BC 1060
BLACK CARBON MONITOR
OPERATION MANUAL
BC 1060-9800, REV B

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1 INTRODUCTION

1.1 About This Manual

This document is organized with the most important information toward the front of the manual. All users should read and understand the sections on setup, operation, and field audits. Toward the back are sections that provide in-depth information on subjects such as diagnostics and accessories. These sections should be consulted as needed.

This manual is periodically revised for maximum accuracy and to incorporate new features or updates. User feedback is welcome. An electronic version of this manual is available upon request.

1.2 Technical Service

Should support still be required after consulting the printed documentation, contact one of the expert Met One Instruments, Inc. Technical Service representatives during normal business hours of 7:00 a.m. to 4:00 p.m. Pacific Time, Monday through Friday. In addition, technical information and service bulletins are often posted on our website. Please contact us and obtain a Return Authorization (RA) number before sending any equipment back to the factory. This allows us to track and schedule service work and to expedite customer service.

Contact Information:	Tel: + 541 471 7111 Fax: + 541 471 7115 Web: http:/www.metone.com Email: service@metone.com	**Address:**	Met One Instruments, Inc. 1600 Washington Blvd Grants Pass, Oregon 97526 U.S.A.

Please have the instrument serial number available when contacting the manufacturer. On most models manufactured by Met One Instruments, it will be located on a silver product label on the unit, and also printed on the calibration certificate. The serial number will begin with a letter and be followed by a unique four or five digit number such as U15915.

1.3 BC 1060 – Two Wavelength Black Carbon Monitor

The Met One Instruments, Inc. model BC 1060 Portable Carbon Monitor is a two-wavelength black carbon monitor. It automatically measures and records optical transmission across filter media onto which particulate matter has been deposited. Two industry standard wavelengths, 880 nm and 370 nm are used to determine the concentration of black carbon “BC” and “UVPM” (UV light absorbing PM), respectively.

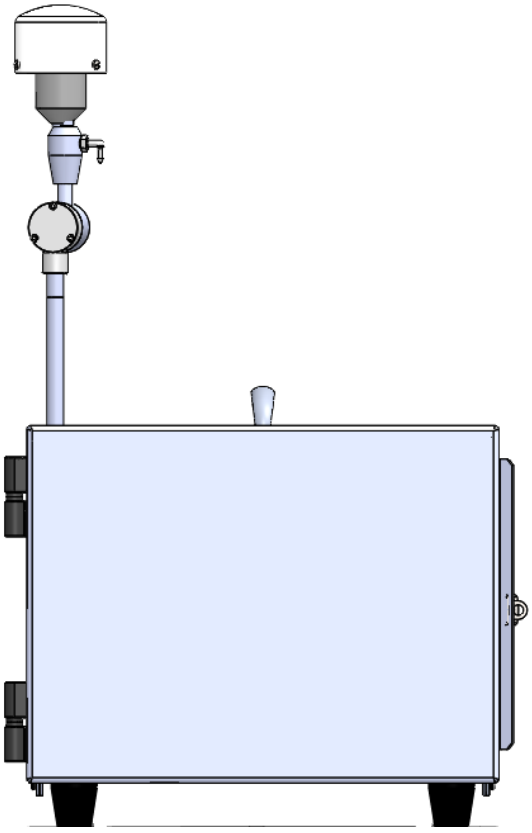


Figure 1-1 The BC 1060

Ambient air is drawn into the instrument at a controlled flow rate, generally though a size-selective $PM_{2.5}$ or PM_1 fractionator. The sampled air is subsequently drawn through a heated inlet section and then through special glass fiber filter tape, capturing ambient particulate matter. Optical transmission at both wavelengths is measured through the filter tape allowing BC mass concentrations to be calculated at each wavelength. The filter tape will advance when sufficient particulate matter has been deposited on the tape to cause the attenuation of the selected channel to exceed a factory recommended level or a user-selected value.

1.4 Safety Warnings

Optical Warnings: The BC 1060 monitor employs an LED light source in the near UV (370 nm) and one the near IR (880 nm). This light is outside the range of normal human vision and could present a potential invisible ocular exposure hazard. The UV light source is a 15 mW LED, emitting at 370 nm. The near infrared source is a 7 mW IR LED emitting at 880 nm. Appropriate precautions should be employed.

A protective housing with this warning symbol fully encapsulates the light sources and optics system during normal operation. Whenever the optical module is disassembled for service, the power cord must be disconnected in order to prevent accidental exposure to UV and IR radiation.

Electrical Warnings: The BC 1060 is a 12 Volt DC powered system, and there are no hazardous live voltages located anywhere inside the instrument. It is equipped with an external desktop power supply module with a 100-240 VAC 50/60 Hz input range, and a 12 VDC, 8.5 A output. The BC 1060 instrument is housed in a weather-proof case for deployment outdoors.

NOTE: Use ONLY Factory Power Supply. NO SUBSTITUTIONS!

Thermal Warnings: The instrument contains a 12 Volt 40 Watt internal heater, in the form of two large, gold colored power resistors and a circulation fan located inside the electronics chassis. These resistors are usually hot and should not be touched while the instrument is powered on, or within several minutes after being powered off. The inlet heater tube located near the top and inside the instrument may also be warm to the touch while operating and for several minutes after powering off.

1.5 BC 1060 Instrument Specifications

PARAMETER	SPECIFICATION
Measurement Principle:	Optical Absorption Wavelength 880 nm BC 370 nm UVPM
Measurement Range:	0.01 µg/m^3 to 100 µg/m^3 BC
Data Display Resolution	0.1 ng/m^3
LLD:	≤ 50 ng/m^3 with 1 minute sample time, ≤ 8 ng/m^3 with 1 hour sample time
Measurement Interval:	1, 5, 10, 15, 30, or 60 minutes
Sample Rate:	2 LPM
Filter Tape:	Proprietary treated glass fiber
Operating Temperature:	0 to +40°C
Inlet Heater:	13 W (setpoints from 25 to 40 °C)
Ambient Sensor:	80866-1 ambient temperature sensor with solar shield included.
Sensor Input:	Support for digital Wind Speed and Wind Direction inputs
Internal Data Storage:	4MB internal memory.
Data Download:	One USB Flash Drive Port, USB Serial, RS-232 serial, Comet Cloud Modem
User Interface:	Menu-driven interface with 4x20 character OLED display and dynamic keypad.
Mounting Options:	Bench top or free standing with optional stand. A weatherproof shelter is not required.
Unit Weight:	Approximately 35 lbs. (18 kg)
Unit Dimensions:	Height: 12” (30.5 cm) Width: 14” (35.6 cm) Depth: 14.5” (36.8 cm).
Input Power:	100 to 240VAC, 102 W

Specifications may be subject to change without notice. See BC 1060 datasheet for latest published specs.

2 SITE SELECTION AND POSITIONING CRITERIA

There are no special installation requirements for the BC 1060. It should simply be positioned in the area containing the air to be sampled based on local monitoring needs.

3 SETUP & DEPLOYMENT

The BC 1060 is designed for easy setup and simple configuration for most applications. This section describes the basic assembly, setup, and start-up of the instrument.

3.1 Unpacking

Unpack the carbon monitor and accessories and compare them to the packing list to make sure all items are present.

Any damages to the equipment during shipping are the responsibility of the carrier. If any damage to the shipment is noticed before unpacking, **a claim must be filed with the commercial carrier immediately**. Follow any special unpacking instructions provided by the carrier as all items are carefully removed from the containers and each component inspected. It is recommended to document and photograph all damaged packages and items before, during, and after unpacking them. Contact Met One Instruments (see Section 1.2 of this manual) to arrange for any replacement items needed.

