

List of symbols/abbreviations/acronyms/initialisms 22

List of figures

Figure 1. MMS v2.0 Icon 2

Figure 2. Main Menu 2

Figure 3. Check inputs screen 3

Figure 4. Flow volume screen 4

Figure 5. Flow calibration screen 5

Figure 6. Gas calibration gases 6

Figure 7. Gas calibration voltages 6

Figure 8. Gas calibration summary screen 7

Figure 9. Subject Info screen 8

Figure 10. Get set-up information dialog 9

Figure 11. Environmental data screen 9

Figure 12. Test set-up screen 10

Figure 13. Variables displayed screen 11

Figure 14. Metabolic Test Screen 12

Figure 15. Menu Bar 13

Figure 16. Calibrate Menu Items 13

Figure 17. Test Set-up Menu Items 13

Figure 18. About MMS dialog 15

Figure 19. Schematic of the Metabolic Measurement System Hardware 18

Acknowledgements

The author wishes to thank Dr. T. McLellan for his physiological expertise and recognition of the system delay issue, Dr. P. Tikuisis for determining the equation for the system lag, and Mr. J. Pope for his assistance in validating the accuracy of the system.

This page intentionally left blank.

Introduction

The DRDC Toronto/HPP Metabolic Measurement System (MMS) v2.0 software is a MS Windows program designed to run on any IBM-PC compatible computer running a minimum of Windows 95 and has a Keithly Metrabyte DAS-800 or KPCI - 3101 series A/D board installed. This software is designed to provide a standardized, user-friendly and customizable system for metabolic data collection. A further advantage is its capability of using almost any model of gas analysers and ventilation monitors in the HPP inventory with little, if any, modification to the software.

Getting started

Start the program by double clicking on the MMS icon located in the Start – Programs - MMS v2.0 program group or via the shortcut icon located on the computer's desktop (Fig. 1).

Figure 1. *MMS v2.0 Icon.*

Upon launching the program, the first screen presented is the 'Main Menu' (Fig. 2).

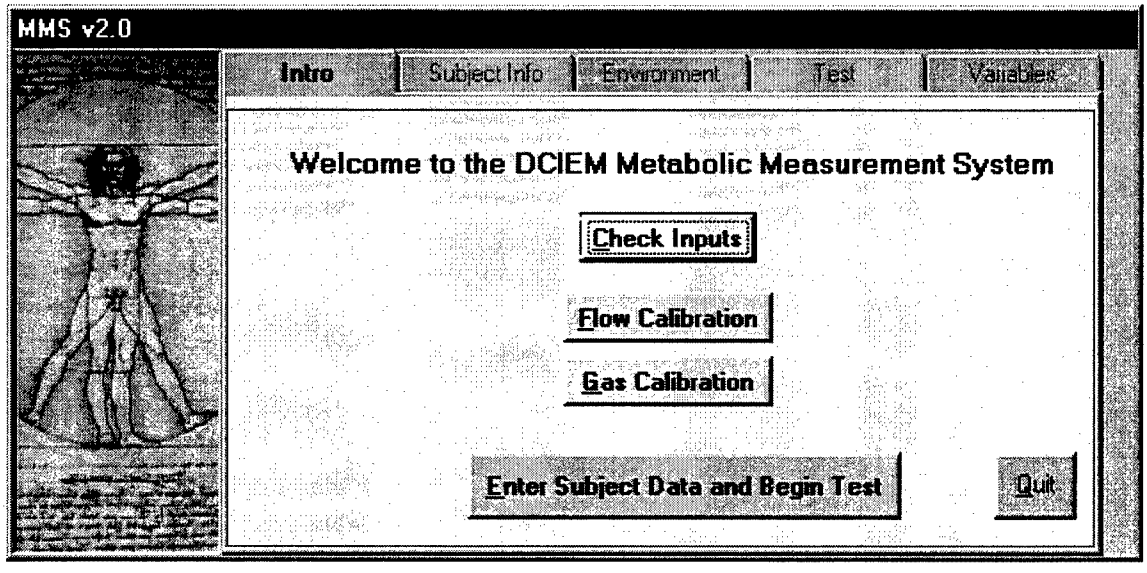

Figure 2. *Main Menu*

From this screen, the user can navigate through the four primary components of this software. The following options are presented:

Check Inputs Displays the current value of all analog channels and counters in real time, to verify proper functioning and reading of gas, flow and breath signals.

Flow Calibration Calibrate flow transducer.

Gas Calibration Calibrate gas analysers.

Enter Subject Data and Begin Test Proceed to the data wizard to enter subject and test setup data. Metabolic data collection may commence once all of the setup information is entered.

Main menu overview

Menu options are presented in a logical sequence guiding the user in ensuring accurate and trouble-free data collection. It is recommended that the user follow the sequence of verifying hardware/software communication (**Check Inputs**), analyser calibration (**Flow and Gas Calibration**) and test set-up and data collection (**Enter Subject Data and Begin Test**). Following these procedures in the sequence described will ensure that metabolic measurements will be accurate and simplify any troubleshooting efforts.

Check inputs

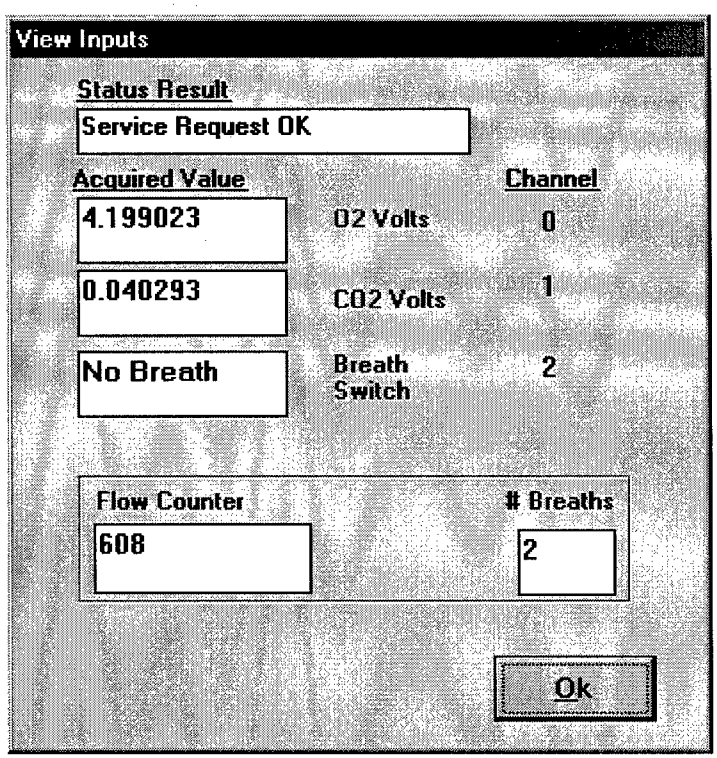

Figure 3. *Check inputs screen*

Viewing inputs allows real-time, simultaneous monitoring of all analyser voltages and flow transducer inputs. It is best used as a troubleshooting aid and system check to validate the proper functioning of all devices **before each metabolic run**.

