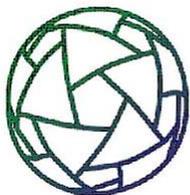


Instructions for Use of the Indoor Air Pollution Meter (IAP Meter) 5000 Series

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Instructions for use of the Indoor Air Pollution Monitor (IAP Meter)

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1. Purpose of the IAP Meter

The purpose of the IAP Meter is to quantify reductions in health-harming emissions from cooking stoves by measuring indoor concentrations of CO and PM. By creating careful studies, the IAP Meter can be used to help identify the potential reduction in IAP created by an improved stove or other intervention. The meter was created to provide a simple, inexpensive, and reliable system to generate quality field data without the need of highly-trained personnel or sophisticated equipment. The meter was designed so that in-field staff will not need to use a computer or conduct any data downloading or processing. The meters can simply be sent to the field, turned on and off as needed for many tests, and then returned to the office for data analysis.

2. Features

- Measures concentration of carbon monoxide and PM 2.5
- Includes backpack and snorkel tube for exposure monitoring
- Three sample frequency modes:
 - Fast Mode: Sample period: 9 seconds
 Battery life: 3 days
 - Med Mode: Sample period: 51 seconds
 Battery life: 2 weeks
 CO over-sampling for noise filtration
 - Slow Mode: Sample period: 9.7 minutes
 Battery life: 1 month
 CO over-sampling for noise filtration
- Serial Port output for live display and communication:
 - RS-232/USB adapter
 - Compatible with Livegraph software for computer display
- LED indicator light: 5 second blink indicates the IAP Meter is on
 Solid light indicates setup mode

3. Uses of the IAP Meter

There are several experimental settings where the IAP meter can be used. As always, the experiments include a spectrum of control from the lab to the field. Controlled lab studies limit variables and isolate the stove but may not reflect reality in a home.

The key is *Relative Improvement* between two stoves when tested under the same circumstances. Absolute values will require larger sample sizes.

Three recommended uses include:

3.1 Lab Based WBT

If stove testing is done in a standard room with a constant level of ventilation, IAP emissions may be used to compare the performance of two or more stoves while the WBT is conducted. Average concentrations during the test can be used to compare the emissions from each stove. However, emissions collection using equipment such as the PEMS provides a much more detailed measure.

3.2 Field Based CCT

If a CCT is done in the same room with the same level of ventilation each time, the IAP meter can give a very good idea of the expected reduction in IAP provided by an improved stove when compared to a traditional stove in that room. Two or more stoves can be compared in this way. However, different rooms should not be compared, although the *% Improvement* between two stoves in several different rooms can be compared. This can be a fairly fast and accurate way to determine if an improved stove is reducing the levels of IAP.

3.3 Population Based IAP Monitoring

To determine what really happens when the stoves are used in homes, IAP can be measured for up to a week in each home. This will tell the true levels of smoke in that home. An average can be taken and compared to the WHO air quality guidelines. If a large enough sample of homes is used, for both the traditional and improved stoves, an idea of the typical IAP reduction seen by the stoves can be found. However, because of the high variability created by the varying kitchens, practice, and ventilation, a large sample size and time commitment is required.