The instrument is supplied with one of each of the following standard accessories:

- TSP Inlet (part number 9441)
- PM2.5 Sharp Cut Cyclone (part number SCC 112)
- Power Supply Assembly (part number 82536) – includes housing, power supply, and US power cord
- RS-232 Serial Communications Cable (part number 82459)
- USB Cable, A-B male (part number 500784)
- Span Check Membrane (part number 83011)
- Ambient Temperature Sensor with Cable (part number 80866-1)
- Solar Radiation Shield for Ambient Temperature Sensor (part number 820471)
- Filter Tape, one roll (part number 460211)
- Operation manual (part number BC 1060-9800)
- Comet Software CD (part number 80248)
- Assorted tubing and fittings

Optional Accessories may include:

- Mounting Stand (part number BCX-901)
- All In One Weather Sensor (AIO 2)
- Met Station One Weather Station (MSO)
- Comet Cloud Modem 2

3.2 Electrical Service

The BC 1060 uses an external DC power supply which can be supplied with 100 - 240 VAC, 50 or 60 Hz input power. The sampler is rated at 70 Watts maximum continuous power with the sample pump running. There are no hazardous live voltages located anywhere inside the instrument. The power supply provides a 12 VDC, 8.5 A output. It is not weatherproof if removed from its protective housing so the power supply should never be deployed outdoors without its case.

NOTE: Use ONLY Factory Power Supply. NO SUBSTITUTIONS!

The sample site needs to be equipped with AC power and a standard weatherproof outdoor electrical outlet.

For critical applications, where possible sample invalidations due to power failures are unacceptable, the sampler should be equipped with an uninterruptable power supply (UPS). The supply must be rated for the electrical load and must be appropriately configured for an outdoor application. Consult a qualified electrical contractor.

3.3 Shelter & Mounting Options

The BC 1060 is a weatherproof monitor designed to be mounted on a stand and then deployed in the outdoors without the need for a shelter or other housing. However, if it is desired, it may also be installed in an indoor location such as a walk-in shelter, a trailer or mobile lab, a mini outdoor shelter, or inside of a permanent structure.

Benchtop Mounting: The BC 1060 may be installed on a table-top. Make sure the mounting surface is level, and that the instrument is secured so that it won't "walk" due to vibration. Always leave adequate clearance at the back of the unit for access to the data port, power, ambient probe connections and sampling lines.

3.4 Sample Inlet Configurations

The BC 1060 is designed to operate with an in-line $PM_{2.5}$ or PM_1 fractionator through flexible tubing connected to the back of the instrument. The fractionators (sharp cut cyclones or SCC) are designed to sample at 2 LPM.

The TSP inlet mounts atop the dilution adapter. The adapter is coupled directly to the inlet of the SCC which is mounted on top of the 82977 support tube. The flexible sample tubing connects onto the bottom of the support tube and is routed to the BC 1060 sample inlet on the rear of the monitor. It connects using a push-to-connect fitting. See Figure 3-2.

3.5 Assembling the BC 1060

The BC 1060 is designed for easy setup and deployment. This allows it to be used for either permanent long-term sampling at a fixed site or for portable audit sampling for temporary applications.

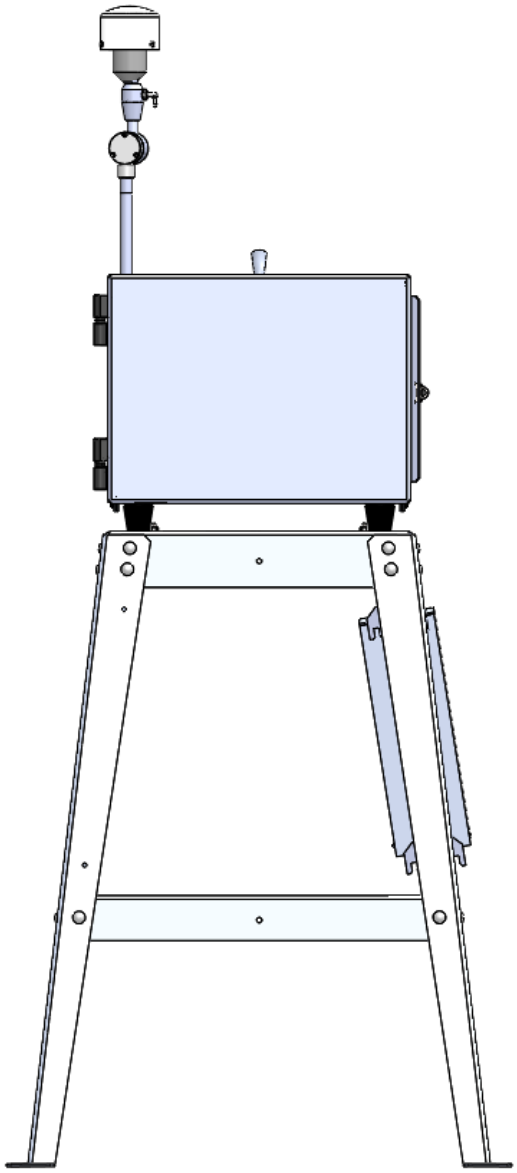


Figure 3-1 The BC 1060 Shown with Optional BCX-901 Stand

The following describes the standard method of setting up the BC 1060. If using the optional mounting stand or sample inlet extension kit, refer to the associated manuals for those items for additional instructions. Refer to Figure 3-2 and Figure 3-3.

1. **Connect the TSP Inlet to the dilution adapter**: Slide the TSP inlet onto the top of the dilution adapter. Be certain the TSP inlet is fully seated onto the dilution adapter.
2. **Connect the dilution adapter to the SCC**: Slide the dilution adapter onto the inlet of the SCC. Be certain the dilution adapter is fully seated onto the SCC.
3. **Mount the SCC to the Support Tube**. The support tube inlet should be inserted into the outlet of the sharp cut cyclone. Be certain the inlet tube is fully seated within the cyclone.
4. **Mount the Inlet Support Tube**: Locate the inlet support tube mount on the back of the BC 1060 housing. Lightly pinch the upper and lower grips together and slide the tube through both mounting holes. At the desired height, release the grips and the tube should be held securely in place.

5. **Connect the Tubing**: The dilution adapter will have a length of small flexible tubing installed. This should be routed through the support tube mount to the appropriate fitting on the back of the BC 1060 and inserted into the push-to-connect fitting. The sample inlet tubing should be installed onto the bottom of the support tube and then into the sample port on the back of the BC 1060. Both connections are made using push-to-connect fittings.
6. **Connect the Ambient Temperature Sensor**: The BC 1060 comes with an ambient temperature sensor. The sensor should be mounted on the rear wall of the BC 1060 using the two threaded studs located in the upper left corner. Remove the captive retaining knobs, place the sensor bracket over the mounting studs and screw the knobs back onto the rear of the monitor. Once mounted, connect the sensor signal cable to the three-pin connector located beneath the sensor on the rear of the monitor.
7. **Connect the Power Supply**: Connect the power supply to the four-pin power connector on the back panel of the BC 1060. The power supply has a universal AC voltage input. The included US-type modular power cord can be changed to another type if needed.

The BC 1060 monitor is now ready to have power applied and begin the initial configuration sequence. Plug in the AC power cable and follow the on-screen prompts. See Section 3.8.

Filter tape installation is described in Section 3.7.

