

*The NIHR Southampton Biomedical Research Centre (BRC) has a tight quality assurance system for the writing, reviewing and updating of Standard Operating Procedures. As such, version-controlled and QA authorised Standard Operating Procedures are internal to the BRC.*

*The Standard Operating Procedure from which information in this document has been extracted, is a version controlled document, managed within a Quality Management System. However, extracts that document the technical aspects can be made more widely available. Standard Operating Procedures are more than a set of detailed instructions; they also provide a necessary record of their origination, amendment and usage within the setting in which they are used. They are an important component of any Quality Assurance Framework, but in themselves are insufficient and need to be used and interpreted with care.*

*Alongside the extracts from our Standard Operating Procedures, we have also made available here an example Standard Operating Procedure and a word version of a Standard Operating Procedure template. Using the example and the Standard Operating Procedure template, institutions can generate their own Standard Operating Procedures and customise them, in line with their own institutions.*

*Simply offering a list of instructions to follow does not assure that the user is able to generate a value that is either accurate or precise so here in the BRC we require that Standard Operating Procedures are accompanied by face-to-face training. This is provided by someone with a qualification in the area or by someone with extensive experience in making the measurements. Training is followed by a short competency assessment and performance is monitored and maintained using annual refresher sessions. If you require any extra information, clarification or are interested in attending a training session, please contact Dr Kesta Durkin ([k.l.durkin@soton.ac.uk](mailto:k.l.durkin@soton.ac.uk)).*

*This document has been prepared from Version 1 of the BRC Standard Operating Procedure for indirect calorimetry using the GEM 1 or GEM 2 analyser. The document was written in October 2014, authorised in April 2015 and the next review date is set for April 2017. The version number only changes if any amendments are made when the document is reviewed.*

## NIHR Southampton Biomedical Research Centre

### Procedure for INDIRECT CALORIMETRY USING THE GEM 1 or GEM 2 ANALYSER

#### BACKGROUND

Energy can be measured from heat. Heat produced can be derived by the amount of oxygen consumed. Energy expenditure can be measured by calorimetry and is based on the law of conservation of energy. There are two types of calorimetry: direct and indirect. The GEM is used for indirect calorimetry. It measures oxygen consumption and carbon dioxide production through assessing expired gases, the results of which are then used to calculate the respiratory quotient and resting energy expenditure.

#### PURPOSE

To ensure correct and safe use of the GEM 1 or GEM 2 calorimeter.

#### SCOPE

This procedure applies to every staff member required to use the GEM 1 or GEM 2 calorimeter.

#### RESPONSIBILITIES

It is the responsibility of staff to ensure they read, understand and use this procedure for measuring calorimetry using the GEM 1 or GEM 2 machine.

#### PROCEDURE

The two GEM machines are operated in the same way. Both machines can be used in Consulting Room 15 or the Low Dependency Ward (bed 2) in the CRF. The only difference is where the gas cylinders are located and how to turn the gases on, which is part of the preparation of the GEM 1 or GEM 2 machine being used.

## TURNING ON THE GASES:

### FOR CONSULTING ROOM 15

1. Attach a laptop/computer with the GEM software on, to the GEM by plugging in the cables that enable the GEM to communicate with the computer.
2. Turn on the GEM analyser and the GEM laptop.
3. Allow the GEM analyser to warm up for a minimum of 20 minutes before calibrating or making measurements.
4. Prepare the participant by instructing them to lie down on the bed/consultation couch also for a minimum of 15 minutes prior to starting the test.
5. Turn on the Nitrogen (zero) gas cylinder by using the cylinder spindle key (figure 1), (resting on the little wooden mount to which the cylinders are secured, on the wall) to turn to the left approximately 180°. Then open the valve of the 1% CO<sub>2</sub>, 20% O<sub>2</sub>, Nitrogen (span) gas cylinder by turning the flat red and black knob on the top of the cylinder, anti-clockwise. You don't need to open it much – one full turn of the knob will be sufficient.
6. Check that one of the two pressure dials on each cylinder are set at 1 bar. There is a black dot on one of the dials of each cylinder, indicating where the 1 bar needle should sit.