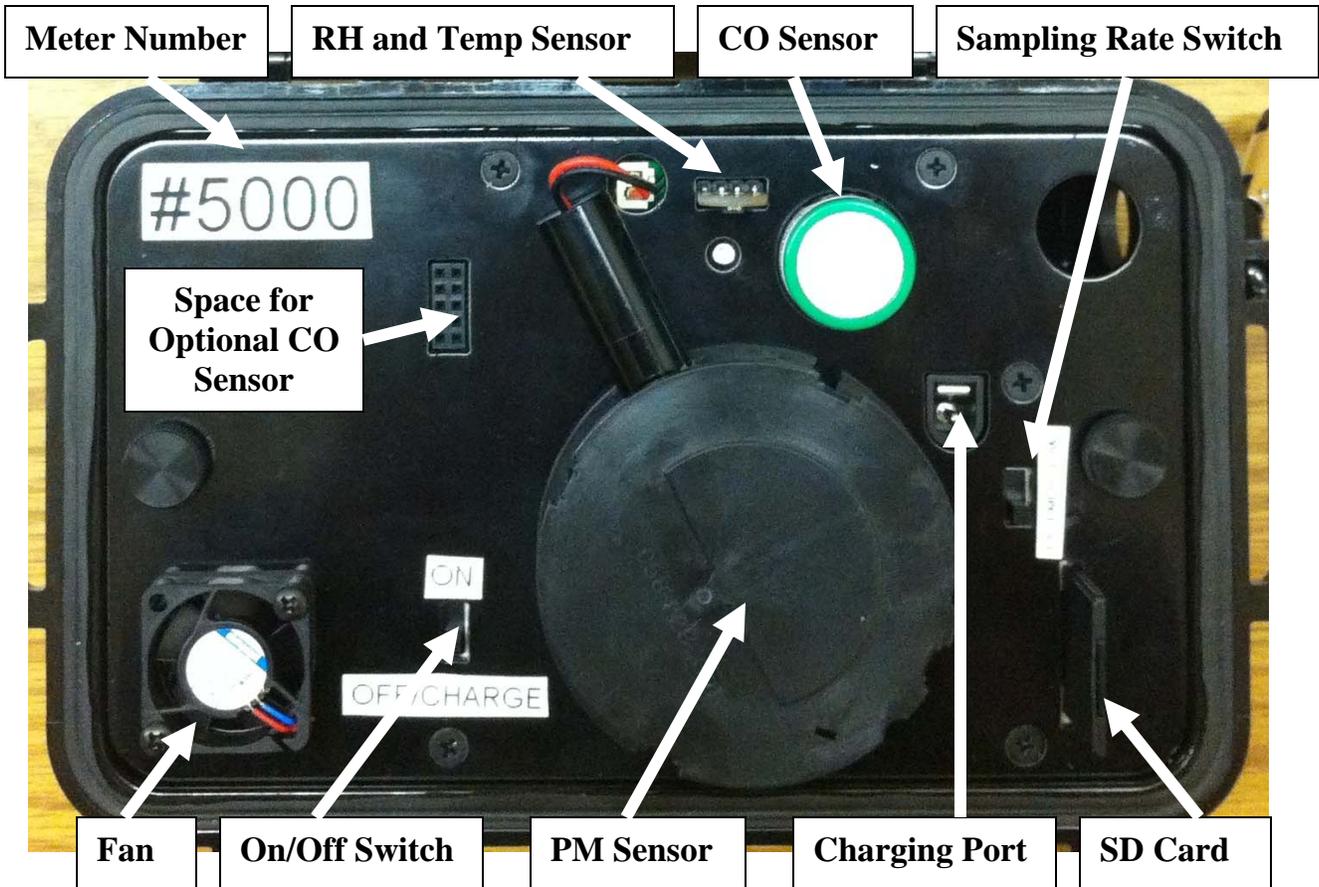
3.4 Exposure Monitoring

When the sample tube is connected to the meter and the meter is worn in a backpack by the cook, actual personal exposure can be measured. There are advantages to measuring what the cook is actually breathing, as opposed to simply monitoring the concentrations of pollution at a certain point in the room. Exposure monitoring is especially useful for health studies.

3.5 Teaching

The real-time emissions display of the IAP Meter can show changes in emissions when variables of the stove are altered, like when too much wood is added, or when only charcoal is burning, or when the intake air supply is adjusted. The real-time display can be a great teaching tool and help fine-tune the design of a stove. It can also be used to show, in real-time, how the emissions in the room change with ventilation and location throughout the room.

4. How the IAP Meter Works



The box contains two sensors, a fan, control circuitry, a rechargeable battery, a memory stick (SD card). The control circuitry turns the sensors on and begins recording the signal they output. In order to save battery life, the fan and sensors are turned on momentarily to take a sample, then turned off again. The fan draws an air sample through the box so that pollutants can be accurately measured. The box stays closed when testing. At the end of a test, the meter is turned off and the data file is closed, allowing for data processing by a computer.

The CO sensor is an electrochemical cell. When exposed to CO, the conductivity between two electrodes changes in proportion to the concentration of CO.

The PM sensor works using optical light scattering. Inside the sensor are both a laser and a light receiver. When smoke enters the sensing chamber, the light of the laser bounces off the particles of smoke into the receiver. More light reaching the receiver indicates more smoke in the chamber. This level of light has been calibrated against a laboratory-standard nephelometer to relate the amount of reflected light to the concentration of smoke particles.

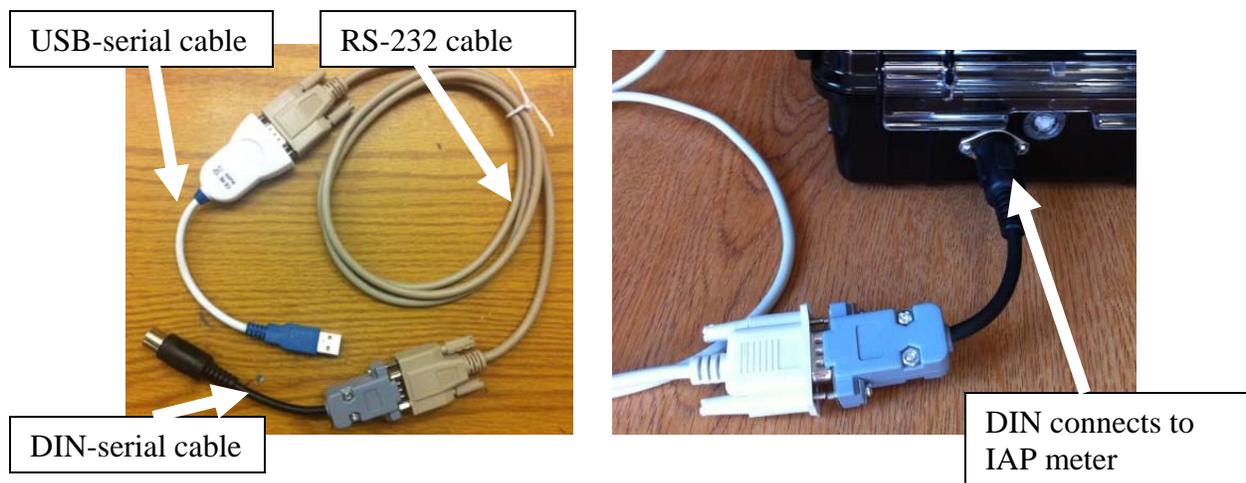
The data is processed using Microsoft Excel or other similar spreadsheet software. This software analyzes the logged data, converts it into physical concentrations, and provides output in graphical and tabular form. Average concentrations as well as highest 15 minute averages are provided automatically in a format that can easily be copied into a master spreadsheet for comparison with other tests.