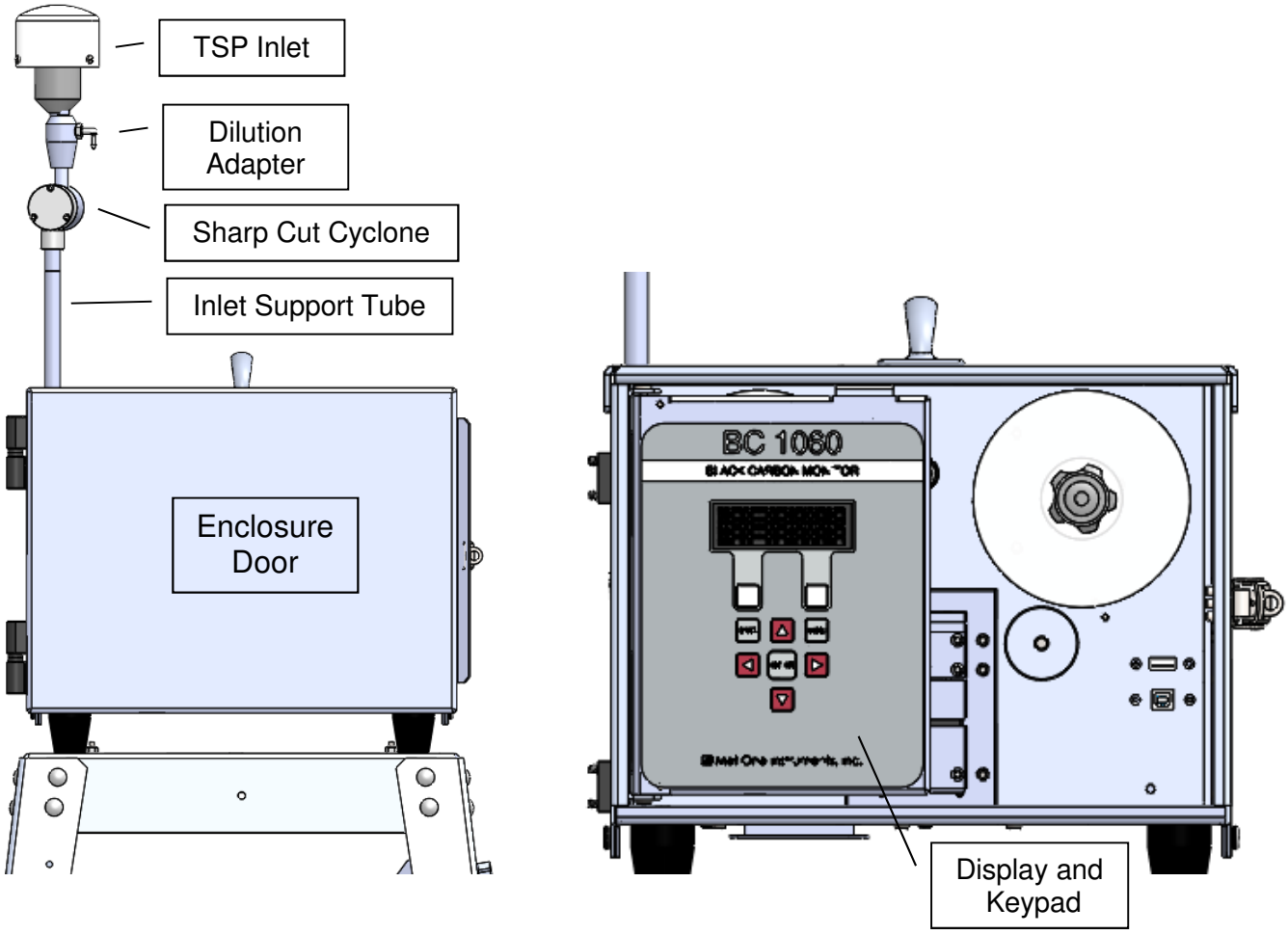


Figure 3-2 BC 1060 Front View

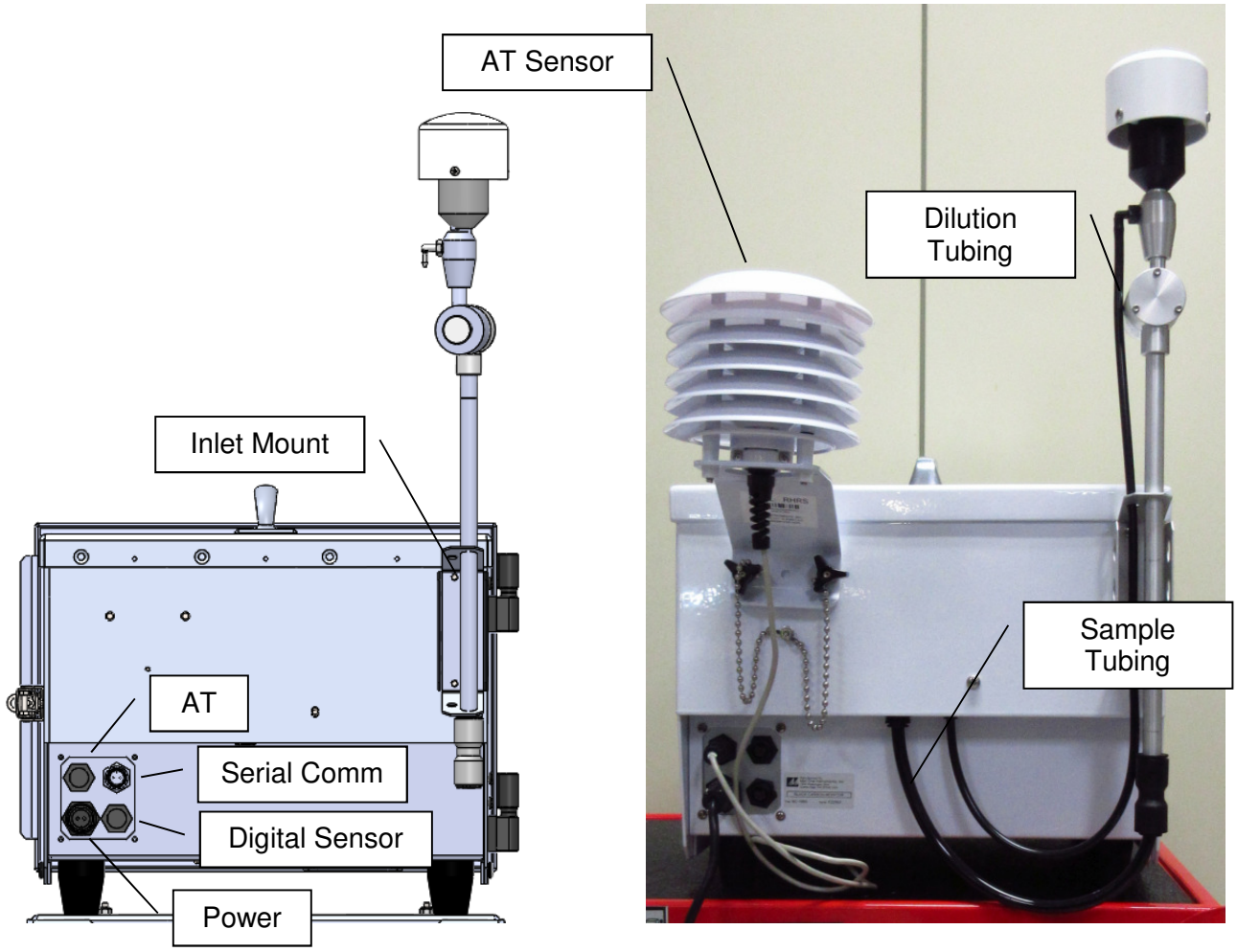


Figure 3-3 BC 1060 Rear Panel Connections

3.6 Installing the Comet Cloud Modem

The Comet Cloud Modem is an optional accessory that allows data collected by the BC 1060 to be automatically pushed to the cloud. Data can then be charted and viewed on a web page from any computer or mobile device with internet access. A cable connects the CCS Modem 2 to the BC 1060 Serial Comm connector (Figure 3-3). See CCS Modem 2 manual for more details.