Figure 1. Gas cylinder spindle key

### FOR THE LOW DEPENDENCY WARD AREA (BED 2 ONLY)

1. Attach a laptop/computer with the GEM software on, to the GEM by plugging the cables that enable the GEM to communicate with the computer.
2. Turn on the GEM analyser and the GEM laptop
3. Allow the GEM analyser to warm up for a minimum of 20 minutes before calibrating or making measurements.
4. Prepare the participant by instructing them to lie down on the bed/consultation couch also for a minimum of 15 minutes prior to starting the test.
5. During this time, take the padlock key (in the key box, SCBR/CRF Admin Office behind Reception), go out to the CRF gas cylinder cage and open the valve of the Nitrogen (zero) gas cylinder by using the cylinder spindle key (figure 1), (on shelf in gas cage) to turn to the left approximately 180°. Then open the valve of the 1% CO<sub>2</sub>, 20% O<sub>2</sub>, Nitrogen balance (span) gas cylinder by turning the flat

red and black knob on the top of the cylinder, anti-clockwise. You don't need to open it much – one full turn of the knob will be sufficient.

6. Turn on the gas supplies in the low dependency ward area, by the GEM machine using the wall mounted valves. Just loosening by turning to the left will make the needles jump up to the 1 bar level which is correct.

### USING THE GEM 1 AND GEM 2 ON PARTICIPANTS

1. Click on the computer desktop icon to load the "GEM nutrition" program. The open program is shown in figure 2.

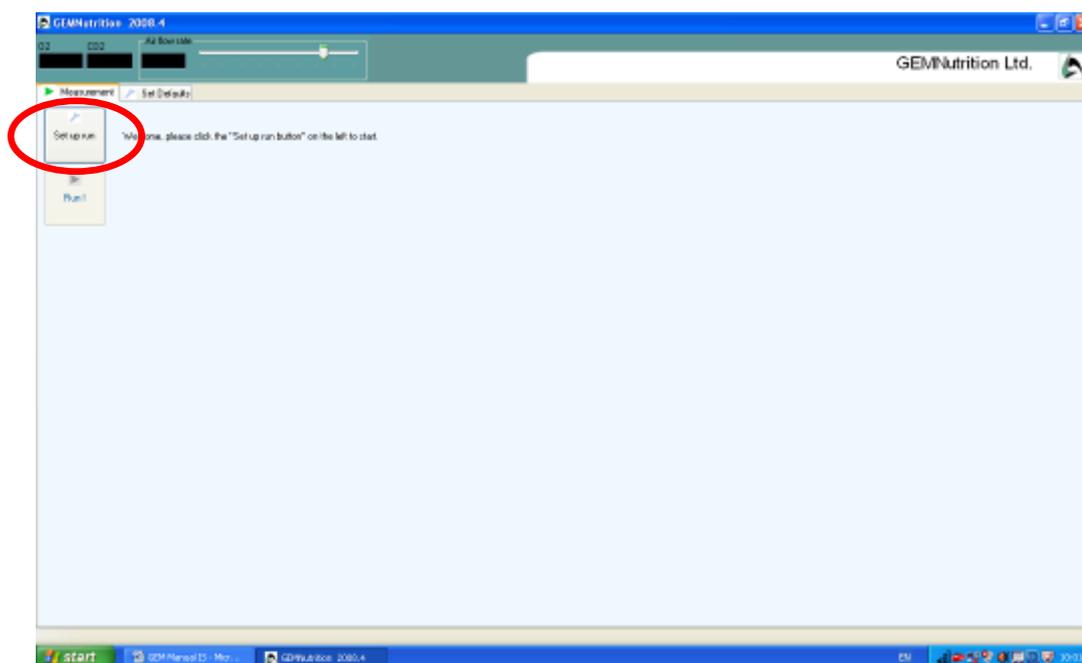
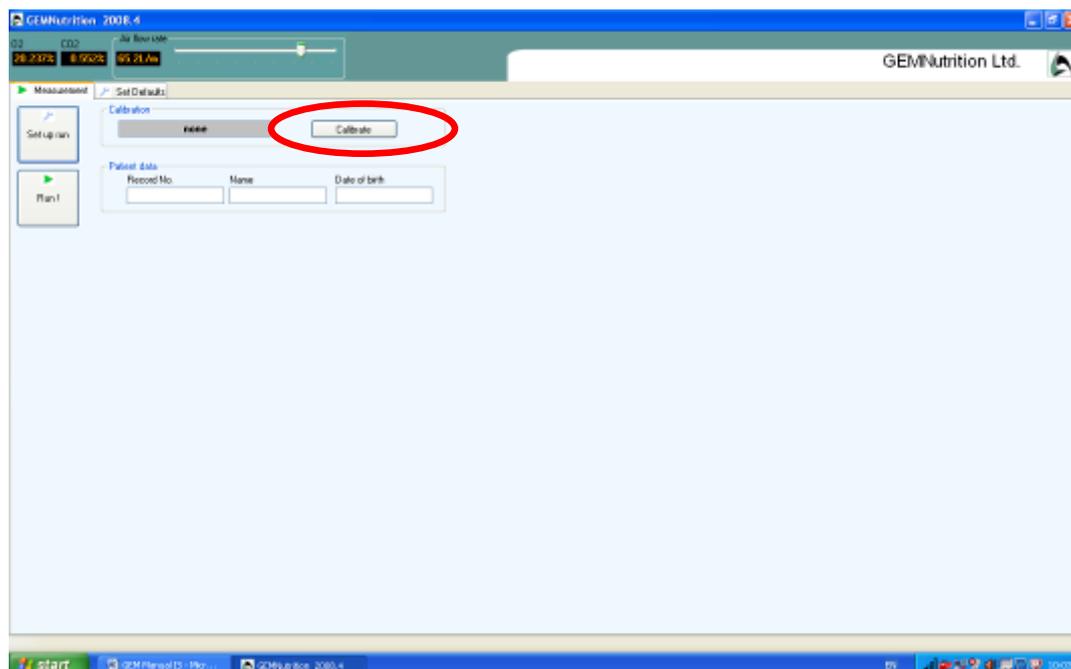


Figure 2. GEM Nutrition software start screen

2. Before any involvement with the participant, you must calibrate the equipment. Click on "set up run" (circled red in figure 2).
3. Then click on "calibrate" (circled red in figure 3).



**Figure 3.** Select “calibrate”.

4. The calibration process will begin automatically and takes about 3.5 minutes.
5. Complete 3 calibrations, clicking “ok” after each, which allows the machine to accept each calibration.

The values from calibrations must fit within these ranges:

	O <sub>2</sub>	CO <sub>2</sub>
ZERO	-0.990 to +0.123	-0.020 to +0.020
SPAN	+19.587 to +21.110	+0.962 to +1.041
INSPIRED	+20.800 to +21.270	+0.047 to +0.139

If your calibration results do not fall within these ranges, you must contact the expert for assistance.

6. Write down the results from each calibration on the calibration log form which is kept by the machine.
7. After each calibration, “OK” in green text will be displayed (circled red in figure 4).

