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Environmental Protection
Agency

CAIRPOL CAIRCLIP O_3-NO_2

Citizen Science Operating Procedure

Office of Research and Development
National Exposure Research Laboratory

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CairPol CairClip O_3-NO_2 Citizen Science Operating Procedure

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CairPol CairClip O_3-NO_2

The CairPol CairClip O_3-NO_2 is a lightweight, portable sensor for measuring ozone (O_3) and nitrogen dioxide (NO_2) in parts per billion (ppb) or micrograms per cubic meter (µg/m^3) in applications such as personal exposure and indoor and outdoor air quality monitoring. It uses a micro fan to actively sample air. The CairClip can run on battery power for approximately 24 hours, but it can also operate continuously for much longer periods when plugged into a power source. This operating procedure explains what you need to do to collect quality O_3 and NO_2 data using the CairClip sensor for your monitoring project.

Pollutants Measured

Ozone

Ozone is a gas that occurs both in the Earth's upper atmosphere and at ground level. Ozone produced naturally in the upper atmosphere (stratospheric) is "good" ozone that protects us from the sun's harmful ultraviolet (UV) rays. Ground-level (tropospheric), or "bad," ozone is an air pollutant that is harmful to breathe and that damages crops, trees, and other vegetation. Breathing ozone can trigger a variety of respiratory problems, particularly in children and elderly people, and aggravate lung diseases such as asthma, emphysema, and chronic bronchitis. Ground-level ozone is produced by chemical reactions between oxides of nitrogen (NO_x) and volatile organic compounds (VOCs), which can result from unburned petroleum-based fuels, in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NO_x and VOCs that stimulate the formation of ground-level ozone.

Nitrogen Dioxide

NO_2 is a highly reactive gas that can irritate the lungs and cause bronchitis (inflammation of large and small airways in the lungs), pneumonia (inflammation of lung air sacs), and other respiratory (breathing) problems. NO_2 pollution occurs both as a result of natural atmospheric processes and as a result of human activities. As a product of fuel combustion, NO_2 can form quickly from automobile emissions, often increasing NO_2 concentrations significantly near major roadways. Power plants and other industrial processes also emit NO_2. In addition, it contributes to the formation of ground-level ozone and fine particle pollution, both of which are linked to adverse respiratory effects.

What You Will Need

- CairClip O_3-NO_2 air sensor
- USB (Universal Serial Bus) cable (mini-USB to standard USB)
- One 100–240 V/5 V 0.8–1.0 A AC adapter
- One EU (European Union)/US (United States) electricity converter
- One red dongle ('switch') – stops the fan and maintains the device in standby mode
- One green dongle ('plug') – plugs the port to prevent clogging when operated on battery power
- Two filters (CairPol patented, approximately 15 mm in diameter)
- CairSoft software (version 4.1 or later) – see "Installing the Software"
- A sensor case – for portable applications (optional)
- Computer running the Windows 7 operating system at a minimum
- Microsoft Excel Spreadsheet Software (2003 or later)

Important Considerations

- The CairClip is delivered already calibrated and does not need recalibration for 1 year, as long as the sensor maintains certain operating conditions. Abrupt changes in environmental conditions, particularly temperature and relative humidity (RH), can affect sensor performance. Refer to the CairClip O_3-NO_2 data sheet for details (Figure 1).
- If the CairClip is regularly exposed to dust, change the removable filter on the back of the device every 4 months (see Maintenance section). Change the filter more often if the sensor is exposed to large amounts of dust.
- Do not allow the device to remain in standby mode (battery almost depleted) and/or to discharge itself completely. Insert the red dongle for long-term storage to prevent depletion of the battery.
- The internal clock time can be set using the CairSoft software. However, the time stamping of data is performed using the internal clock of the computer to which data are downloaded.