Normal values for both gas concentration and flow are detailed in the following discussion on calibration. In brief, normal room air should result in approximately 4.2 O_2 Volts and .06 CO_2 Volts. If you wish to check using a calibration gas, multiply the O_2 concentration by .2 V and CO_2 by .5 V to determine the resultant voltage.

Pushing expired air through the flow transducer will result in the breath switch displaying "Breath", and updating of the flow counter. Do not be concerned with the actual number of pulses counted at this point, just note that they are increasing with flow. As the flow counter and # breaths are updated every 5 seconds, try several short puffs to verify that the number of breaths are being counted accurately.

Once satisfied that all gas analysers and the flow transducer are correctly connected to the metabolic interface box, which is in turn connected to the DAS 800 A/D card in the computer via the 32 pin cable, vary the outputs of the gas analysers by drawing a non-ambient gas sample through them, or push air through the ventilation monitor. You should notice Check that changing voltage and pulse outputs occur on the 'Check Inputs' screen (Fig. 3). If any of the channels are not being properly updated, check all cables for proper connections. **Please shut down the computer before disconnecting any cables.** The data acquisition card is very sensitive to electrical spikes and is easily damaged. Rebooting the computer has the added advantage of resetting any hardware or software problems that may have been responsible for invalid readings.

Calibration

The following calibration routines are provided for both the flow transducer and gas analysers.

Flow calibration

Flow calibration requires counting the number of pulses generated by the flow transducer for a given volume of air. The volume of the calibration syringe is entered on the 'Flow Volume' (Fig. 4).

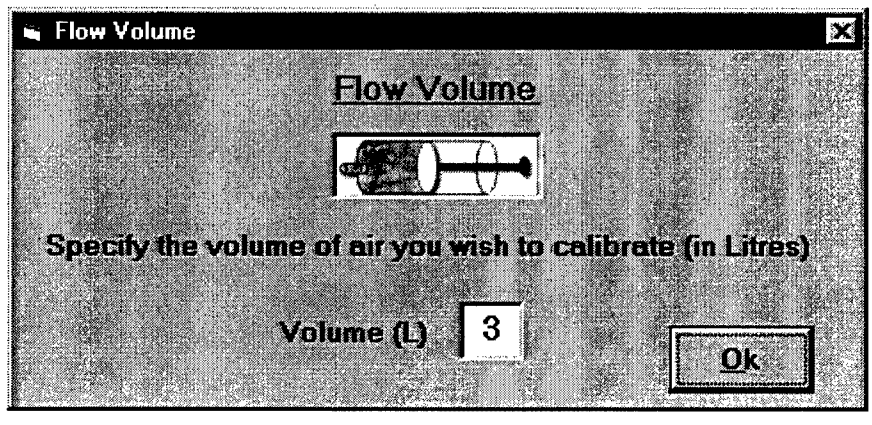

Figure 4. *Flow volume screen*

This volume of air is introduced through the flow transducer at a known rate. Although volume measured should be independent of flow rate, calibration may be matched to the ventilation rates measured during the actual stress test (resting, walking, maximal exercise). The default flow rate for the stress test calibration is 50 L/min. Various rates can be calibrated by selecting the flow rate spin buttons

(up/down arrows) (Fig 5.). This will affect the speed of animation of the syringe icon. Using a calibrated syringe to introduce the flow into the transducer, and following the animated syringe as a guide can accurately produce the required flow rate.

Clicking on 'Begin Flow' resets the pulse counter to zero, initiates the animation of the syringe icon and begins the measurement of the pulse output from the flow transducer. Once the desired volume of air has been pushed through the flow transducer, clicking 'Flow Complete' will display the number of pulses that have been counted. Depending on the configuration of the KL Engineering flow transducers, one should expect approximately 100 (normal) or 123 (high resolution) pulses per litre of air.

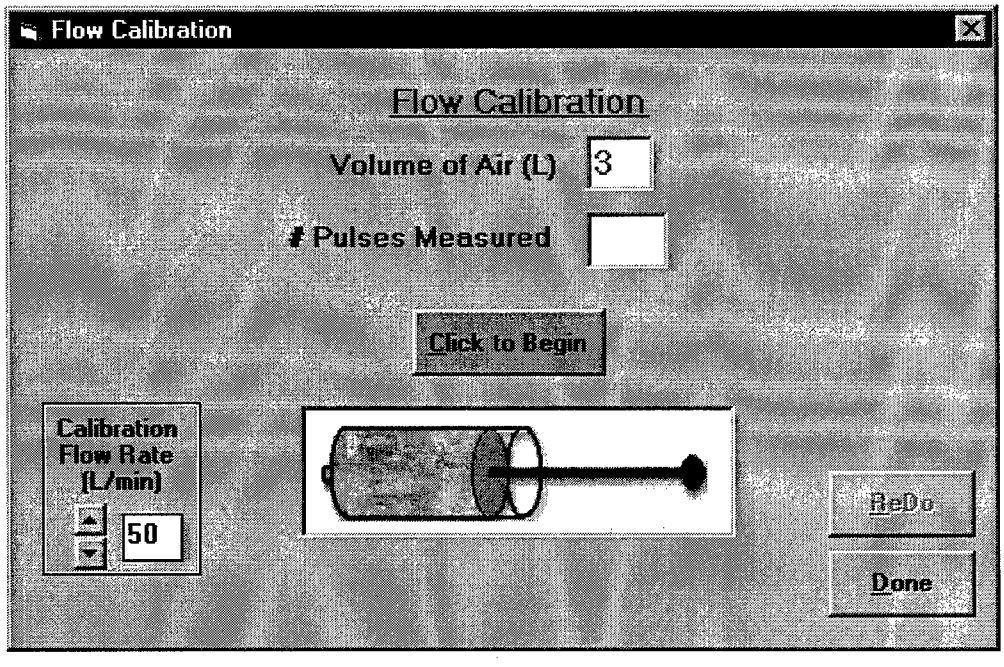

Figure 5. *Flow calibration screen*

Gas Calibration

Gas Calibration requires the flow of two calibrated gases through analysers. As each gas is introduced, the user is prompted to enter the current O_2 and CO_2 concentrations (Fig. 6). Upon clicking 'Calibrate', the gas analysers are read by the data acquisition system (Fig. 7), and a calibration slope and intercept are calculated. The MMS software converts the voltage outputs from the O_2 and CO_2 analysers to known gas concentrations using this slope and intercept.