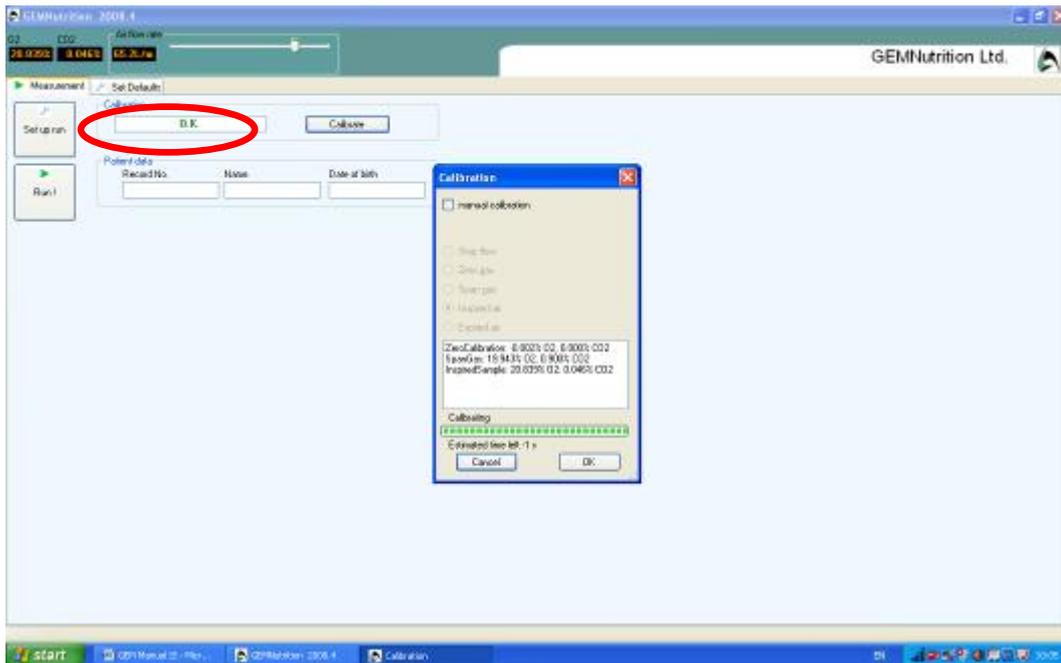


Figure 4. Calibration result.

- When 3 calibrations have been performed, select the “defaults” tab and check that the program is set to discard the first three measurements and that the bin size is 60 seconds, unless otherwise required by the study protocol. Make any appropriate changes but do not alter the values in the calibration settings (the values in these boxes are set according to the percentages of O<sub>2</sub> and CO<sub>2</sub> in the gas cylinders). All outlined in red in figure 5.