3.7 Filter Tape Installation, Loading, and Filter Material Notes

The BC 1060 carbon monitor uses treated glass fiber filter tape rolls, available from Met One Instruments under part number 460211. It is essential that this tape be used in the BC 1060 in order to maintain proper instrument calibration and reproducibility. Since the filter tape advance frequency depends upon filter-loading, the frequency with which the tape needs to be replaced is variable. A roll of filter tape is expected to last anywhere from 2 to 12 months, depending on the sampling conditions, tape load level, load channel and dilution settings selected.

Note: The BC 1060 tape transport system runs the filter tape from left to right. Notice that this places the clean roll on the left side of the monitor. This is the opposite of the configuration used in the Met One Instruments BAM-series monitors.

Warning: The filter tape is rolled with the checker pattern on the outside of the roll, and the softer side on the inside. If the new roll is installed backwards on the supply reel, then the backing material will be on top inside the measurement module, resulting in improper measurement. **The instrument cannot identify this incorrect condition**.

3.7.1 Installing Filter Tape on Initial Setup

1. Apply power to turn the instrument ON.
2. Select SETUP when prompted (see Figure 3-8).
3. Advance past the first two setup screens (see Section 3.8.1).
4. Press the NO softkey on the “IS TAPE LOADED” screen.
5. Select YES to ARE YOU LOADING A NEW ROLL OF TAPE. The sequence will advance to the tape counter reset screen (see Figure 3-4).

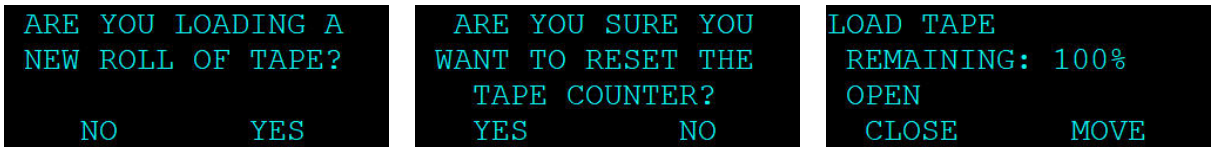


Figure 3-4 BC 1060 New Tape Loading Sequence Screens

6. Select YES to reset the tape counter to 100% TAPE REMAINING and advance to the LOAD TAPE screen (see Figure 3-4).
7. Select OPEN to open the measurement module, if not already open.
8. Loosen the two tape reel knobs and remove the reel covers.
9. Install the new filter tape roll onto the left (supply) reel, with the tape coming off the left side of the roll. Route the tape exactly as shown in Figure 3-5. It should go under the metal idler, through the slot in the measurement module, under the encoder wheel, and then up to the take-up reel on the right side of the instrument. Fasten the loose end of the tape to the left edge of an empty core tube installed on the take-up reel, with cellophane tape. **Make sure that the softer side is UP** and the textured side is **DOWN**.
10. Align the filter tape and take up the slack by turning the left (supply) reel.
11. Press the MOVE softkey. Verify that the tape spools correctly. Advance at least one turn of filter tape over the take-up core.
12. Use the ESC key to return to the main menu.

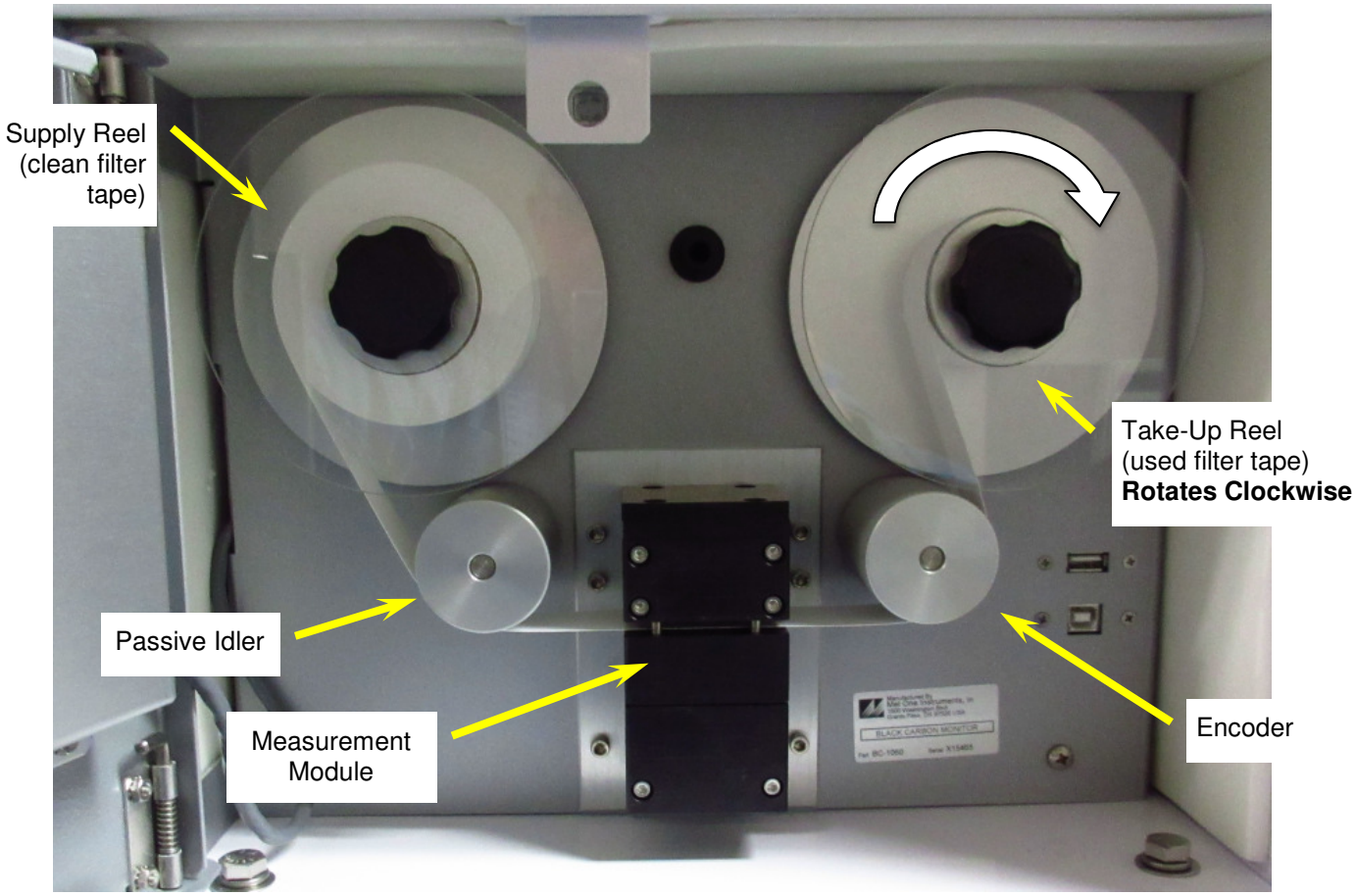


Figure 3-5 BC 1060 Filter Tape Routing

3.7.2 Replacing Used Filter Tape

1. From the Main Menu, select LOAD TAPE.
2. Select YES to ARE YOU LOADING A NEW ROLL OF TAPE. The sequence will advance to the tape counter reset screen (see Figure 3-6).

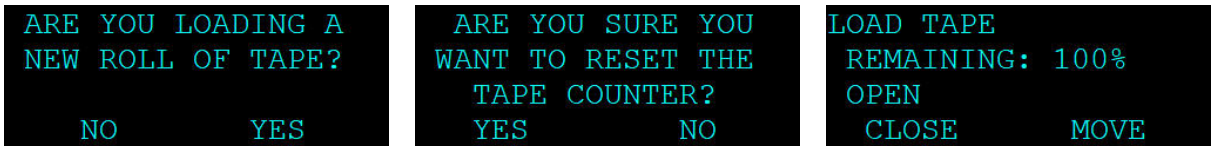


Figure 3-6 BC 1060 Replacement Tape Loading Sequence Screens

3. If installing a new full roll of tape, select YES to reset the tape counter to 100% TAPE REMAINING and advance to the LOAD TAPE screen (see Figure 3-6).