5. Setting up the System

5.1 Additional Requirements

Card Reader – A reader for the SD card provided with the IAP meter. This is required for transferring the data to a computer. Some computers are equipped with this drive already.

Live-Output Cables – The cables provided with the IAP meter 5000 series are connected and plugged into a computer to view live data output from the meter as well as enter the calibration menu. They are a DIN-serial cable, which is plugged directly into the meter and a serial-USB cable, which is plugged into the computer.



Software – The data can be processed on Windows, Mac, and Linux operating systems using Microsoft Excel or other similar spreadsheet software. There are two versions of spreadsheet software, one with Visual Basics Macros and one without Visual Basic Macros. The data processing software with Visual Basics Macros only works on PCs with Microsoft Excel 2003 and newer. The current data processing software and other software for using the meter in live-output mode are included in the IAP Meter Software Folder on the SD card. You may also go to www.aprovecho.org and download the data processing software for series 5000 IAP meters.

Power Cord for Charger – The charger comes with a power cord with a US-style plug. If this does not fit local outlets, a simple adapter can be used with the cord provided.



Power Cord

5.2 Software Folder

There is an IAP Meter Software Folder on the SD card. It contains this instruction manual, data processing spreadsheets, Terreterm (program used for connecting the meter directly to computer), and Livegraph (for graphing the output). Before using the IAP Meter, copy or transfer this folder to your computer hard drive. In addition, create a folder on your C:\ drive called C:\IAP-Output\. This is where you will copy all .csv files from your meter.

5.3 Meter Setup

Depending on shipping method, the IAP meter may arrive with the battery disconnected. If this is the case, the battery must be installed. To install the battery, you must remove the meter panel. Please watch “IAP Meter 5000 Series, Removing the Panel”, found on your SD card, to see how to remove the panel. Or view the video at: www.youtube.com/watch?v=e8Wf2bBn8KI

Once you have removed the panel, you will see a place where the battery and its matching wire connect. Simply connect this and securely place the battery in the bottom of the case. Ensure that the wire jack makes a tight connection. Replace the panel following instructions from the video.

Turn the meter on to ensure it is functioning. When the meter is first turned on, the red LED will light up for about 5 to 10 seconds. Then it will flash about once every 5 seconds, indicating the meter is functioning. Depending on the sample speed selected, you may be able to watch the IAP meter sample. You can gently remove the top of the PM sensing chamber and see the red laser turn on every sample. You can also see the fan spin every sample. It may take up to 1 minute for the meter to start up. A third way, and the best way, to verify the meter is functioning, is to connect it to a computer through the serial port and view the output. Instructions on how to do this are explained in section 9 of this document.

6. Running a Test

A test involves selecting the sample rate, turning on the meter, closing the lid, taking at least 10 minutes of clean background air data, sampling, and then powering down and processing data.

When arriving at the sample location, it is a good idea to let the meter acclimate to the local temperature, especially if it is being moved from a hot car into a cool room. Let the meter sit for a few minutes with the lid open and the meter turned off, out of direct sun. The signal from the CO sensor is affected by temperature, so this helps to establish the proper temperature and CO baseline.

6.1 Selecting the Sample Rate

Set the sample rate switch to fast, medium, or slow sample rate. If the sample rate is switched to a different rate while the IAP Meter is on, the sample rate will not change until the device is turned off then on again.

6.2 Powering Up

To begin, simply turn the meter switch to on. **On your printed data collection sheet record the exact time the meter was turned on.** This time will be needed when data is processed.

Recording the local time in this way makes direct connection of the meter to the PC unnecessary for setting the time in the meter. A printable sheet for recording data from each test is provided within the data analysis software/spreadsheet. This should be printed out and filled in entirely for each test.

Verify that the meter is running by watching the LED blink once every 5 seconds. Then close the lid immediately. Whenever the lid is open, readings will not be accurate. You can verify the meter is running when the lid is closed by listening for the fan to spin every sample.

Every time the meter is turned on, a new data file is created on the memory card. So, you should keep track of what number data file you are generating each time the meter is turned on. There is a space for this provided in the data collection sheet.

	A	B	C	D	E
1	IAP Meter Data Collection Sheet				
2					
3					
4	Data File Folder				
5	Consecutive Data Filename (Data01,Data02,etc.)				
6					
7	Meter Number				
8	Meter On Date and Time				
9	No. of Background Minutes				
10	No. of Test Minutes				
11					
12	Test Name				
13	Description of Test				
14	Location				
15	Tester/Cook Name				
16	Type of Test				
17	Further Details				
18					
19	Start time of Test Period				
20	End time of Test Period				
21					

Figure: Data recording sheet

6.3 Zeroing Period

Background readings are necessary to determine the addition of IAP to the ambient air quality. This is done by leaving the meter running for at least 10 minutes in a nearby location where direct smoke is not present. This can be done in the kitchen when no cooking is happening, or outside in a non-windy area. Leave the meter running (with the lid closed) for at least 10 minutes

of background sampling, and then begin testing. Note the time when the background sampling is finished. A longer background period will yield a better sample, especially in cases where background may be fluctuating. 30 minutes to 1 hour may be better.

It is important to consider whether you would like your “background” to be clean air, free of pollution, or the average air quality to which smoke from cooking is added. It is likely you prefer to measure the additional pollution directly caused by cooking, in which case you will take a background of “normal” air in the area.

Note that each test file must begin with at least 10 minutes of background readings, before the meter is moved to the testing location. The background readings should NOT be taken as a separate file. So please be sure to leave the meter running when transitioning between the background and testing phases.