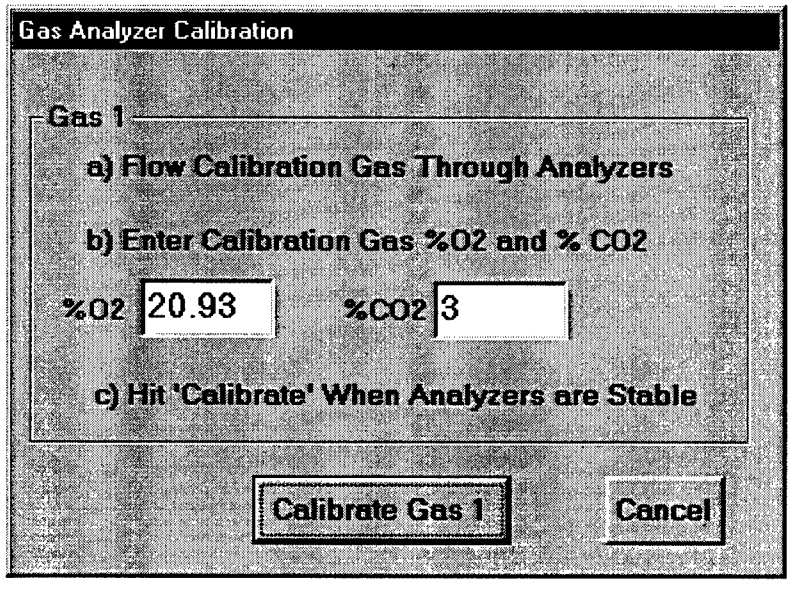

Figure 6. *Gas calibration gases*

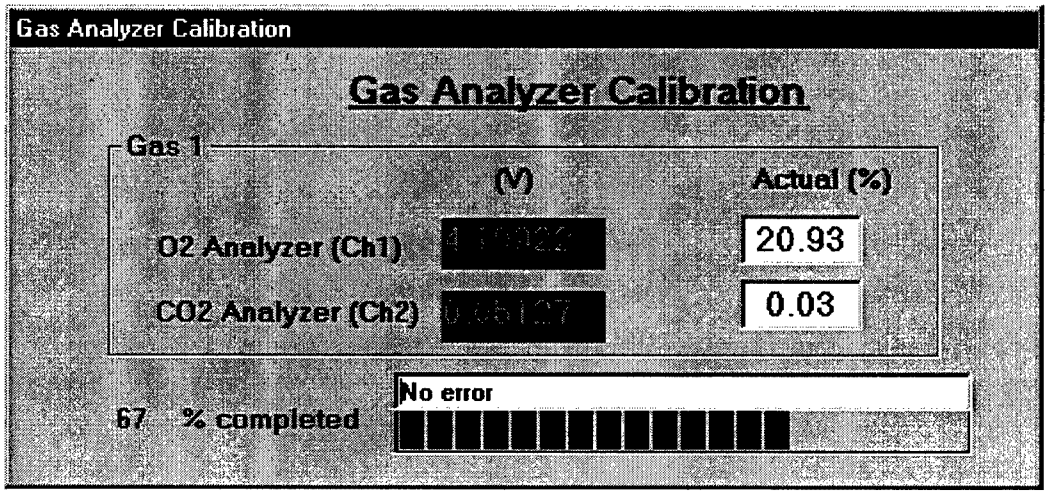

Figure 7. *Gas calibration voltages*

After the second gas is analysed, a summary report is generated which displays the data from the calibration (Fig. 8). This information is useful for verification of the quality of the calibration. For instance, the Ametek S-3A analyser output range is 0 to 5V for 0 to 25% O_2, while the Ametek CD-3A's output range is 0 to 5V for 0 to 10% CO_2. Thus a calibration gas of 15% O_2 and 5% CO_2 should result in an output of 3V and 2.5V, respectively. Acceptable calibration values are displayed with **green** text, and suspect values in **red**. A value of "NA" is displayed when calibration gas concentrations are very low and the resultant voltage is essentially 0V. If the summary is suspect, the entire calibration procedure maybe repeated by clicking **'Recalibrate'**.

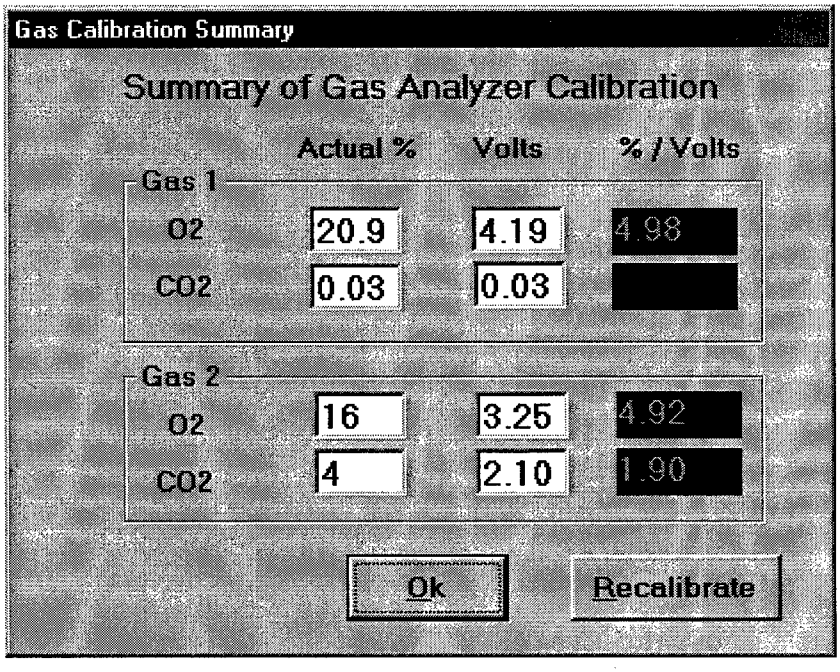

Figure 8. *Gas calibration summary screen*

Data entry wizard

Before metabolic measurements can be made, information regarding the subject's characteristics, environment, test set-up and displayed variable must be obtained. This is accomplished by presenting the user with a data entry 'wizard', which presents a series of input forms that requests all necessary information in a logical manner. Validation checks are made to all data, and progression to the next form is permitted once all data fields have been entered on the active screen. Once all screens are completed, this set-up data may be saved for later retrieval, or edited at anytime prior to beginning the test.