   If it is not desired to reset the counter to 100%, press the NO softkey to *keep the current remaining percentage*. This may be necessary, for example, if the tape has been removed for maintenance and then the same partial roll is being reinstalled.
4. Select OPEN to open the measurement module, if not already open.
5. Loosen the two tape reel knobs and remove the reel covers.
6. Remove the used tape and cores from the tape spools.
7. Install the new filter tape roll onto the left (supply) reel, with the tape coming off the left side of the roll. Route the tape exactly as shown in Figure 3-5. It should go under the metal idler, through the slot in the measurement module, under the encoder wheel, and then up to the

take-up reel on the right side of the instrument. Fasten the loose end of the tape to the left edge of an empty core tube installed on the take-up reel, with cellophane tape. **Make sure that the softer side is UP** and the textured side is **DOWN**.

8. Align the filter tape and take up the slack by turning the left (supply) reel.
9. Press the MOVE softkey. Verify that the tape spools correctly. Advance at least one turn of filter tape over the take-up core.
10. Use the ESC key to return to the main menu and then resume normal operations.

3.7.3 Verifying Remaining Filter Tape

1. From the main sampling screen, scroll to the bottom of the display with the ▼ (down arrow) key.
2. The remaining percentage of tape will be displayed as the last line (see Figure 3-7).

Figure 3-7 BC 1060 Tape Remaining

3. Scroll to the top of the main sampling screen with the ▲ key for the default main sampling screen view.

3.8 Starting and Stopping Sample Operation

When 12 VDC power is applied to the rear power connector, the BC 1060 will boot up and display a splash screen identifying the instrument. After about three seconds, the Welcome screen is displayed and the options to immediately begin sampling or to enter the setup menus are presented.

Figure 3-8 BC 1060 Boot Sequence Screens

3.8.1 Entering the Setup Menu

Press the SETUP softkey to verify the required hardware connections and instrument configuration settings. Pressing the NO or EDIT softkeys on any of the SETUP menu screens will provide options for correcting or updating the items being displayed.

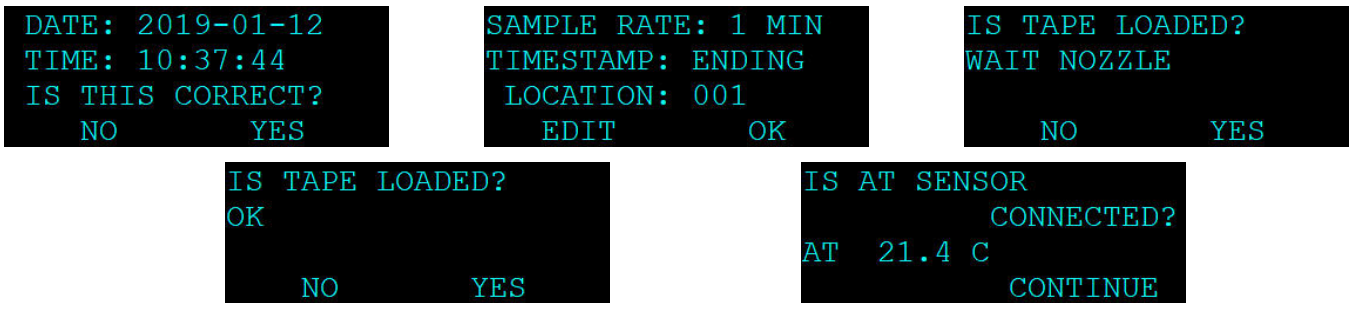


Figure 3-9 BC 1060 Setup Menu Screens

Waiting on the TAPE LOADED? screen will force the BC 1060 to perform a tape test operation. If the tape must be loaded, pressing the ESC key once it is installed will return to the SETUP sequence. If the YES softkey is pressed on the TAPE LOADED? screen, the monitor will skip the test and advance to the final screen to verify the AT senor is connected. Once complete, the BC 1060 will begin sampling as described in Section 3.8.2.

3.8.2 Starting Initial Sample Operations

Pressing the START NOW softkey will place the BC 1060 into the sampling mode. A timer will display indicating that sampling will begin soon. The timer starts at 60 seconds and counts down in one second intervals.

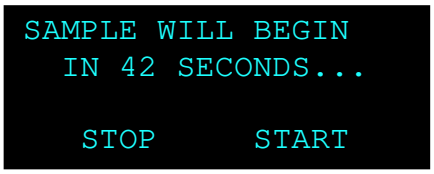


Figure 3-10 BC 1060 Boot Sequence Screens

The BC 1060 will automatically start sampling when the timer reaches zero. To start sampling immediately, press the START softkey option. To cancel the startup sequence and enter the Sampling Screen, press the STOP softkey option. After 30 minutes of inactivity, the unit will automatically resume sampling.

If the START softkey is pressed, the monitor will advance to a fresh spot of filter tape, turn on the pump, and display WAIT TOP-OF-MINUTE in the status field. Then the status field will change to SAMPLING… It will take two full minutes before BC concentrations will appear if Sample Time is set to 1 minute. If Sample Time is set for a longer period, the BC 1060 will display concentrations after 1 full sample period.

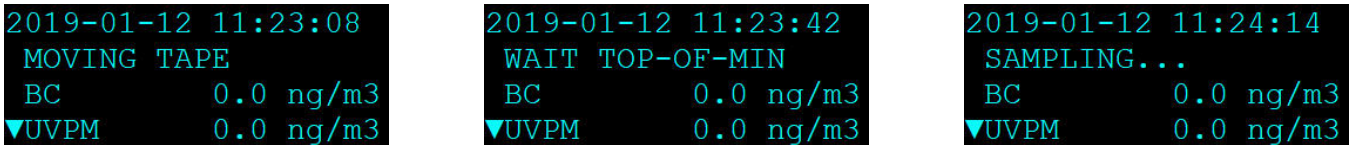


Figure 3-11 BC 1060 Startup Screens

The ▼ icon on the left side of the screen indicates that the down arrow on the keypad can be used to view the additional measurement channels. Press the down and up arrows, when indicated, to cycle through the additional screens. The down arrow will navigate to the next screen and the up arrow will return to the previous screen. Additional parameters available in the main screen are the BIO measurement, total sample flow rate, dilution flow rate, ambient temperature, barometric pressure, (Wind Speed, Wind Direction and RH, if digital sensor is enabled) sample flow path temperature at the filter tape, internal temperature of the BC 1060 enclosure, and filter tape remaining percentage. See samples of these screens in Figure 3-12. Note that the optional digital sensor screens are not shown in these examples.

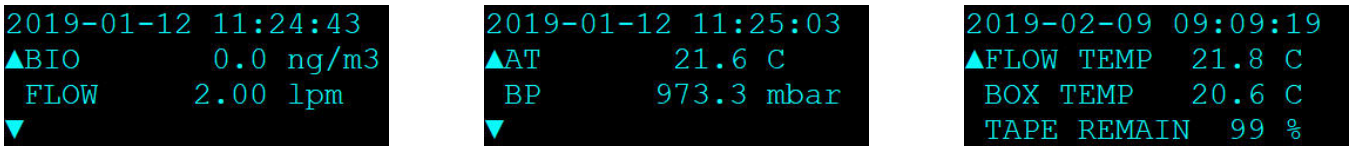


Figure 3-12 BC 1060 Additional Main Menu Screens

After powering up and starting sampling, the BC 1060 takes 1 – 3 hours to warm up and equilibrate before optimal measurement stability is achieved.