6.3.1 Zeroing Period for Slow Mode: 10 minutes per sample

When the IAP Meter is set to sample once every 10 minutes, the zeroing period should be at least a few hours long. For multiple day tests, the zeroing period can also be chosen from the data points when the data is being processed.

6.4 Running the Test

The meter can now simply be hung in a safe location and left running during the sampling period. Always operate the meter with the lid closed.

6.4.1 Placement of the Meter

Consistent meter placement is necessary for comparable measurements. Generally it is recommended that the meter be placed about 1.3 m aside the stove and 1.3 m up from the floor, as that replicates a common breathing location of the cook. Some recommend 1.4 or 1.5 meters as this factor. House structure and ventilation complicates this location. When doing a before and after study in a house, it is necessary to place the meter in the same place in that house. There has been more detailed work done on recommended meter placement by the University of California -- Berkeley.



6.4.2 Exposure Monitoring

If your study involves personal exposure monitoring, the meter can be worn on the subject. To do this, first connect the provided sampling tube to the left side of the meter box by screwing the fitting into the box. This tube is designed to curve over the left shoulder of the wearer with its inlet positioned on top of her shoulder. It can be rotated so that the meter sits flat against her back while the tube curves over her shoulder.



Use the backpack provided with meter, and adjust the backpack and meter position so the tube sits on the shoulder of the wearer. The tube can be painted or covered in fabric as appropriate.

6.5 Ending a Test

When the test is finished, simply open the lid and turn the switch to off. The SD card can then be removed and transferred to a computer at your leisure. Or, the meter can be turned back on again

at anytime to begin another test. The SD card will hold 99 test files before it needs to be erased. Note that the last test completed will be the last data file on the card, organized by date. Every time the meter is turned on, a new file is created. If the card fills up, the next recorded file will overwrite the last file name instead of making a new file name.

7. Downloading and Processing Data

There are two spreadsheets available for processing data from the 5000 series IAP meters: IAP Meter Processing 5.0.xls and IAP Meter Processing 5.0 Macro-Free.xls. The difference between the version with Macros and the Macro-Free version is how the data is loaded. For the spreadsheet with Macros, the IAP Meter data file is loaded into the spreadsheet by pressing the “Process Data” button. Your computer must have Microsoft Excel 2003 or newer and be capable of running Macros for this to work. This spreadsheet can accept up to 40,000 data points. For the spreadsheet without Macros, the IAP Meter data file is loaded by copying and pasting columns A-E of the .csv file into the processing spreadsheet. This spreadsheet works on any operating system with virtually any type of spreadsheet software. This spreadsheet can accept up to 10,000 data points.

Feel free to contact Sam Bentson sam@aprovecho.org if you have any problems with the software.

7.1 Processing Data with Macros

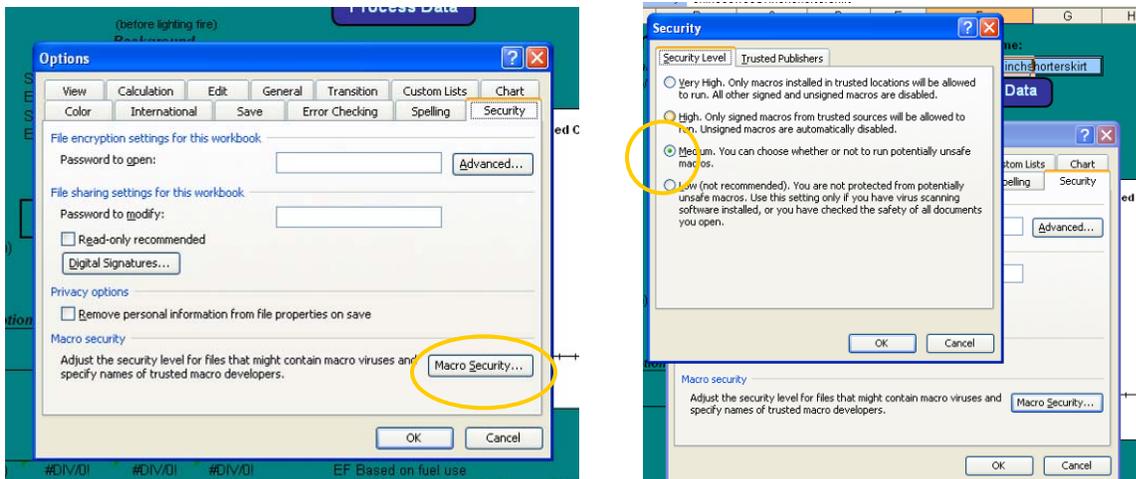
7.1.1 Transferring Data

The data is saved on the SD card under the last file name. Simply copy the file from the SD card using a card reader into a folder on your computer you create called C:\IAP-Output\. You may rename your data files with simple, more specific names once they are copied onto your computer.

7.1.2 Processing Data

The software is written for Microsoft Excel 2003 and newer. It likely won't work on Mac computers. For Macs, see section 7.2.

To use the data processing spreadsheet, Macros must be enabled on your computer. This can be done by choosing (in Excel) Tools – Options – Security – Macro Security. It is best to choose “Medium” security within these options. Then whenever you open a file with a Macro, it will ask if you want to Enable or Disable the macros.



To process, simply open the IAP Meter Data Processing spreadsheet provided. If you are using a non-English version of Excel, you may need to click the “Change Language” button at the top of the sheet before beginning. This will change your computer’s default time formats to the ones used for processing.