Figure 1

CAIRPOL

MINIATURE AIR QUALITY MONITORING SYSTEMS

P049D.OZ.Technical Data Sheet O3-NO2.160812

Technical Data Sheet CairClip O_3-NO_2

(document prone to modifications)

Range	0-250 ppb (0 - 240 ppb analog)
Limit of detection [1,2]	20 ppb
Repeatability at zero [1,2]	+/- 7 ppb
Repeatability at 40 % of range [1,2]	+/- 15 %
Linearity [1,2]	< 10%
Uncertainty	< 30% [2,3]
Short term zero drift [1,2,4]	< 5 ppb/24 H
Short term span drift [1,2,4]	<1% FS [5]/24 H
Long term zero drift [1,2,4]	< 10 ppb/1 month
Long term span drift [1,2,4]	< 2% FS [5]/1 month
Rise time (T10-90) [1,2]	<90s (180s if large variation of RH)
Fall time (T10-90) [1,2]	<90s (180s if large variation of RH)
Effect of interfering species [1]	Cl_2: around 80% Reduced sulphur compounds : negative interference
Temperature effect on sensitivity [2]	< 0.5 % / °C
Temperature effect on zero [2]	+/- 50 ppb maximum under operating conditions
Maximum exposure	50 ppm
Annual exposure limit (1 hour average)	780 ppm
Operating conditions	- 20°C to 40°C / 10 to 90% RH non-condensing 1013 mbar +/- 200 mbar
Recommended storage conditions	Temperature: between 5°C and 20°C Air relative humidity: > 15% non-condensing
Power supply [6]	5 VDC/200mA (rechargeable by USB via PC or 100V-240V/5V 0.8A-1.0A with adapter)
Communication interface	USB, UART Analog (UART & 4-20 mA / 0-5 V converter)
Dimensions	Diameter: 32 mm - Length: 62mm
Weight	55g
Protection	IP42 (according IEC60529)
Electrical certification	Intertek 4003892 — Conform to UL Std. 61010-1 Certified to CSA Std. C22.2 N°. 61010-1 — CE
Parameters Set up / Downloading	CairSoft

[1] *According to our operating conditions during tests in laboratory: 20°C +/- 2°C / 50% RH +/- 10% / 1013 mbar +/- 5%*
[2] *Values possibly affected by exposures to high gradients of concentration*
[3] *In accordance with the Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe*
[4] *Full scale continuous exposure*
[5] *FS = Full Scale*
[6] *The complete discharge of a device (screen turned off) can lead to a deterioration of its performances*

Any use of the sensor not complying with the conditions specified in herein, including exposures, even short ones ,to environments other than ambient air, to dry and / or devoid of oxygen air or other atmosphere not composed in majority of air, even during calibration, will invalidate the warranty.

Main options	CairTub: autonomy 21 days CairNet: wireless communication & battery powered by solar panel Software: CairSoft, CairMap, CairWeb

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Preparing the Device

The CairClip must be powered on continuously for proper operation. In other words, either its lithium-ion (Li-ion) battery must have sufficient charge, or it must be plugged into a power source such as a fully-charged or plugged-in computer (Figure 2). You must also download and install the CairClip software and then configure your device. The following procedures will prepare your device for data collection.

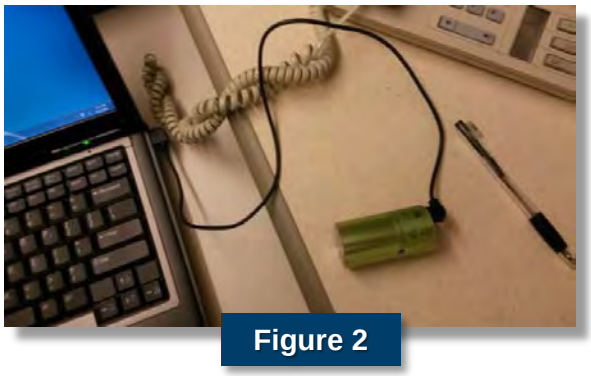


Figure 2

Charging the Battery

The sensor can be charged by connecting it directly to a power source or by connecting it to a USB port of a computer, which is connected to a power source (Figure 2). It takes approximately 4 hours to charge the device. When fully-charged, the CairClip can operate for more than 24 hours. It is strongly recommended that the sensor battery be recharged frequently, preferably after each 24 hours of operation. This is important especially if the battery is nearly depleted, which causes the unit to switch to standby mode (indicated by the warning triangle shown in Figure 3).