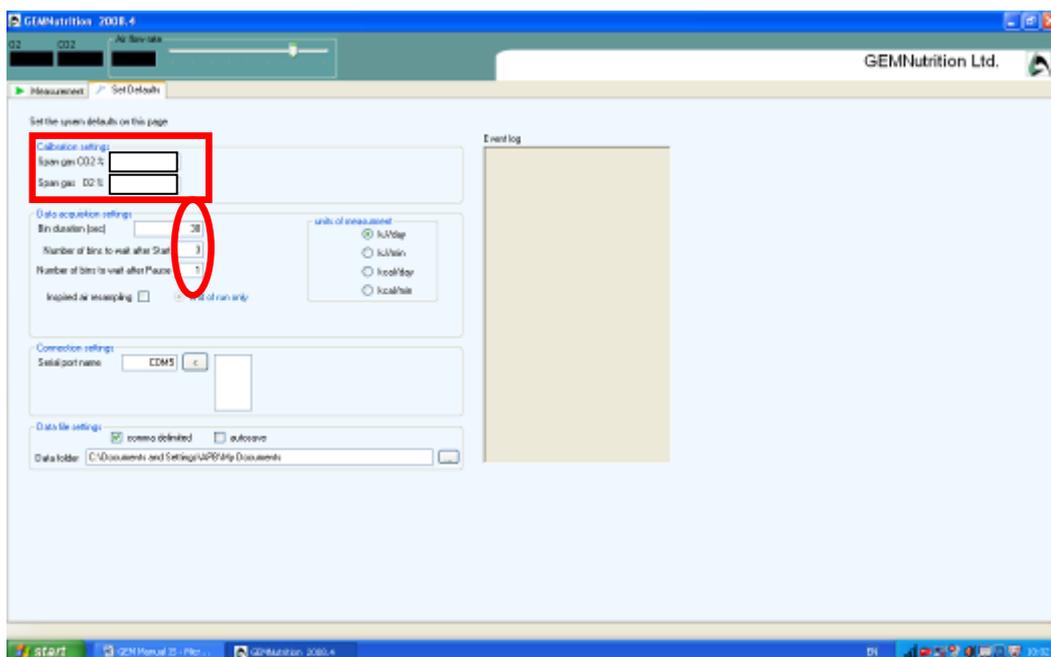


Figure 5. Set defaults tab

9. In order to save participant results enter some participant details into the "record number", "name" and "date of birth" boxes (circled red in figure 6).

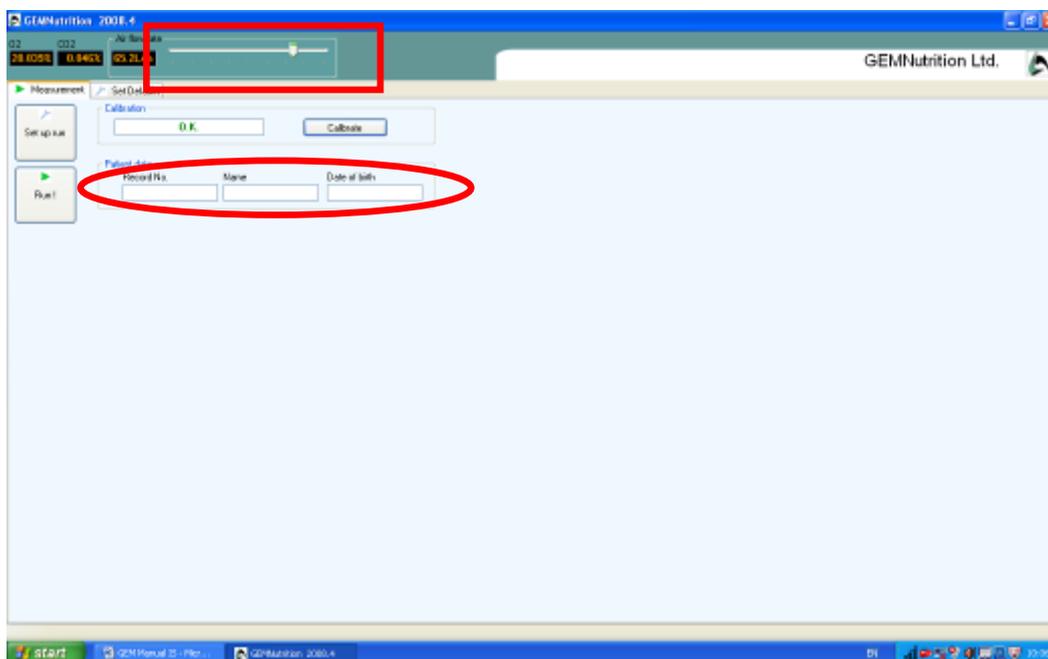


Figure 6. Participant details.

10. Ensure that the participant is comfortably lying on the bed (check with the protocol for details of any study specific resting periods).
11. Place the hood over the participant with the air-intake at the top of the head. Tuck in the sheeting to ensure that there are no leaks. This can be done before the calibration if it is necessary to allow the participant further time to adjust.
12. After the protocol required resting period, go to running screen and start run.
13. Use the slider bar to set the flow rate to the appropriate value. Following the guidelines below will help.

You need to adjust the flow rate by moving the sliding bar (outlined in red in figure 6) until the  $\text{FeCO}_2$  value reads approximately 0.5. For adults 38-45L/m is usually satisfactory.