Subject info screen

Upon clicking 'Enter Subject Data and Begin Test' from the 'Main Menu' screen, the following form is presented:

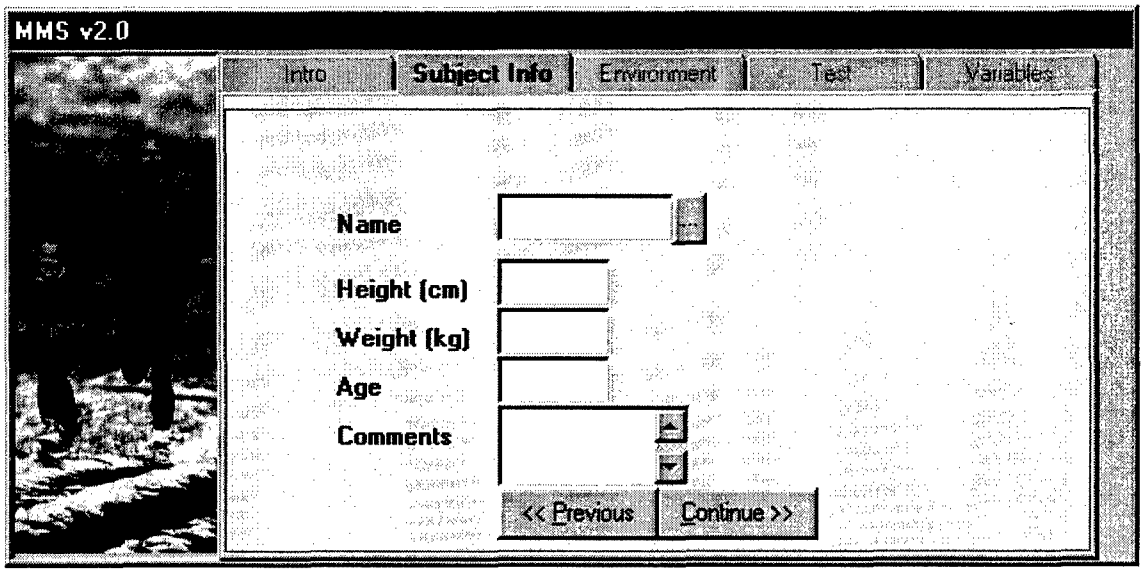

Figure 9. *Subject Info screen*

This screen requests the user to input subject identity and anthropometric data. Name, height, weight and age are all required inputs, while the comment field is optional. Selecting the small button to the right of the 'name' field brings up the 'Get Set-up Information' dialog which allows the retrieval of previously saved set-up information.

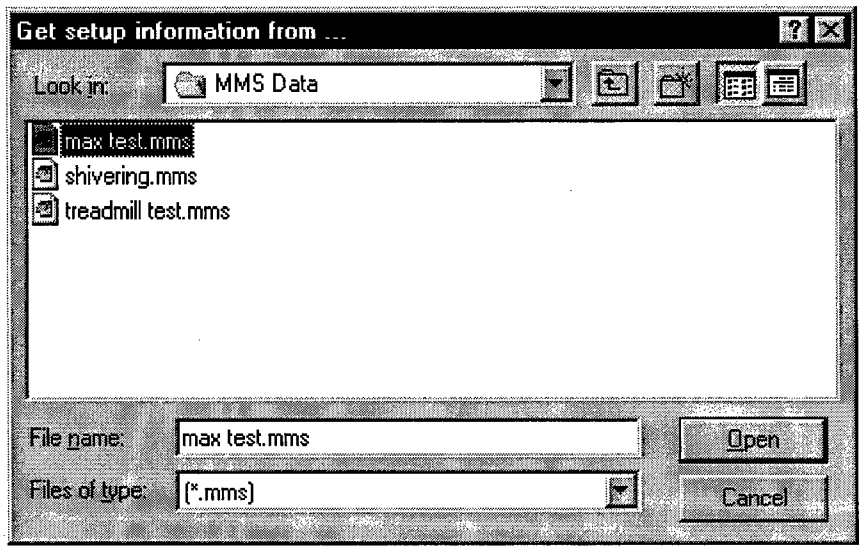

Figure 10. *Get set-up information dialog*

Environmental data

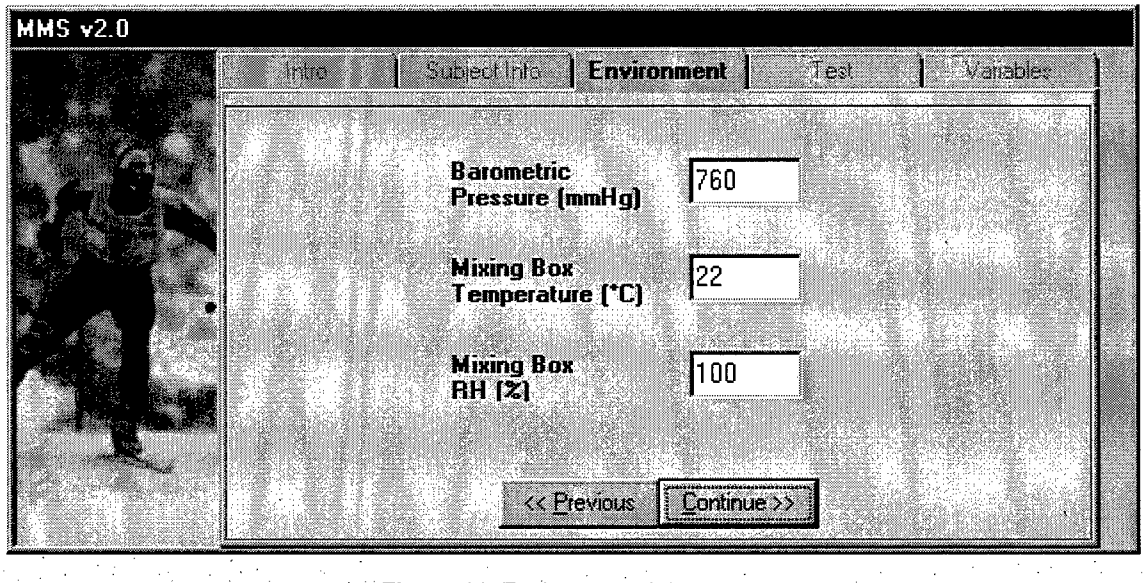

Figure 11. *Environmental data screen*

Environmental parameters are entered on this form. All of these data are required in order for the test to proceed. Since expired ventilation is being measured, the relative humidity and temperature inputs should be from the **mixing box**, not the ambient environment. In the future, this software may be easily adapted to allow for the real-time monitoring of these environmental variables. Until the appropriate electronic sensors and signal conditioning board become available, manually inputted values can be assumed to be valid for short-term testing in a stable environment. If the test progresses over several hours, barometric pressure and temperature should be verified

and updated. As will be illustrated later, this can be accomplished through the 'Metabolic Test Screen'.