Enter all of the information on the “Interface” sheet, and then click the “Process Data” button. The program will run, and you can then see the results on the “Output” sheet. Further instructions are provided in the software.

Make sure the date and time are entered in the correct format: **mm/dd/yy 08:00:00 AM** or **PM**. During entry it must be typed as AM/PM specific. After the data is processed, you should review the times and make sure they are correct, this will affect the rest of the data.

If you receive a Run Error, it is likely because the folder or file name you entered was incorrect. If this happens, click “End.” Then ensure the folder and file name are correct, and that the file is in that folder. The folder name should always end in a slash.

7.2 Processing Data without Macros

7.2.1 Transferring Data

The data is saved on the SD card under the last file name. Simply open the file on the SD card using a card reader.

7.2.2 Processing Data

To process, simply open the spreadsheet titled IAP Meter Processing Macro-Free. If you are using a non-English version of Excel, you may need to click the “Change Language” change your computer’s default time formats to: **mm/dd/yy 08:00:00 AM** or **PM**.

Enter all of the information on the “Interface” sheet, and then proceed to the “Raw Data” sheet to paste in the IAP Meter data. Open the csv file you took off the SD card and copy the first 5 columns (A-E). Paste them into the Processing Sheet in the Raw Data section columns A-E. Then save and rename the file with a unique name. It is important to rename the file so you do not overwrite the master file. Keep a spare copy of the master file in case it does get overwritten. Additional copies can also be downloaded from www.aprovecho.org.

The test results can be viewed on the “Output” sheet. Further instructions are provided in the software. Make sure the date and time are entered in the correct format: **mm/dd/yy 08:00:00 AM** or **PM**. During entry it must be typed as AM/PM specific. After the data is processed, you can change the times in the test cells at the bottom to see the calculations for different time periods when the meter was running.

8. Using the Data

The data is provided in a columnar format so that it can be easily copied into a summary spreadsheet for comparison with other tests. Be sure to choose Paste Special – Values when transferring data to another spreadsheet. Below is an example of how data may be combined to provide the average and variation of a test series.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Data Summary												
2													
3	Data File Folder	C:\IAP-Output-2007\IndiaCCT	C:\IAP-Output-2007\IndiaCCT	C:\IAP-Output-2007\IndiaCCT				C:\IAP-Output-2007\IndiaCCT	C:\IAP-Output-2007\IndiaCCT				
4	Data Filename:	dec1	dec3	dec11				dec12	dec12				
5													
6	Meter Number	1001	1001	1001				1001	1001				
7	Meter On Date and Time	12/1/2007 9:10	12/3/2007 9:06	12/11/2007 9:11				12/12/2007 9:05	12/12/2007 9:05				
8	No. of Background Minutes	18	18	18				18	18				
9	No. of Test Minutes	240	240	240				240	240				
10													
11	Test Name	Kerosene Cook E Test 1	Kerosene Cook H Test 2	Kerosene Cook I Test 3				Three Stone Fire Cook I Test 1	Three Stone Fire Cook I Test 2				
12	Description of Test	IAP Improved	Kerosene	Kerosene				IAP Traditional	IAP Traditional				
13	Location	Pondicherry	Pondicherry	Pondicherry				Pondicherry	Pondicherry				
14	Tester/Cook Name	Chandra	Chandra 2	Janaki				Janaki	Janaki/Chandra				
15	Type of Test	CCT Series	CCT Series	CCT Series				CCT Series	CCT Series				
16	Further Detail	0	0	0				0	0				
17													
18	Start time of Test Period	12/1/2007 12:26	12/3/2007 11:37	12/11/2007 11:24				12/12/2007 13:13	12/12/2007 14:49				
19	End time of Test Period	12/1/2007 13:45	12/3/2007 12:43	12/11/2007 12:45				12/12/2007 14:43	12/12/2007 16:05				
20													
21	Number of Readings	11940	12153	10731				13816	13816				
22	Reading Frequency, seconds	2.0	2.0	2.1				2.1	2.1				
23	Battery Check	Battery Good	Battery Good	Battery Good				Battery Good	Battery Good				
24													
25	If unclean air was used for background, enter zero in two cells below:												
26	Background PM	96	-317	-144				-240	-240				
27	Background CO	3.3	5.4	3.6				3.2	3.2				
28													
29	Average PM Concentration	1,034	870	1,651	1,185	35%		4,213	3,444		Average	3,829	14%
30	Average CO Concentration	6.4	14.7	40.7	21	87%		38.2	38.2		COV	38	0%
31													
32	Highest PM Concentration	12,672	8,813	11,904	11,130	18%		20,976	16,512			18,744	17%
33	Highest CO Concentration	11.1	23.7	68.2	34	87%		70.7	67.4			69	3%
34													
35	Highest 15-minute PM Concentration	2,041	1,736	3,499	2,426	39%		7,553	5,205			6,379	26%
36	Highest 15-minute CO Concentration	7.7	20.1	58.9	29	92%		53.9	43.9			49	14%
37													
38	Lowest 15-minute PM Concentration	745	188	269	401	75%		2,027	2,019			2,023	0%
39	Lowest 15-minute CO Concentration	1.0	1.0	1.0	1.0	20%		1.0	1.0			1.0	21%

9. Live Data Output

The IAP meter comes with an RS-232 (9 pin) computer connector cord, as well as an RS-232/USB adapter. The IAP Meter can be connected to a computer serial port to view the raw data output, graph the output, and change the calibration constants.