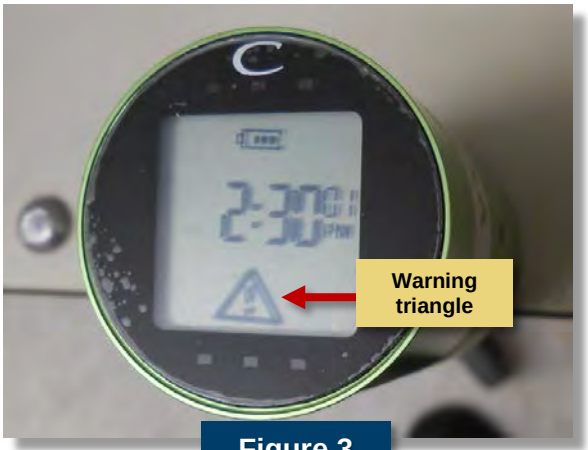


Figure 3

Installing the Software

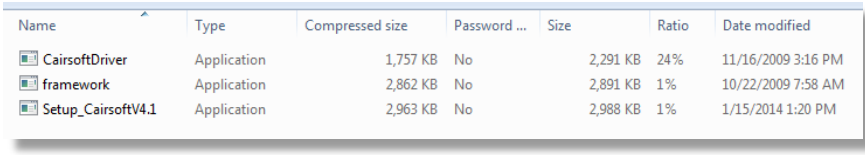
The CairSoft software must be downloaded from the CairPol Web site and installed on a computer as follows before taking measurements.

Procedure: Install Software

1. Go to the CairPol Web site (www.cairpol.com) and click the **'Downloading'** link.

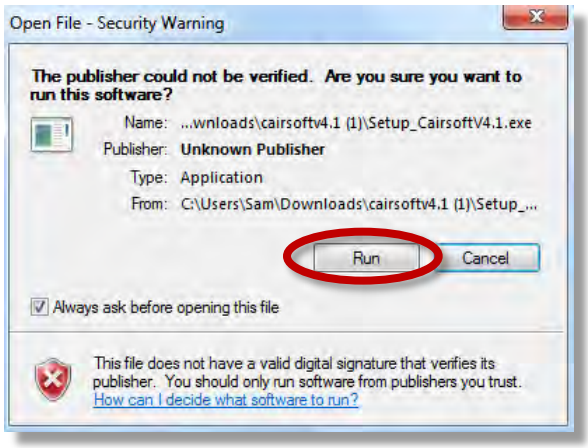
2. Click **'Softwares' [1]** and then select **'Download CairSoft V4.1 (for USB CairSens)' [2]** (or latest version) to begin the software download. A file named **'Cairsoftv4.1.zip'** is created in the computer's **'Downloads'** folder.

3. Use extraction software, such as WinZip, to extract the three files in the **'Cairsoftv4.1.zip'** file.

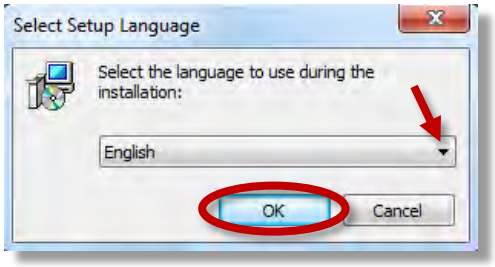


Name	Type	Compressed size	Password ...	Size	Ratio	Date modified
CairsoftDriver	Application	1,757 KB	No	2,291 KB	24%	11/16/2009 3:16 PM
framework	Application	2,862 KB	No	2,891 KB	1%	10/22/2009 7:58 AM
Setup_CairsoftV4.1	Application	2,963 KB	No	2,988 KB	1%	1/15/2014 1:20 PM