Test set-up

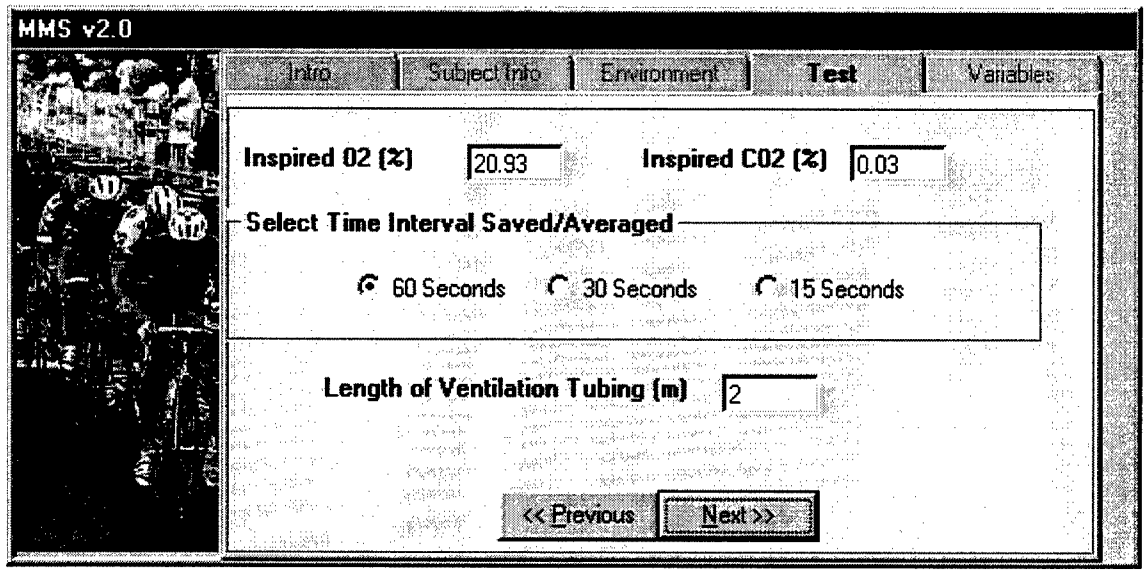

Figure 12. *Test set-up screen*

The 'Test Set-up' screen allows the user the flexibility to customize test parameters.

If gas mixtures other than room air are being used, then the new inspired O_2 and CO_2 percentages may be entered at this point. Otherwise, default values of 20.93% O_2 and .03% CO_2 will be used.

Data averaging is determined by choosing either one of the three default options (15, 30 or 60 second periods). This option controls the updating and plotting of the averaged data on the 'Metabolic Test Screen', and the exporting of data to Excel.

Finally, the length of the ventilation tubing must be entered in meters. This value is retained by the system, and only requires editing the first time the program is run after the ventilation tubing has been changed. Accurate measurement of the length of the ventilation tubing is important, as the calculation of the system delay (mismatch between ventilation and gas readings) is dependent on the total volume of the mixing box plus tubing and the flow rate.

Variables displayed

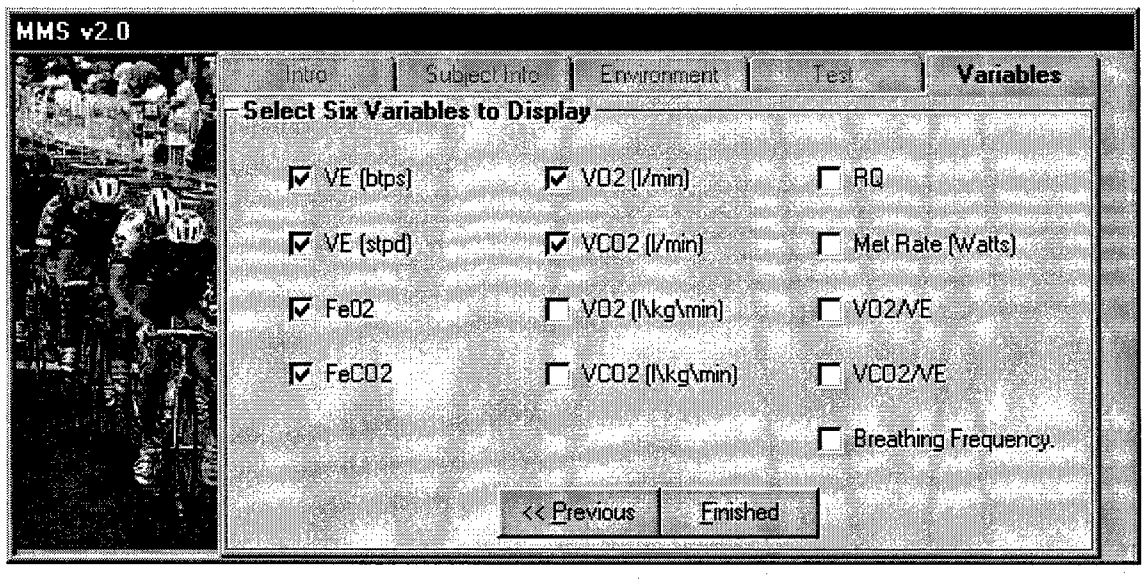

Figure 13. *Variables displayed screen*

The 'Variables Displayed' screen (fig. 13) allows the user to customize the display grids to monitor the metabolic variables of interest during a test. A maximum of six variables may be selected.

Once all of the subject, environment, test and variable data have been entered, clicking on 'Finished' button presents the user with the opportunity to save these set-up data. If file saving is selected, then a dialog box will be presented, prompting for a file name and location. This file will be saved with a '.mms' extension and can be retrieved as a template for future tests from the 'Subject Info' screen.

Metabolic Test Screen

Completion of the Data Wizard enables the Metabolic Test Screen (Fig. 14). This form allows the user to initiate, pause or terminate the collection of metabolic measurements, manipulate environmental inputs online, and observe data collection in real-time (with or without system lag).