If you are using a USB connection, you will need to install the proper drivers in order for the adapter to function properly. To install, copy the appropriate driver folder to your C:\ drive. This folder is located on your software CD. It is labeled “FTDI Chip - USB Serial Adapter” – **make sure to copy the appropriate 32-bit or 64-bit folder for your computer**. Plug the RS-232 to USB adapter into a USB port on the computer. A window should pop up, asking you to install the driver software for the UC232R device. If it does not, then go to the Device Manager found in the “Control Panels” in the system folder, or click on the Device Manager icon installed on your desktop. Double click on the Universal Serial Bus device that has a small yellow triangle

with an exclamation mark. In the window that opens, click the “Drivers” tab at the top. Then click “Update Drivers”. This will open the driver install window. While you are installing the drivers, be sure to choose the option to choose your own drivers, and select the folder you installed earlier on the C:\ drive. You may have to go through the driver installation process twice before the device is recognized by your computer.

If these drivers did not work for your USB-Serial converter, you may need to download the latest drivers from the internet. You can find the newest drivers here:

<http://www.ftdichip.com/Drivers/VCP.htm>

9.1 Open Serial Port Software

Terminal port software is required to communicate with the IAP Meter. We recommend the following software for:

Windows:	Terreterm (provided in the IAP Meter Software Folder)
Mac:	Zterm (\$20 honor system price)
Linux:	Picocom (included with Linux)

9.1.1 For Windows: Terreterm

1. Transfer the Terreterm folder from the IAP Meter Software Folder to your hard drive. Open the folder and find the file with the computer icon called “ttempro Tera Term Pro T. Teranishi”. Drag the file to your desktop.

2. Plug the USB adapter into the computer. Go to Control Panel, then System, then the Hardware tab, then Device Manager. Click the plus sign in front of Ports to see the recognized ports. You should see “Prolific” followed by the port number in parenthesis (“COM4” or “COM5” etc.). Take note of this port number.

Note: If you do not see the Prolific port that it because your computer does not have the driver required to communicate with the Prolific USB adapter. You must download and install the pl3202 driver from the following link in order to continue:

www.waltech.com/software-win/PL-2303_Driver_Installer.exe

It is an .exe file and you must reboot after it is installed.

3. Once you have taken note of the Prolific port number, open the Terreterm program that you put on your desktop in step 1. A “New Connection” window will pop up. Select the serial button and choose the port number from the dropdown menu that matches the Prolific port you noted in step 2.

Note: If the Prolific port number is not available in the dropdown menu, you need to change the Prolific port number in Device Manager to be one of the unused ports in the dropdown menu. This is done by going back to Control Panel, System, Hardware tab,

Device Manager. Double click on the Prolific Port, select the Port Settings tab, then Advanced. Change the COM port number to one that is in the Terreterm dropdown menu and is not being used. Then you can go back to Terreterm and select the Prolific port number.

4. Click “OK” and you are now communicating with the IAP Meter. If the IAP Meter is already on you will see the output, or turn the IAP on to begin viewing the output.

5. RS-232 Connector: To use the RS-232 connector without the USB adapter, remove the USB adapter and plug the RS-232 connector into the computer. Open Terreterm and select COM1 (or COM2 if there are multiple jacks). No special driver is required to use the RS-232 connector.

9.1.2 For Mac: Zterm

1. Download Zterm.app from the internet. When it is downloaded, click to mount it as a disk image. Drag Zterm out of the disk image folder to the desktop.

2. Open Zterm. Select the Settings tab, then Modem Preferences. In the Serial Port dropdown box choose “USB serial”. For the initial setup, set the data rate to 9600 and make sure “No Flow Control” is unchecked.

Note: If the USB serial terminal is not available in the serial port drop down menu, check to see if the computer recognizes the USB adapter. Do this by going to the Utilities folder inside the Applications folder. Open a Mac command line terminal. Type “sudo dmesg” <enter> and provide your password. (See section 6.1.3 for details about the dmesg command.) If the USB adapter is not listed as a PL2303, the driver needs to be installed. You must download and install the PL3202 driver for free from the Prolific website in order to continue.

<http://www.apple.com/downloads/macosx/drivers/pl2303usbserialdriver.html>

3. You are now communicating with the IAP Meter. If the IAP Meter is already on you will see the output, or turn the IAP on to begin viewing the output.

9.1.3 For Linux: Picocom

Most Linux operating systems have Picocom. If your computer does not have Picocom it can be downloaded by using the Package Manager.

1. Plug the USB adapter into computer. Open a terminal port. Type “dmesg” <enter> in the command line. This command will show all recent activity on the computer. Near the bottom of the list of activity, look for the name of the computer port that the USB connector is plugged into. It should read “pl2303 converter now attached to ttyUSB0”. The port number may also be ttyUSB1, ttyUSB2,etc.

2. Type “picocom /dev/ttyusb0” then <enter>, replacing 0 with your port number, in the command line (notice there is a space after picocom). A list of the port settings and information will be displayed followed by “Terminal ready”.
3. You are now communicating with the IAP Meter. If the IAP Meter is already on you will see the output, or turn the IAP on to begin viewing the output.
4. RS-232 Connector: To use the RS-232 connector without the USB adapter, remove the USB adapter and plug the RS-232 connector into the computer. Open a terminal port and type the command “picocom /dev/ttyS0”.