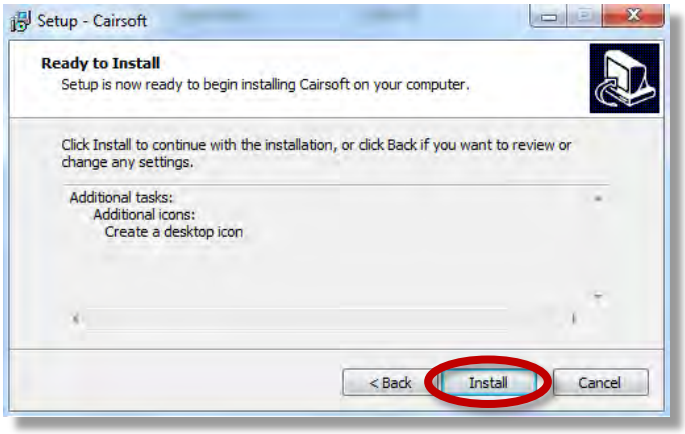
4. Double click the **'Setup_CairsoftV4.1'** file, and click **'Run'** on the **Security Warning** screen to begin the setup.



5. Select the desired language using the drop-down menu, and click **'OK'**.



6. Click **'Install'** to begin the installation.



Configuring the CairClip

Once you have downloaded and installed the CairSoft V4.1 software, you must configure your device for collecting data. The following options are available for customizing the CairSoft software:

- Assign a device name
- Set the date and time (can be used to set the device's internal clock, but time of data collection is recorded using the clock of the computer (where data are downloaded)

- Set the data logging time interval
- Modify the screen (display)
- Modify how data are retrieved and saved (see “Routine Data Collection”)

These settings should, if desired, be customized before acquiring data. Note that the CairClip is manufactured in France, so options on the software screens are in both French and English or, in some instances, just French.

Procedure: Configure Software

1. Connect the CairClip to the computer using the USB cable as shown above in Figure 2.
2. Start the CairSoft software by clicking the **CairSoft** icon (Figure 4) that was created on the desktop during software installation. The login screen shown in Figure 5 will then display for a few seconds.
3. Modify any of the parameters by clicking the buttons on the main CairSoft screen shown in Figure 6.
4. On each parameter modification screen shown on the following pages, click to accept your changes or to cancel and close that screen.

Figure 4

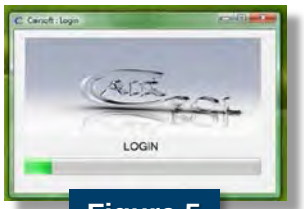
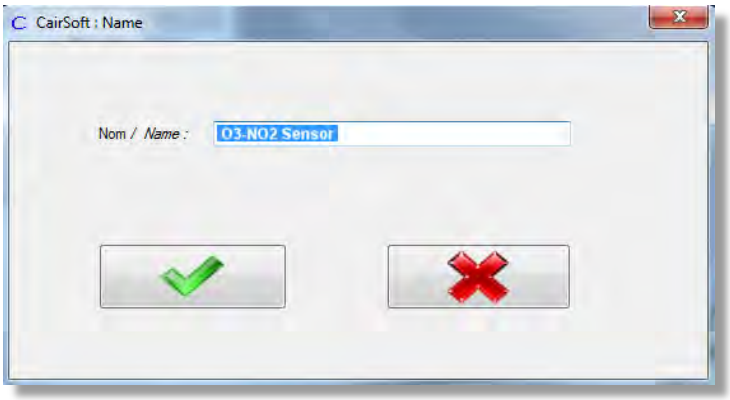