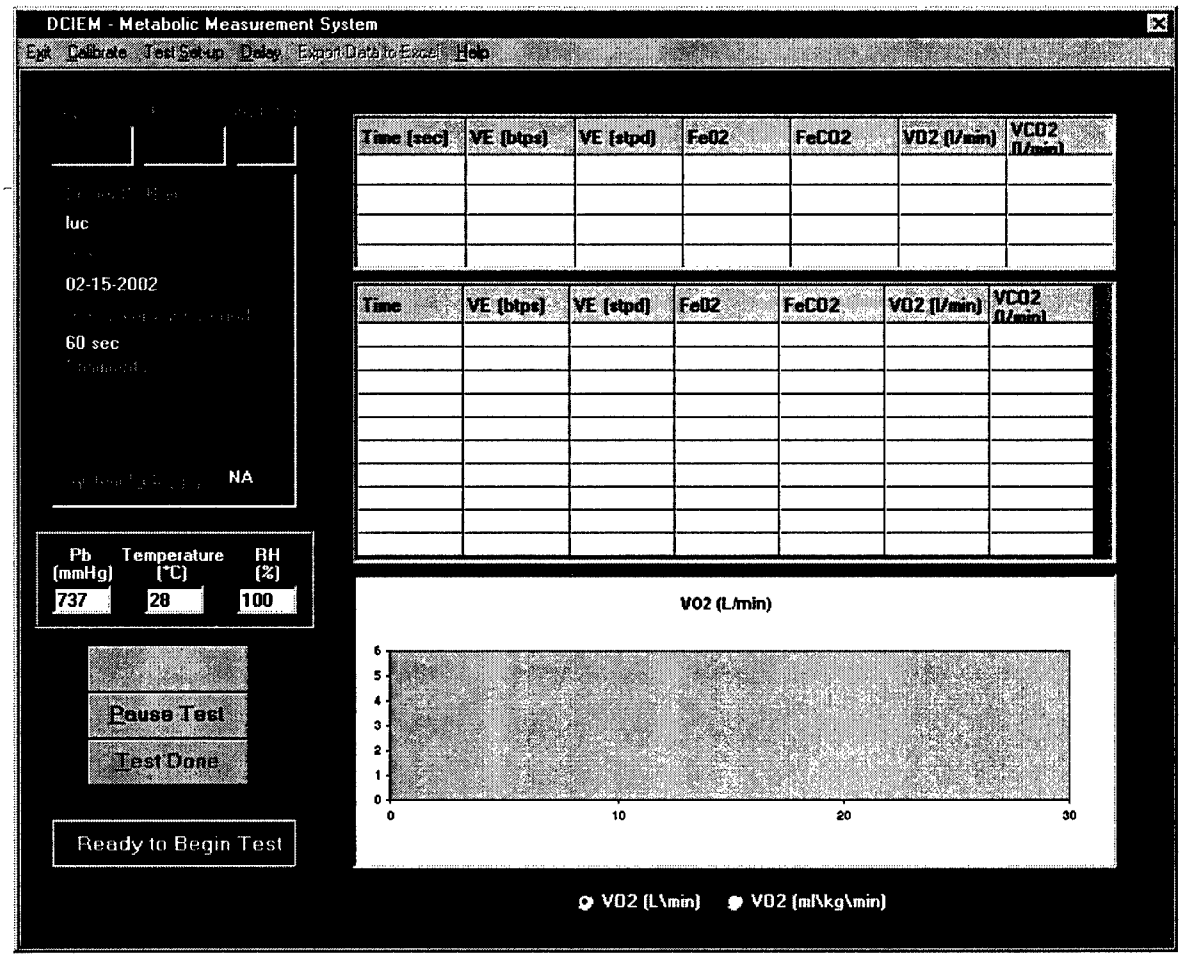

Figure 14. *Metabolic Test Screen*

Menu Bar

Figure 15. *Menu Bar*

The menu bar allows quick access to software features prior to, during or post testing. Menu items are enabled or disabled according to the availability of their functions during the test sequence.

Exit

Clicking on 'Exit' causes the MMS program to terminate. It is not available during a metabolic test.

Calibrate

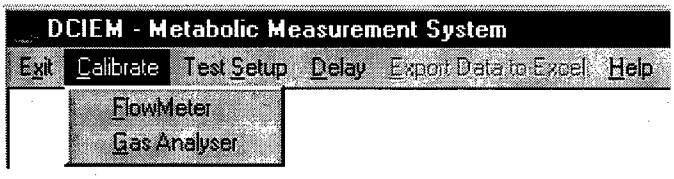

Figure 16. *Calibrate Menu Items*

Before test commencement, 'Calibrate' allows the user to select calibration of the flow transducer or gas analysers. Its function is identical to the 'Calibrate Gas' and 'Calibrate Flow' buttons on the 'Welcome Screen'. Once a test has begun, this menu item is disabled.

Test set-up

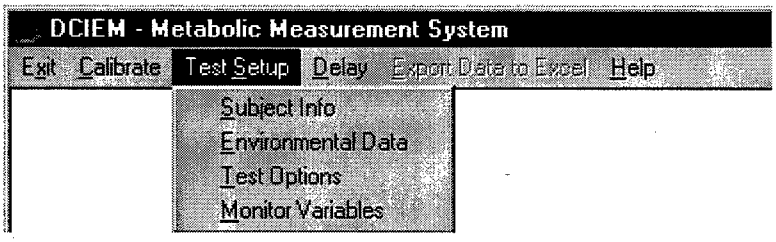

Figure 17. *Test Set-up Menu Items*

This menu item allows the user to make any last minutes changes to the test set-up data, as defined by the 'Data Wizard'. Selecting any of the menu sub items brings up the corresponding page of the 'Data Wizard' for editing. This menu item is disabled once a test has begun.

Delay

One of the enhancements to the MMS includes the compensation of the delay between flow and gas measurements due to collection tubing and ventilation rate.

Flow will not experience any measurement delay since the column of expired air travels through the non-distensible collection tubing and mixing box to the flow transducer. Since there is no change in collection system volume with each breath, the volume expired from the subject will simultaneously equal the volume exiting through the flow transducer at the distal end.

A flow/gas mismatch occurs due to the fact that the expired gas must pass through the volume of collection tubing and mixing box before reaching the sampling line. Thus, for any given breath, the expired gas will not be measured at the analysers until it has passed through the entire volume of collection apparatus. The relationship between flow and gas measurements is directly related to the ventilation rate and collection system volume. For the systems tested at DRDC Toronto, this relationship may be described as follows:

$$SystemDelay = \frac{589.6 + (7.21 \bullet Length)}{Flow} + 16.84$$

where:

System Delay = Lag in measuring gas concentrations (s)
Length = Length of collection tubing (m)
Flow = Ventilation rate ($L \bullet min^{-1}$)

System delay becomes more substantial at low flow rates, when the system collection volume is large (e.g. using a long length of collection tubing) or when the exercise is not at steady state. This feature is selected by default, but may be disabled by this menu item.