The BC 1060 carbon monitor is factory configured with an array of default settings that are appropriate for most sampling requirements. The operator may consider changing some of these settings depending on specific requirements. See Section 4 for details about the user interface and the instrument settings.

3.8.3 Stopping and Resuming Sample Operations

To stop sampling, press either the ESC or MENU button while on the main screen. This will exit the main screen and enter the main menu. Place the flashing cursor next to the STOP SAMPLE option at the top of the menu and press the ENTER key. The BC 1060 will ask the user to confirm if the sample should be stopped. If confirmed, the BC 1060 will stop running and return to the main menu.

To resume sampling after the unit has been stopped for any reason, return to the main menu. The top option of the menu will now read START SAMPLE. Place the cursor on this option and press the ENTER key. The BC 1060 will ask the user to confirm if the sample should be started. If confirmed, the BC 1060 will begin the startup sequence (see Section 3.8.2) and return to the Sampling Screen.

Figure 3-13 BC 1060 Stop/Start Sample Screens

4 USER INTERFACE and MENU SYSTEM

This section describes the BC 1060 user interface system, and describes the functions of the main menu options, including how to view data and errors.

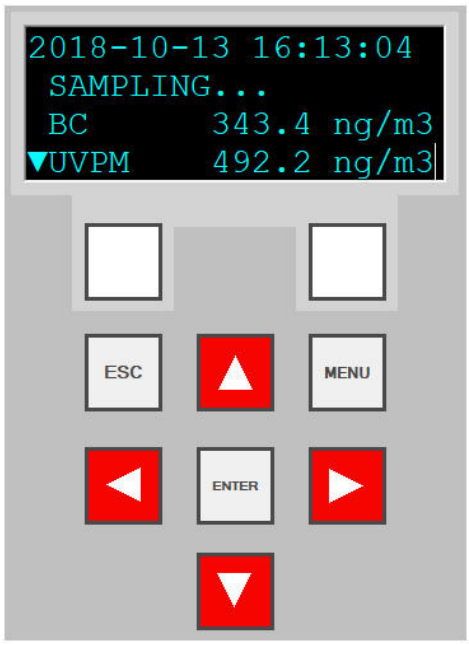


Figure 4-1 BC 1060 User Interface and Display

4.1 The User Interface Keypad and Display Functions

The BC 1060 user interface consists of a 4x20 OLED display and a dynamic keypad. The two white keys under the display are called “softkeys” or “hot keys”. These are dynamic keys which change in response to a menu option displayed directly above them on the bottom row of the display. The function of these keys depends on which menu is shown on the display.

The four arrow (cursor) keys are used to scroll up, down, left, and right, to navigate in the menu system, and to select items or change fields on the screen. The arrow keys are also often used to change parameters or increment/decrement values in the menu system.

The MENU key is used to enter the main menu. The ESC key is used to escape or exit out of a screen or menu. The ENTER key enters parameters in a selected field or selects an item in a list.

4.2 Main Sampling Screens

The BC 1060 main sampling/operation screens are shown in Figure 4-2. The current date and time are always fixed at the top line of the display in these screens. The up/down arrow keys can be used to scroll to additional viewable parameters. Note: Digital Sensor WS/WD/RH reports not shown.

Figure 4-2 Main Sampling Screen order

The definitions of the fields shown in Figure 4-2 are as follows:

Parameter	Description
BC	Sample period average of the black carbon concentration. Nanograms per cubic meter.
UVPM	Sample period average of the UV particulate concentration. Nanograms per cubic meter.
BIO	Calculated concentration value: UVPM – BC. May be an indicator of organic aerosol (Biomass) content. Nanograms per cubic meter.
FLOW	Sample period average of the actual sample flow rate (through the sample filter). Liters per minute.
DILUTION	Sample period average of the actual dilution flow rate. Liters per minute.
AT	Sample period average of the real-time ambient temperature. Celsius.
BP	Sample period average of the real-time ambient barometric pressure. millibar.
WS	Sample period average of the wind speed as reported by the digital sensor, if present and enabled. Meters/second
WD	Sample period average of the wind direction as reported by the digital sensor, if present and enabled. Degrees
RH	Sample period average of the relative humidity as reported by the digital sensor, if present and enabled. Percent.
FLOW TEMP	Sample period average of the temperature of the sample air flow measured just after the filter tape. Celsius.
BOX TEMP	Sample period average of the temperature of the inside of the BC 1060 enclosure. Celsius.
TAPE REMAIN	Estimated filter tape remaining. Percent.

Table 4-1 Main Display Parameter Descriptions

4.3 Menu Hierarchy and Navigation

The BC 1060 menu structure is outlined in the following table:

Main Menu	Sub Menu Options	Overview
Power-On Start-up Menu Section 3.8	No sub menu	Guided Set-Up to help ensure instrument is ready to start sampling
Sampling Screen Section 4.2	No sub menu	Displays date, time, operational mode, carbon concentrations, flow rates, ambient conditions and internal temperatures.
Start/Stop Sample Section 4.4	No sub menu	Start and stop sampling operations
Load Tape Section 4.5	No sub menu	Install the filter tape, verify tape movement, View filter tape remaining percentage, and reset tape counter
View Alarm Log Section 4.6	No sub menu	View alarms
Copy to USB Drive Section 4.7	No sub menu	Copy data files to USB flash drive
Setup Menu Section 4.8	Clock Sample Serial Port Memory Password Digital Sensor	Set the date and time Configure sample settings and set Location Configure serial port Clear stored data and alarm logs Change or disable the user password Enable/Disable optional WS/WD/RH sensor
Calibrate Menu Section 4.9	Calibrate AT Calibrate BP Calibrate Flow Calibrate Dilution Calibrate Audit	Calibrate temperature sensor or restore default settings Calibrate pressure sensor or restore default settings Calibrate sample flow rate or restore default settings Calibrate dilution flow rate or restore default settings Verify the attenuation calibration
Test Menu Section 4.10	Self-Test Tape Test Leak Test Digital Link	Verify tape movement, flow and optical system operation Verify tape movement Check the flow system for leaks Verify communications with optional WS/WD sensor
Advanced Menu Section 4.11	Setup Calibrate Test Factory Data Download to USB	Configure advanced settings, set alarm & operational set points, and restore factory default settings Set LED Set Point Test LED and box heater operation Copy Factory data to USB flash drive
About Section 4.12	No sub menu	View the current model, serial, and firmware revision numbers

Table 4-2 BC 1060 Menu Hierarchy

Menu selections and instructions are detailed in the following sections of this operating manual as assigned in the Main Menu column of Table 4-2 above.

Field editing in the BC 1060 is slightly different than the methods used in some of the other similar Met One Instruments products.

The flashing cursor ■ is moved to the field to be changed with the ▼▲ keys. Once the desired field is highlighted, the ENTER key must be pressed to open it for editing.

A ▼ symbol will appear next to opened fields where a pick list is available and the ▼▲ arrow keys can then be used to cycle through the available choices. Once the preferred option is highlighted, press the ENTER key again to select it and lock the field. To return to the previous menu, press ESC.

If a numeric field is opened for editing, the cursor will be positioned at the leftmost digit. Use the ◄► keys to move the cursor to the digit to be modified and then use the ▼▲keys to increment/decrement the value. Once all of the digits have been set to the required value, press the ENTER key again to lock the field. To return to the previous menu, press ESC.

Use the ESC key to cancel any edit that may be in progress. The ESC and MENU keys are used to exit the current menu and return to the previous menu level. If the Main Menu is currently selected, the monitor will exit to the Main Sampling Screen.