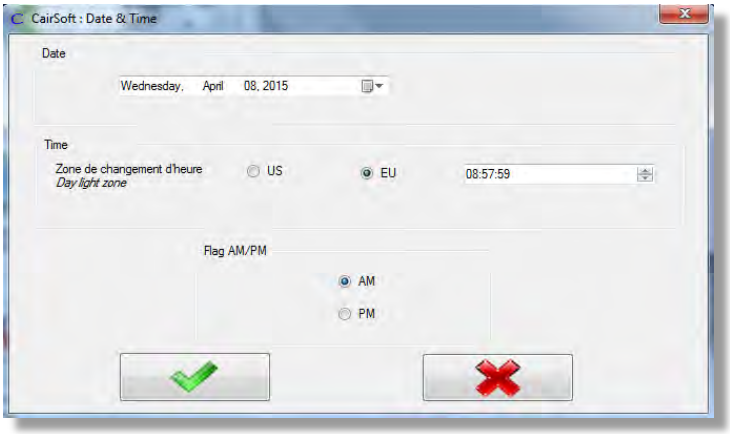
Figure 5

Figure 6

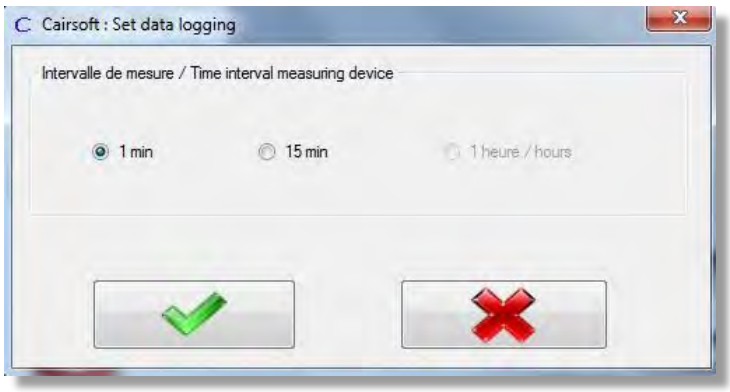
Name



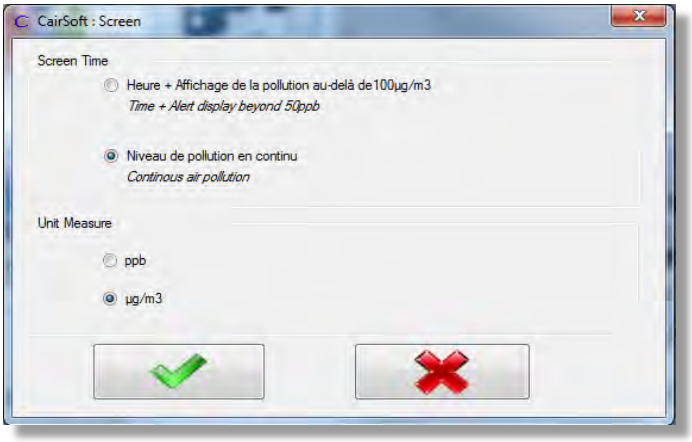
Date and Time



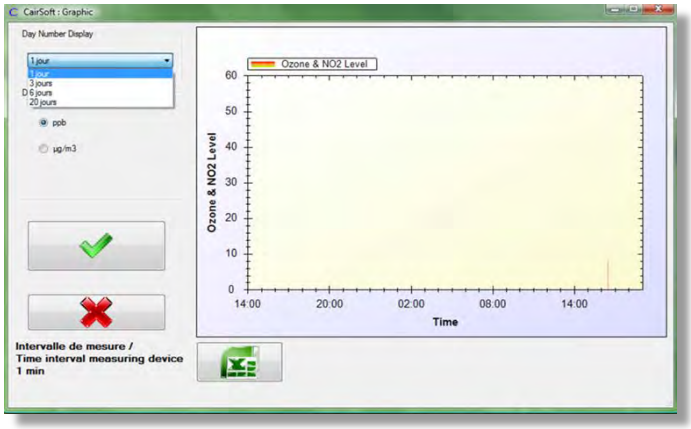
Set Data Logging



Screen



Graphic (used for retrieving and saving data)



Routine Data Collection

The CairClip should be sheltered from rain when deployed outdoors. While orientation has no effect on data, make sure the active air-sampling inlet (fan) is not blocked and avoid any obstructions to the exit of air through the lateral hole (Figure 7). If operating on battery power, the green dongle should be inserted to keep the mini USB/dongle port from clogging. It is also recommended that the sensor not be touched at all immediately prior to and during measurements.