Export data to Excel™

After data collection has been terminated, selecting this menu item opens a new Excel workbook containing the current metabolic data. This provides the user with the ability to create graphs or further analyze these data as well a providing greater control of printed output and file saving options.

This menu item is disabled until the 'Test Done' button is pressed at the end of data collection. If the user decides to exit the program without sending the data to Excel, an alert prompt notifies the user that the data has not been saved and is given a final opportunity to export the data. Once in Excel, the data may then be saved.

Help

An online version of this users manual is accessible through the 'Help' menu item. This version is fully hyperlinked, allowing the user to quickly jump to any topic

Also included in the help menu selection is the 'About MMS' item, which displays a dialog box detailing software and system specific information (Fig. 18).

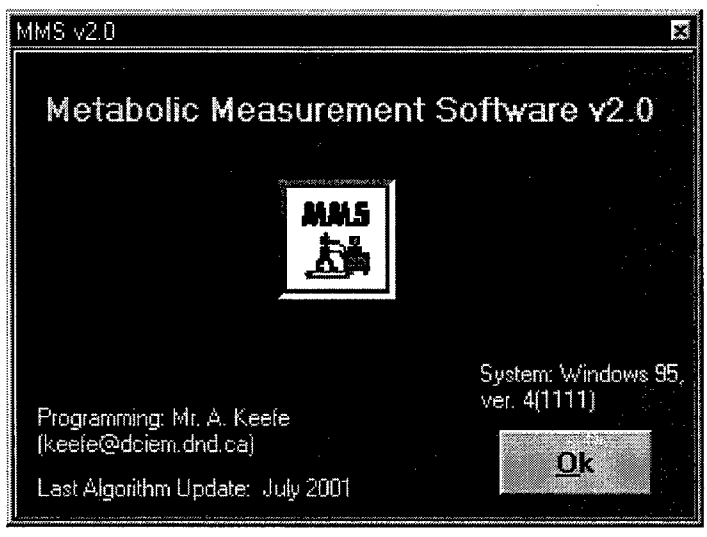

Figure 18. *About MMS dialog.*

Metabolic Test Screen

The Metabolic Test Screen displays the current operational status of the metabolic software and sensors, metabolic calculations as well as permitting the user an interface to control the initiation, pausing or termination of data collection. This on-screen information is essentially divided into two groups; basic system set-up and parameters monitored (left side) and metabolic display (right side).

System set-up and parameters monitored

Of the system parameters monitored, F_eO_2, F_eCO_2 and $\dot{V}_{E\ ATP}$ are monitored and updated every 15 seconds, displayed in real-time and are not subject to any system delay. Temperature, barometric pressure and relative humidity reflect the values currently in use by the program. These values may be edited at any time to reflect changing environmental conditions.

Control of program flow is accomplished through 'Start', 'Pause' and 'Quit' buttons. The 'Start' button is only available once all required set-up information has been entered. Normally, the 'Data Wizard' would ensure the complete entry of test data.

If the 'Start' button is not active, return to the wizard from the 'Test Set-up' menu item and verify all inputs.

Before pressing the 'Start' button, ensure that the subject is connected and breathing through the system ventilation apparatus. Once a test has begun, the system measures ventilation for 10 seconds in order to determine the system delay. This is followed by a washout period equivalent to the delay time before actual metabolic data collection begins. The user is kept informed of the testing status by the status window below the 'Test Done' button, and is reminded to ensure that ventilation is being collected by a pop-up dialog.

Pausing the program temporarily terminates the calculation and display of averaged metabolic data but has no influence on the 15-second data display. This is illustrated by the greying out of the averaged data grid and a halt in the updating of the data plot window. Once resumption of data collection is required, click the button now labelled 'Continue' to proceed. If the test subject had been disconnected from the ventilation hose, allow at least one minute for the system delay to return to acceptable values.

Selecting the 'Test Done' button terminates all data collection. It is recommended to select the 'Export Data to Excel' menu item if you wish to save, print or further analyze these data. Once selected, the button caption changes to 'Quit'. Selecting it again causes the MMS program to terminate. If the data have not been exported to Excel, a warning will be given. **Note:** If the data have not been printed or saved, a temporary data file named 'latestmmsfile.csv' may be retrieved from the 'c:\windows directory'. This must be done before the MMS program is run again, as it is overwritten each time.

A status window at the bottom of the screen is continuously updated, informing the user of the current status and operation of the software.

Metabolic display

Two grids are available for displaying metabolic data, as they are collected. If selected, system delay is reflected in these measures. The top grid gives a continuous 15-second averaged update of metabolic data, while the bottom grid is updated with averages according to the 15, 30 or 60 second period defined by the user. It is the data appearing in the bottom grid that are considered 'true' may be exported to Excel for saving or printing.

A third window, below the grids, displays a real-time plot of the averaged $\dot{V}O_2$ in user selected units of $mL \cdot kg \cdot min^{-1}$ or $L \cdot min^{-1}$

Appendix A: Pin Out tables

DAS 8/800 main I/O connector (37 pin)

Pin number	Function	Variable Measured
2	clk 0	flow
12 to 18	low level common	ground
29	+5V	+5V to flow transducer
37	analog ch 1	$\%O_2$
36	analog ch 2	$\%CO_2$
35	analog ch 3	respiration

KL Engineering KTC-3D

Pin Number	Variable
2	Power supply ground
4	flow (100 PPL)
5	flow (123 PPL)
6	Respiration (0-5 V)
7	Power supply +5V