If the  $\text{FeCO}_2$  value reads higher than 0.5 then the flow rate needs to be INCREASED. If the  $\text{FeCO}_2$  value reads lower than 0.5 then the flow rate needs to be DECREASED.

14. The results are collected in sections at intervals set by the bin size.
15. After determining the correct flow rate based on the value for  $\text{FeCO}_2$ , continue collecting data for 30 minutes or as otherwise specified in the study protocol.
16. Click "stop" to end run.

17. Remove the hood from the participant
18. Save file as CSV file – naming it according to your study participant ID.
19. Click “OK”.
20. The results file will be given a name identifying the date and run start time. The participant information will be displayed within the file.
21. Copy the file onto a memory stick for analysis elsewhere. Leave the original on the GEM computer.
22. To read the file on another computer, open Excel and import the GEM data file into Excel and then resave/“save as” an Excel file.
23. Turn the gas valves off at the wall in the Low Dependency Ward (GEM 2). Turn off the gas flow at the cylinders in room 15 (GEM 1).
24. REMEMBER TO TURN OFF THE GASES IN THE CRF CAGE OUTSIDE.
25. If you encounter the error message below which says “cannot communicate with bedside unit, running in demo mode!” (figure 7) then it could be that the GEM software was started too soon so that first thing to do is close and re-open the GEM Nutrition software.

If this does not solve the problem then you can try the following:

- a. Check that the instrument is turned on
- b. Check that the cable connecting the GEM to the laptop/computer is securely connected at each end.
- c. Go to the “default settings” tab (shown in figure 4) and check under “connection settings” and “serial port name” it says “COM3.

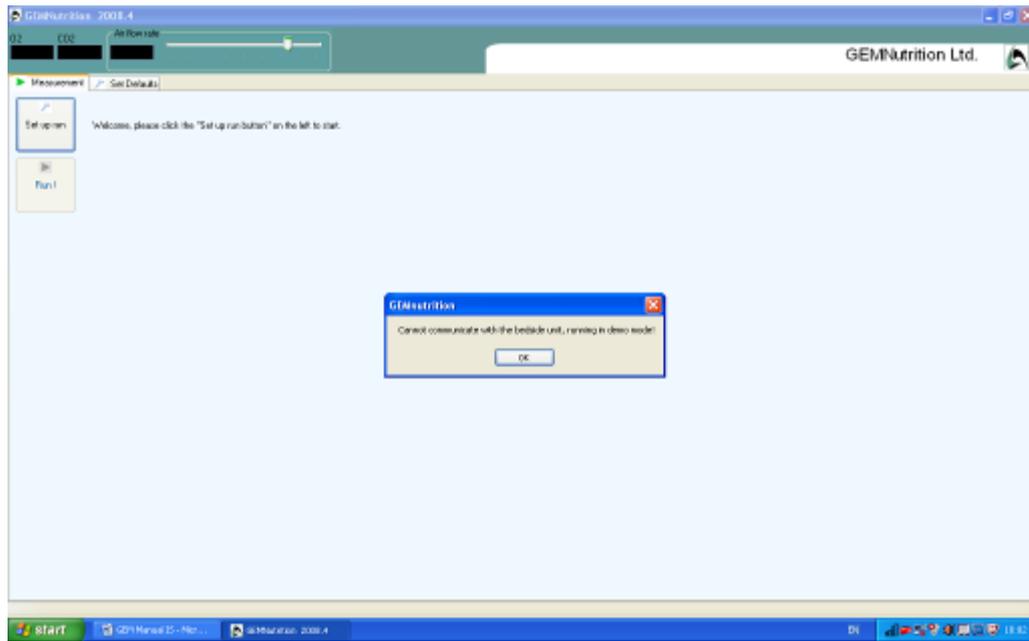


Figure 7. "Cannot communicate with bedside unit"