Figure 7

Collecting Data

Data are collected continuously from the moment the CairClip is on (plugged in or battery charged). The device can log and store 1 data point every minute for 20 days (28,800 data points) or 1 data point every 15 minutes for 300 days (108,000 data points) before previously recorded data are overwritten. Make sure you have selected the desired data-logging interval, as described above in “Configuring the CairClip.” The CairClip automatically saves data in a Microsoft Excel spreadsheet file.

Retrieving Data

To avoid losing data, it is recommended that data be exported every 3 days at a minimum during data collection. Use the procedure below to retrieve the data using the CairSoft software.

Procedure: Retrieve Data

1. Connect the CairClip sensor to the computer using the USB cable.
2. Click the **CairSoft** icon to launch the software. The login screen then displays for a few seconds, as described in the section "Configuring the CairClip."
3. Click the **Graphic** button (see Figure 6).
4. Choose the time period for the data you want to retrieve from the drop-down menu ([1] in Figure 8), and confirm your selection by pressing the green **Check** button [2]. Options for time periods are 1, 3, 6, and 20 days (jours).
5. Double click the **Excel** logo [3] below the graph display area in Figure 8, and save the file in the desired location. Be sure to include the date in the file name for easy identification.

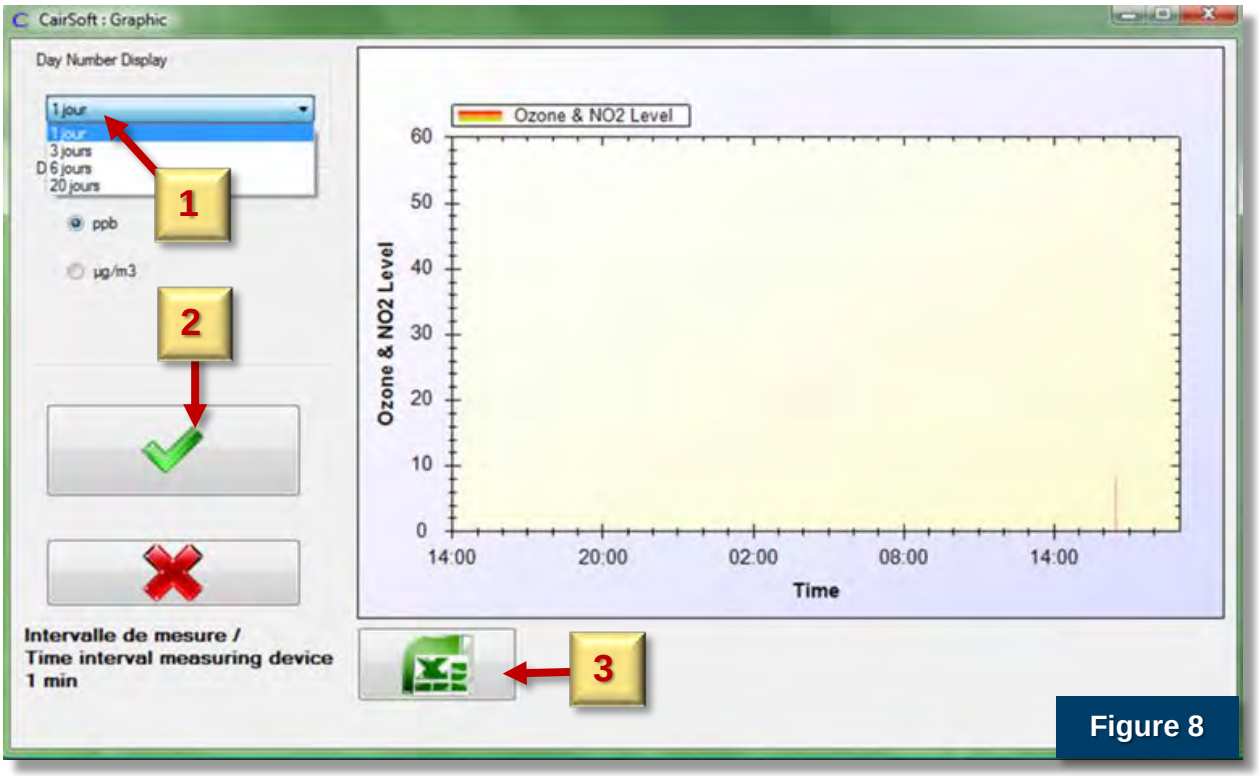


Figure 8

Processing Data

The CairClip automatically saves its data in a Microsoft Excel spreadsheet file in a two-column format with date/time in one column and measured O_3-NO_2 concentration in parts per billion (ppb) in the other, as shown in Figure 9. The CairClip, however, uses a time stamp format that will need to be modified. As shown in Figure 9, the hours and minutes in the timestamp contain "h" for hour, which needs to be replaced with a colon. The following procedure will guide you through modifying the time stamp. Microsoft Excel 2013 is used to illustrate this procedure, but the process is similar in versions of Excel back to 2003.

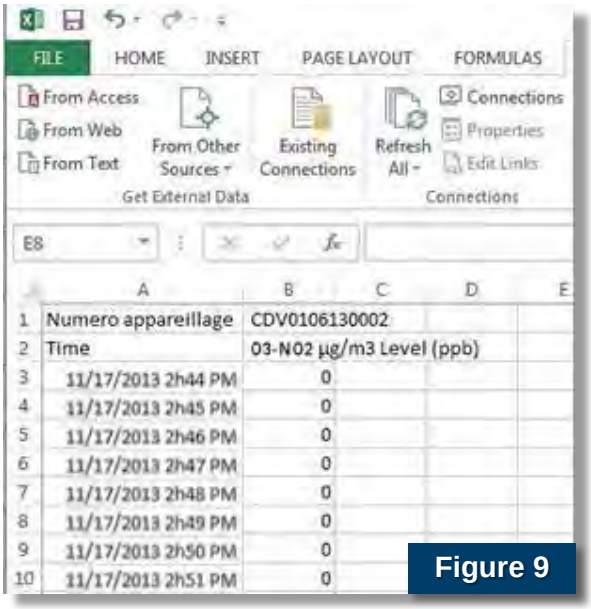


Figure 9

Procedure: Format Data

1. Click on the **A** in the column index to highlight all of column A.
2. Hold down the **Ctrl** key and press the **F** key to open up the **Find and Replace** window (Figure 11).
3. In the **Find and Replace** window, click the **Replace** tab.
4. Enter **"h" i**n the **Find what:** field.
5. Enter **":"** (colon) in the **Replace with:** field, and then click **Replace All**.