Appendix B: Hardware schematics

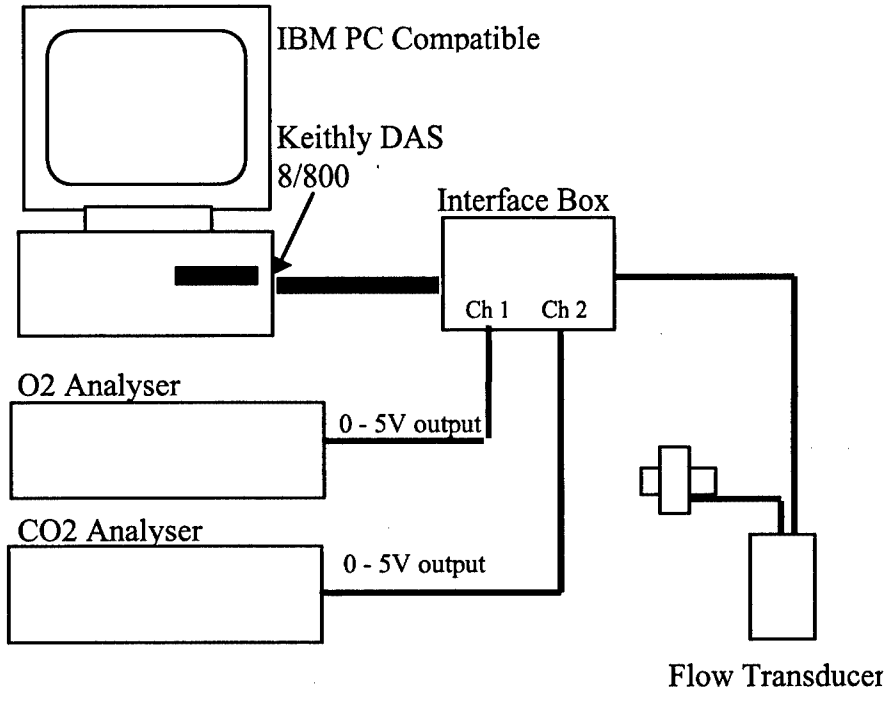

Figure 19. *Schematic of the Metabolic Measurement System Hardware*

Appendix C: Metabolic calculations

Summary of metabolic formulae used in the calculation of metabolic data.

$$F_IN_2 = 1 - (F_ICO_2 + F_IO_2)$$

$$F_EN_2 = 1 - (F_ECO_2 + F_EO_2)$$

$$\dot{V}_{I(ATP)} = \dot{V}_{E(ATP)} \times \frac{F_EN_2}{F_IN_2} \qquad (L \bullet min^{-1})$$

$$\dot{V}_{E(BTPS)} = \dot{V}_{E(ATP)} \times \frac{(273.23 + T_B)}{(273.23 + T_A)} \times \frac{(P_B - P_{H2O(A)})}{(P_B - P_{H20(B)})} \qquad (L \bullet min^{-1})$$

$$\dot{V}_{E(STPD)} = \dot{V}_{I(STPD)} \times \frac{F_IN_2}{F_EN_2} \qquad (L \bullet min^{-1})$$

$$\dot{V}O_2 = \dot{V}_{I(STPD)} \times (F_IO_2) - (\dot{V}_{E(STPD)} \times F_EO_2) \qquad (L \bullet min^{-1})$$

$$\dot{V}CO_2 = \dot{V}_{E(STPD)} \times (F_ECO_2) - (\dot{V}_{I(STPD)} \times F_ICO_2) \qquad (L \bullet min^{-1})$$

$$RQ = \frac{\dot{V}CO_2}{\dot{V}O_2}$$

$$Energy = 352 \times (.23 \times RQ + .77) \times \dot{V}O_2 \qquad (W)$$

$$SA = .202 \times wt^{.425} \times ht^{.725} \qquad (m^2)$$

$$P_{H2O(A)} = 4.579 \times 10^{\frac{7.5 \times T_A}{T_A + 273.23}} \times \frac{RH}{100} \qquad (mmHg)$$

$$P_{H2O(B)} = 4.579 \times 10^{\frac{7.5 \times T_B}{T_B + 273.23}} \qquad (mmHg)$$

Where:

F_IN_2 = Inspired fraction
F_EN_2 = Expired fraction

$\dot{V}_I$ = Inspired minute ventilation

$\dot{V}_E$ = Expired minute ventilation

STPD = Standard temperature and pressure, dry

ATPS = Ambient temperature and pressure, saturated

P_B = Barometric pressure (mmHg)

RH = Relative humidity (%)

SA = Body surface area (m^2)

wt = body weight (kg)

ht = height (m)

$P_{H_2O_A}$ = Water vapour pressure (ambient or body temperature)

T_A = Ambient temperature (°C)

T_B = Body temperature (37°C)

References

1. Keefe, A.A., Pope, J. (1997). DRDC Toronto/HPP Metabolic Measurement Software V1.0 – Users' Manual. DCIEM Report No. 97-38.

List of symbols/abbreviations/acronyms/initialisms

DND	Department of National Defence
DRDC	Defence Research and Development Canada
HPP	Human Protection and Performance
MMS	Metabolic Measurement Software
$\dot{V}O_2$	Volume of oxygen consumed per minute

DOCUMENT CONTROL DATA SHEET

1a. PERFORMING AGENCY

DRDC Toronto

2. SECURITY CLASSIFICATION

UNCLASSIFIED
Unlimited distribution -

1b. PUBLISHING AGENCY

DRDC Toronto

3. TITLE

(U) DRDC Toronto/HPP Metabolic Measurement Software V2.0 Users' Manual

4. AUTHORS

Allan A. Keefe

5. DATE OF PUBLICATION

August 1 , 2002

6. NO. OF PAGES

32

7. DESCRIPTIVE NOTES

8. SPONSORING/MONITORING/CONTRACTING/TASKING AGENCY
Sponsoring Agency:
Monitoring Agency:
Contracting Agency :
Tasking Agency:

9. ORIGINATORS DOCUMENT NO.

Technical Memorandum TM 2002-038

10. CONTRACT GRANT AND/OR PROJECT NO.

11. OTHER DOCUMENT NOS.

12. DOCUMENT RELEASABILITY

Unlimited distribution

13. DOCUMENT ANNOUNCEMENT

Unlimited announcement

14. ABSTRACT

(U) As a result of changes in computer technology, an update to the DRDC Toronto/HPP Metabolic Measurement Software was deemed necessary. In addition to making this software compliant with the WindowsTM 32-bit operating system, several enhancements were made to improve its usability and accuracy of measurements. These include; a 'wizard' to facilitate test set-up data entry, protection of data loss due to equipment failure, compensation for system lag, graphical display of data, and integration with Microsoft ExcelTM for data exporting, saving and analysis. This document is a manual to assist the operator in the usage of this software.

(U) Par suite des changements qui se sont produits dans le domaine de la technologie informatique, une mise à niveau du logiciel DRDC Toronto/HPP Metabolic Measurement a été jugée nécessaire. En plus de faire en sorte que ce logiciel soit conforme au système d'exploitation 32-bits de WindowsTM , un grand nombre de modifications y ont été apportées pour améliorer sa convivialité et l'exactitude de ses mesures. Celles-ci incluent : un assistant qui facilite la saisie des données de préparation des essais, la protection contre la perte de données causée par une panne de matériel, une compensation pour le retard du système, l'affichage graphique des données et l'intégration à Microsoft ExcelTM pour permettre l'exportation, l'enregistrement et l'analyse des données. Ce document est un manuel de référence à l'intention de l'utilisateur de ce logiciel.

15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U) metabolic measurement; ventilation, oxygen consumption; exercise stress test