9.2 Serial Port Output

The IAP Meter will give an output like this when it is turned on:

```
#testing: humid OK    CO OK    CO2.....CO2 err
#IAP-4000j_cell_8
#type cal (in 5 seconds)
# ? ...starting logging
#CO initialized.
#initializing SD card...done
#clock initialized
#year: 2013 month:2 day 1:hour: 17 min: 26 sec: 55
#start time: 56159
#make new file name:
#new name: 2013_02_01_172655.csv
#file open
#wait for timer
#fast sampling
#init i2c libs....done, measure and log
# cal vals: XX ,PB, TE, CO, PM, TO, C2
# ,614, 0.0408, 0.0326, 1.65,1
##,##
seconds, batt, adc_temp, CO, PM, humidity, top_temp
9, 81, 710, 111, 551, 47, 19
```

- Line 1: when you see line 1, you have 5 seconds to type the word “cal” to enter setup mode and change the calibration constants
- Line 12: sample speed
- Line 15: calibration constants.
- Line 18: start of the data output
 - Column 1: time (seconds)
 - Column 2: Battery life (percent charged)
 - Column 3: Temperature (logunits)
 - Column 4: CO (logunits)
 - Column 5: PM (logunits)
 - Column 6: RH (relative humidity)
 - Column 7: Temperature (degrees C)

9.3 Livegraph

Livegraph is a graphical interface for viewing the data output from the IAP. A free Livegraph download is available on the internet. However, we recommend you use the Livegraph program provided in your IAP Meter Software Folder. It has been modified to work better with the IAP Meter.

Java must be installed on the computer to run Livegraph. If Java is not installed, a free download and installation instructions are available on the web from Sun Micro Systems.

Once Java is installed, open the IAP Meter Software Folder and drag Livegraph to the desktop. It is ready to go. Just click the icon to open the file. Before you can graph the IAP meter output, you must first capture the data in a CSV (comma separated value) file so it is a format that is readable by Livegraph.

9.3.1 Capture Data to CSV File

For Windows

Once you have Terreterm open and connected to the IAP Meter, go to the File tab and select Log. Save the file to the desired location with the file name ending with “.csv”.

For Mac

Once you have Zterm open and connected to the IAP Meter, go to the File tab and select “Start Capture”. Save the file to the desired location with the file name ending with “.csv”.

For Linux

Open a terminal port with the IAP Meter connected to the computer. In the command prompt, copy and paste:

```
picocom --send-cmd “cat>/home/USERNAME/filename.csv” --receive-cmd  
“cat>/home/USERNAME/filename.csv” /dev/ttyUSB0
```

Replace “filename.csv” with the name of the file, replace “ttyUSB0” with the correct port, and replace USERNAME with your username.

You will now be able to view the IAP Meter output.

To log data to the CSV file, type the command: <ctrl> a <ctrl> r

When you see “***file:” hit <enter>

To stop logging data to the CSV file, but remain in Picocom, type: <ctrl> c

To exit Picocom, type: <ctrl> a <ctrl> q

9.3.2 Using Livegraph

There are 4 Livegraph windows.

1. Data file settings window

- Select “open” to open the desired csv file.
- Move the bar to change the update frequency.
- Big files will flash when updated if the “Do not cache data” box is checked

2. Graph settings window

- change the axis range
- add gridlines
- set the x-axis to seconds by setting the Type to “Series” and the Series to “seconds”

3. Data series settings window

- check and un-check the series that you want displayed
- click color bars to change color
- click “Actual value” in Transformation column and drop down to “scale by specific”, then double-click and change the scaling factor in the next column.

4. Plot window

- move cursor over a point to see the coordinates

10. Calibration

The unit can be sent to Aprovecho for calibration whenever desired. Recommended calibration frequency is about once every six months. If on-site calibration is desired, please contact Aprovecho for required equipment and instructions. The following instructions explain how to change the calibration constants stored in the IAP Meter.

The calibration constants are stored in the data logger memory and are output with the data file. The calibration constants appear on line 1 of the csv file. The calibration constants are also labeled in the header of the serial port output. When the IAP Meter is recalibrated, the constants must be changed by entering setup mode through the serial port. To enter Setup mode:

1. Turn on the IAP meter when it is connected to a serial port. . The output will display “type cal (in 5 seconds)”. When you see this, you have 5 seconds to type the word “cal” <enter>. Depending on the serial port program you are use, the “c” might not appear on the display and it will return “al”. If anything besides a lower case c is entered as the first character, the IAP Meter will automatically continue on to log data.

2. Once you have entered setup mode the display will read:

enter CO, PM, PB, TE, time, C2, TO, CO2cal, IN

CO: carbon monoxide calibration constant

PM: particulate matter calibration constant

PB: particulate matter baseline of a clean sensor

TE: chip temperature calibration constant

time: date and time in 24 hr format

C2: relativity humidity

TO: chip temperature zero offset

CO2cal: not applicable unless you have installed a CO₂ sensor

IN: meter name and number (do not change this)

Type one of the four case-sensitive commands and press <enter>. The current value will be displayed and a new value can be entered at the prompt. If you do not wish to change the value then press <enter> to return to the previous prompt.

3. Turn off the IAP Meter to exit setup mode.

11. Important Notes

Keep the meter out of direct sunlight.

Please use only the SD card provided. Other cards may not be formatted properly.

Clear off the SD card memory occasionally. A maximum of 99 files can be written to the SD card. If the card fills up, meaning file “Data99” has been written to the SD, the next recorded file will overwrite Data99 instead of making a new file name.

Always wait a few moments after turning the switch off before removing the memory card to allow the data file to close.