4.4 Start or Stop Sample

This screen is used to begin or end the BC 1060 sampling operations. It will be labeled on the main menu as either START SAMPLE or STOP SAMPLE. The label indicates the action that can be taken when entering this screen. Once selected, press the START or STOP softkey (shown in the START mode in Figure 4-3) to begin or end sampling. See Section 3.8 for more details.

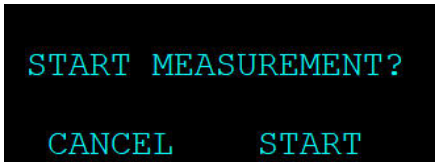
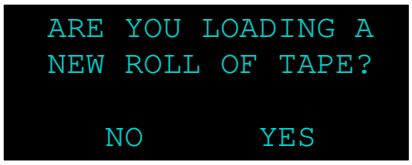
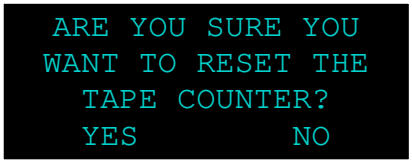


Figure 4-3 The Start Sample Screen

4.5 Load Tape

This screen enables operation of the Measurement Module assembly and tape spools. Use the OPEN softkey to lower the bottom of the measurement module and open the tape path. When opened, the OPEN softkey will read as CLOSE, indicating that when pressed, the key will close the measurement module assembly. Use the MOVE button to advance the tape one sample space. If the measurement module is closed when the MOVE key is pressed, the BC 1060 will automatically open it and then advance the tape. Provides the ability to reset the filter tape remaining counter. REMAINING is the estimated percentage of filter tape remaining on the current roll. See Section 3.7 for instructions on loading the filter tape.





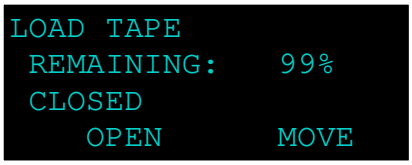


Figure 4-4 The Load Tape Screen

4.6 View Alarm Log

This screen is used to view time-stamped alarm events with the most recent alarm displayed first. To view earlier alarms, use the arrow keys to navigate through the list. The ◄ and ▲ keys will scroll to the previous alarm in the list (earlier time stamps) and the ► and ▼keys will scroll to the next alarm (later time stamps). This information is also reported in the Alarm File (see Section 7.3).

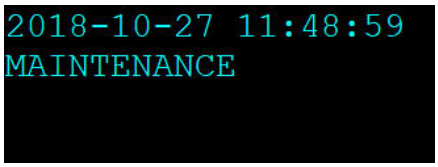


Figure 4-5 The View Alarm Log Screen

4.7 Copy to USB Drive

This screen is used to copy the stored user data files onto a USB flash drive. Select ALL days or any number of days between 1 and 999. See Section 7.1 and Section 7.3 for more details.

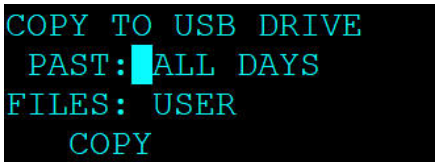


Figure 4-6 The Copy to USB Drive Screen

4.8 The SETUP MENU

The BC 1060 setup menu contains the settings and configuration parameters used by the instrument. The factory default values will be correct for most applications but can be reviewed and altered to suit the specific needs of the local monitoring program, as needed. The settings will not be lost if the unit is unplugged or powered down.

The unit will prompt for the password in order to enter the SETUP menu, if a password has been set up by the user (see Section 4.8.5). Use the ▲▼ keys to select the desired sub-menu and press the ENTER key to enter. The SETUP menu is shown below:

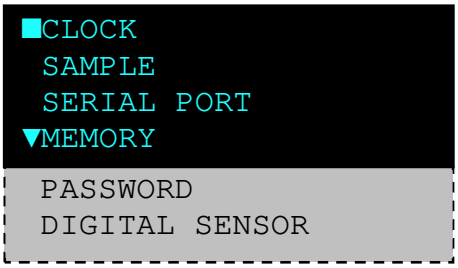


Figure 4-7 The BC 1060 Setup Menu

4.8.1 The CLOCK Setup Screen

The CLOCK setup screen is used to change the instrument date and time.

Press the ENTER key to open the fields for editing. Once open, use the arrow keys to set the desired date and time and then press the ENTER key again to lock the field. Press the SET softkey to set the clock and exit out to the SETUP menu screen. It is recommended to exit the menu system to the main sampling screen and verify that the date and time are correct.

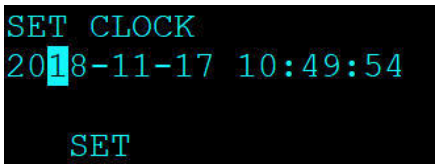


Figure 4-8 The BC 1060 Clock Setup Screen

4.8.2 The SAMPLE Setup Screen

The SAMPLE setup screen allows users to set the Sample Rate, Timestamp style, and the Location ID of the unit. The Sample Rate is the average period logged in the user report.

Setting this value to one hour will return hourly data, whereas setting it to one minute will log data using a one minute sample period.

The TIMESTAMP setting determines if the timestamp logged with the data indicates the end or beginning of the average period. Consider a one hour sample period.

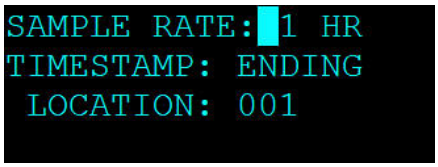


Figure 4-9 The Alarms Menu

If the TIMESTAMP is set to ENDING and data is collected from 8:00 to 9:00, the data will be stored at 9:00 (when the sample ends) and the time will be logged as 9:00. If the TIMESTAMP is set to BEGINNING, that same data set will still be stored at 9:00, but the time will be logged as 8:00.

The location ID is a simple ID number that will appear in the data files. When using multiple monitors, it can be used as a Unit ID number to indicate a data collection location independent of serial number. The range is 001 to 999.

4.8.3 The SERIAL PORT Setup Screen

The SERIAL PORT setup screen provides a means of setting the communications baud rate. This setting will affect the configuration for the “Serial Comm” connection on the back of the monitor and the B-Type “USB” port located on the transport plate behind the front door.

The BAUD setting is the data transfer rate for the serial data output. Downloading large data files will take longer at low baud rates, so set it to the fastest rate supported by the data collection system. The value can be set to 1200, 2400, 4800, 9600, 19200, 38400, 57600, or 115200 baud. The default setting is 9600.

Figure 4-10 The Serial Port Setup Screen

4.8.4 The MEMORY Setup Screen – Clearing the Memory

The MEMORY screen is used to clear/erase files in the BC 1060 memory. CAUTION: This menu function will permanently delete the selected files from the instrument memory!

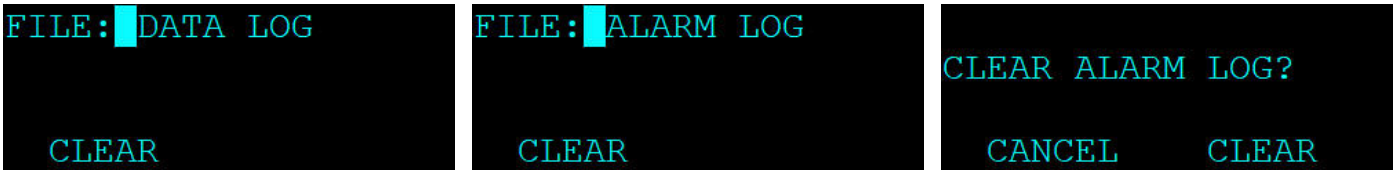


Figure 4-11 The BC 1060 Clear Memory Menus

The FILE value can be set to the DATA LOG, ALARM LOG, or ALL LOGS. Pressing the CLEAR softkey will cause the confirmation screen to appear before the selected files are cleared as shown in Figure 4-11.