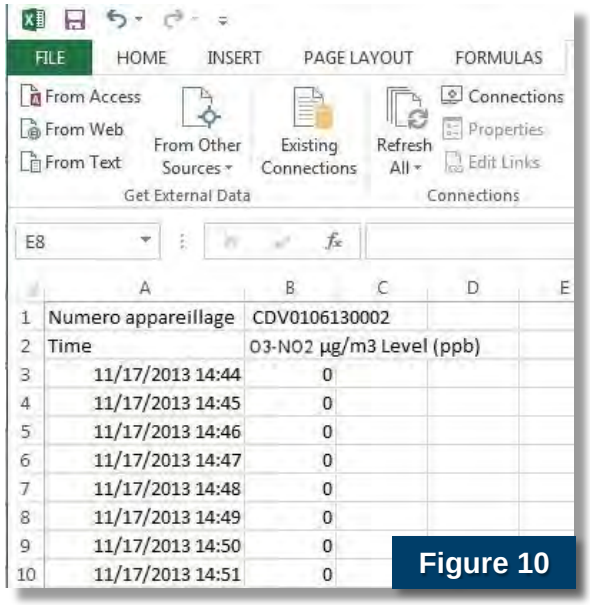


Figure 10

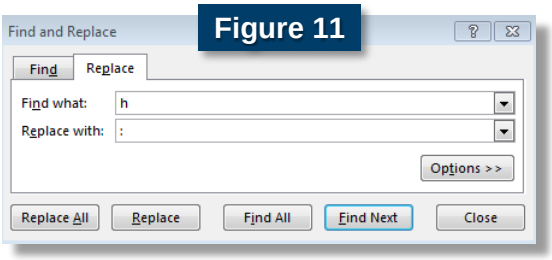


Figure 11

Maintenance and Storage

Changing the Filter

If the CairClip is regularly exposed to dust, the manufacturer recommends changing the removable filter every 4 months. The filter comes premounted in its holder and is removed and replaced from the back of the device as a single unit (Figure 12).

Figure 12

Procedure: Change Filter

1. Insert the red dongle (provided with the sensor) into the CairClip, as shown in Figure 13. The dongle prevents the small fan inside the device from turning.
2. Remove the filter/filter holder assembly from the back of the CairClip by gently pulling the filter holder with your fingers.
3. Place a new filter/filter holder assembly into the opening and gently press until it is secure.
4. After changing the filter, remove the red dongle and reconnect the mini USB cable.

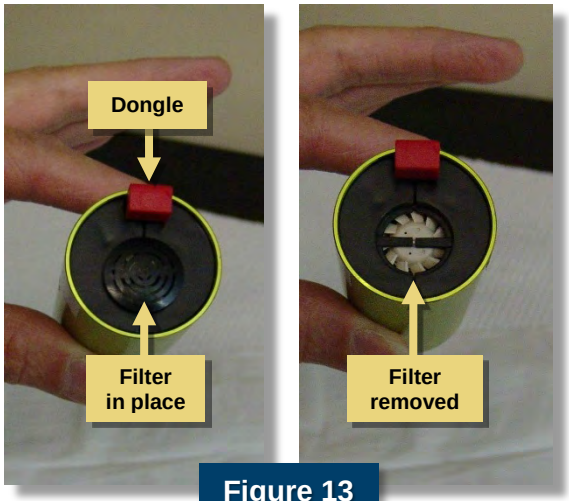


Figure 13

Storing the CairClip

It is recommended that the red dongle is connected to the unit to maximize storage time. Connecting the red dongle stops the sensor's fan, which reduces the CairClip's power consumption, decreases its frequency of recharging, and consequently increases its storage time up to 150 days (battery fully-charged). It is strongly recommended that data be downloaded before extended periods of storage.

For Additional Help

CairClip User Manual, CairSoft Software, and Sensor Datasheets. P058C.MLL.CairClip user manual.160512, CairPol, Méjannes les Alès, France, www.cairpol.com.

CairPol CairClip O_3-NO_2 data sheet, http://www.cairpol.com/images/pdf/O3-NO2/technical%20datasheet%20o3-no2%2015072013.pdf, last accessed May 13, 2015.

U.S. Environmental Protection Agency, What Are the Six Common Air Pollutants?, http://www.epa.gov/airquality/urbanair/, last accessed May 13, 2015.

U.S. Environmental Protection Agency, EPA's Air Sensor Toolbox for Citizen Scientists, http://www.epa.gov/heasd/airsensortoolbox/, last accessed May 13, 2015.

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SCIENCE

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