Do not charge the battery with anything but the provided charger. Any other charger may cause harm to the battery, and possibly fire.

Avoid turning the unit on and off repeatedly.

Do not remove the memory card while the unit is running. This may require the memory card to be re-formatted.

Do not leave the unit and battery in a hot location such as inside a car or above a fire. The battery may overheat and explode.

Whenever the lid is open, readings will be inaccurate. So it is important to close the lid quickly after turning the meter on, and turn it off quickly after opening the lid. Never open the box during a test.

Please try not to destroy the unit with static electricity. Ground yourself before opening it.

Please do not connect any other sensors or batteries to the unit. This will likely damage the meter and void the warranty.

If you have not run the meter for a long time, say several weeks, or it was last run down to a dead battery, please recharge the battery fully and then run the meter for about 2 hours to “wake up” the CO cell. Then proceed with testing as needed.

12. Care and Maintenance

12.1 Battery Removal for Travel

When traveling with the meter on an airplane, it is wise to remove the battery so the unit does not look suspicious. Please review the video on removing the panel before changing the battery. This is easily done by removing the two screws holding the panel in place and lifting it up. You will see the battery has a connector to the panel. Simply disconnect this and remove the battery.

When replacing the battery, be sure to fit the connector fully back into the jack until you feel a click.

12.2 Battery Charging

The battery will last anywhere from 3 to 30 days depending on the sample rate. Column two of the IAP Meter data is the battery state-of-charge expressed as a percent. When the battery state-of-charge drops to 0%, the meter will shut off and the file will stop logging and be saved. The meter will not turn back on until the battery is charged to 70%. It is best to fully discharge battery before recharging.

To recharge the battery, simply plug the charger into the jack on the panel of the meter. Make sure the charger adapter is fully seated in the IAP Meter jack, otherwise the battery may not charge. Make sure the meter switch is turned to off. The charger can be powered by 110V or 220V. If the plug does not fit into a local socket, an adapter can be used. Please do not leave the battery unattended while charging and use only the charger provided. A full charge can take up to five hours to complete. The indicator light on the charger will turn RED to indicate charging and will turn GREEN when a charge is complete.

When the meter is not used for an extended period, it is best to store the unit with the battery disconnected. Also, the battery should be fully discharged and recharged about once every two months to preserve its life. If the meter has not been run for quite some time, recharge it and then run it for about 2 hours before taking any data.

12.3 Cleaning the PM Sensor

When the inside of the box begins to become dirty, the PM sensor should also be cleaned. This can be done by gently lifting the top of the sensing chamber. Every surface inside should be cleaned using a Q-tip soaked in rubbing alcohol, including the PM chamber lid and the surface lens of the laser. Another Q-tip soaked in clean/de-ionized water ONLY should also be gently inserted into the mirror tube and twisted. Be careful not to get the rubbing alcohol on the mirror too often, as it will start to corrode mirror. When finished, carefully ensure that no fibers are remaining in the path of the light. When replacing the top of the PM sensor, ensure it is facing the correct direction.



Picture 1: Cleaning the smoke chamber with rubbing alcohol



Picture 2: Cleaning the laser lens with rubbing alcohol



Picture 3: Cleaning the mirror chamber with de-ionized water

13. Troubleshooting

Once the meter has been turned on, it will automatically create a new data file on the SD card. Once it has finished, (about 10-30 seconds) the fan should turn on to take a sample. If the fan is running continuously or not at all there is usually a problem with the creation of the file on the SD card and the system has halted.

If meter does not turn on

- Make sure the SD card is properly inserted
- Make sure the battery is fully connected
- Make sure the battery is charged
- Make sure there is memory space on the SD card
- Make sure the SD card is not “locked” by checking the switch on the side of the card.

Put the SD card in a PC:

- Make sure there is memory space on the SD card.
- Make sure the card is formatted FAT or FAT16. See below.
- Try writing a small file to the card, and reading it back.
- If the SD card is corrupted, for example, because it was removed while logging, it must be reformatted. See below.

Reformatting the SD card:

- Put the SD card in a PC.
- Right click on the Icon in “My Computer” and choose “Format”
- Under format, choose FAT (NOT FAT32)
- If a new SD card is ever purchased for the meter, this must be done before it will work in the meter.

CO output is negative or low:

- Run the IAP Meter for 1 or 2 hours until the CO output comes back up to its normal baseline.
- This occurs when the switch is left in the on position and the battery dies or is removed.

Other problems occur because of battery connection or low voltage. If the battery voltage is below 6 volts the meter will create a file, then shut down without logging any data. If the IAP Meter is turned on when the battery has not been recharged, the IAP Meter will output “Please charge batt battery exhausted?” through the serial port, unless the battery is completely dead.

- Make sure the battery is properly connected.
- Make sure the battery is charged. If you have a voltmeter, the battery should read 8.4 V fully charged, and 6 V if dead. If the battery voltage is 0 V, it is because the battery has turned itself off to protect from low voltage damage. Charge the battery and notify Aprovecho of the problem.
- Excessively noisy data:
- Move the meter away from motors, computer equipment, fluorescent lamps.

Latest data not showing in file manager on PC

- Refresh file manager screen.
- Is card full?
- Run a short test to verify fan runs.

For technical assistance please contact Sam Bentson: sam@aprovecho.org

14. Credits

Livegraph: Centre for Intelligent and Complex Systems at Monash University

Terreterm: T. Teranishi

Picocom: Nick Patavalis

Zterm: Dave Alverson