4.8.5 The PASSWORD Setup Screen

Some of the menu options in the BC 1060 can be password protected to prevent unauthorized access. This helps avoid unwanted sampling interruptions and aids in maintaining the integrity of the data.

The PASSWORD setup screen is used to set, change, or remove the 4-digit numeric password that is used to restrict access to these areas including the setup menu.

The default password is **0000**. This disables the password and allows unrestricted access to all password-controlled functionality.

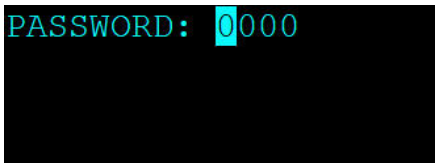


Figure 4-12 The BC 1060 Password Setup Screen

If the password is changed to any value between 0001 and 9999, it will subsequently be required for access to these screens.

4.8.5.1 Recovering a Lost or Forgotten Password

Should the password ever be lost or forgotten, the Met One Instruments service department can assist in password recovery. Serial communications must be established (see Section 7.4.1) and then the RPW command must be sent. The BC 1060 will provide an encrypted response which should then be emailed to the Met One Instruments service department (see Section 1.2) for decoding.

4.8.6 The DIGITAL SENSOR Setup Screen

Turn ON or OFF the digital sensor. When a digital sensor is connected, WS, WD and RH fields will be added to the sampling screen. If the digital sensor is ON, but no digital sensor is connected, you will receive a DIGITAL LINK DOWN error on the front panel and a Digital Sensor Link error will be written to the alarm log. The sampling screen will include WS, WD and RH measurements, but all values will be zero. If a digital sensor IS connected but loses communication to the sensor while in operation the values reported in the data file and the sampling screen will be the last good values measured until the power is cycled or the digital sensor is restored.

4.9 The CALIBRATE MENU

The BC 1060 CALIBRATE menu provides access to a system of calibration menus which allow the operator to audit or calibrate various system parameters for optimal performance. This password protected menu provides a means to calibrate the Ambient Temperature (AT), Barometric Pressure (BP), sample flow rate (FLOW), and the dilution system flow rate (DILUTION). The CALIBRATE AUDIT menu allows verification of the optical system calibration. Access to the CALIBRATE menu will require a password if the password protection is enabled (see Section 4.8.5).

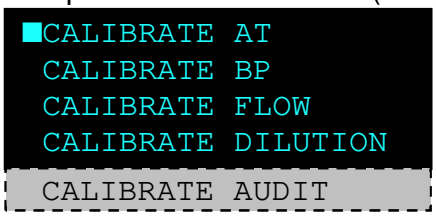


Figure 4-13 The BC 1060 Calibrate Menu

4.9.1 The CALIBRATE AT Screen

This screen provides a means of auditing, calibrating, and resetting to default values the AT. The AT field shown in Figure 4-14 is the current reading from the 80866-1 temperature sensor. The STANDARD field is where the value from the traceable temperature standard is entered, if necessary. See Section 6.4.1 for details on using this screen for performing periodic flow audits and calibrations.

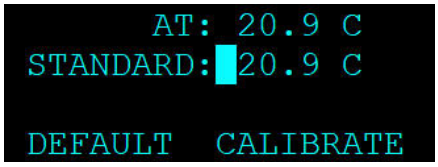


Figure 4-14 The BC 1060 AT Calibration Screen

4.9.2 The CALIBRATE BP Screen

This screen provides a means of auditing, calibrating, and resetting to default values the BP. The BP field shown in Figure 4-15 is the current reading from the internal barometric pressure sensor. The STANDARD field is where the value from the traceable pressure standard is entered, if necessary. See Section 6.4.2 for details on using this screen for performing periodic flow audits and calibrations.

Figure 4-15 The BC 1060 BP Calibration Screen

4.9.3 The CALIBRATE FLOW Screens

The CALIBRATE FLOW screen is used for field audits and calibrations of the sample flow measurement of the BC 1060.

Note: The dilution pump will remain OFF when calibrating the sample flow. See Section 4.9.4 for calibration of the dilution flow sensor.

In Figure 4-16, the first screen allows for verifying and then setting the zero flow condition, if needed. The second screen is used for verification and calibration of the actual sample flow rate. Press the CONTINUE button on the zero flow screen to advance to the sample flow rate screen.

Figure 4-16 BC 1060 Calibrate Flow Screens

The SET POINT field is the target flow rate the monitor should be maintaining. The FLOW field indicates the current flow rate being measured by the internal flow sensor. The STANDARD field is where the value from the traceable flow standard is entered, if necessary. See Section 6.4.3 for details on using this screen for performing periodic flow audits and calibrations

4.9.4 The CALIBRATE DILUTION Screens

The CALIBRATE DILUTION screens are used for field audits and calibrations of the dilution flow measurement of the BC 1060 Dilution Flow System. The dilution system is enabled in the ADVANCED MENU (see Section 4.11). If it is configured to be OFF, the WARNING screen shown in Figure 4-17 will be displayed. Press the CONTINUE softkey to display the Dilution System Enable screen (MENU > ADVANCED MENU > SETUP > FLOW). Enable Dilution Flow and press ESC to return to the Dilution Flow Calibration screen.

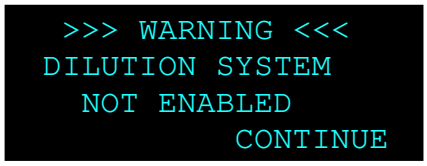


Figure 4-17 Dilution System Warning Screen

All flow values are in actual volumetric conditions. Figure 4-18 shows the various screens that will be displayed during the dilution flow rate calibration.

Figure 4-18 The BC 1060 Dilution Flow Calibration Screens

In all four of these screens, the first two lines are used to convey the same information. The SET POINT parameter is the target flow rate that is to be maintained. The DILUTION parameter is the current flow reading from the dilution flow sensor. On the second and third screens, the STANDARD field is where the value from the traceable flow standard is entered, if necessary.

On the first screen, the DEFAULT softkey resets any previous calibration changes to factory defaults. Use the CONTINUE softkey to advance to the low setpoint calibration.

On the low flow setpoint screen use the CALIBRATE softkey to calibrate the 1.00 lpm flow rate. The CONTINUE softkey advances to the high flow set point screen.

On the high flow setpoint screen use the CALIBRATE softkey to calibrate the 1.60 lpm flow rate. The CONTINUE softkey advances to the final flow audit screen.

The final screen is used to verify that the settings have properly adjusted the flow rates. Press the EXIT softkey to return to the main CALIBRATE menu. If there is an error between the Set Point flow rate on the final audit screen and the reference standard of more than 0.05 LPM, repeat the Dilution Calibration procedure. See Section 6.4.4 for detailed instructions.

4.9.5 The CALIBRATE AUDIT Screens

This series of screens is used to verify the optical measurement system of the BC 1060 monitor. A calibration tool is used in conjunction with these screens to perform the calibration audit. See Section 6.4.6 for full details on using these screens and verifying the monitor's calibration.

4.10 The TEST MENU

The BC 1060 TEST menu allows the operator to perform various diagnostic tests, both for troubleshooting and verification of proper system operation.

The unit will prompt for the password in order to enter the TEST menu, if a password has been set up by the user (see Section 4.8.5). Use the ▲▼ keys to select the desired sub-menu and press the ENTER key to enter. The TEST menu is shown below:

Figure 4-19 The BC 1060 Sample Screen

4.10.1 The SELF TEST Screen

The SELF TEST screen is used to activate an automatic test of most of the BC 1060 subsystems in order to verify that the instrument is in operational condition.

Once the test is initiated, the instrument will test for properly loaded filter tape and test the function of all tape control hardware. The pump, flow sensor, LED light sources and detectors are also tested and any detected failures are shown on the display.

Upon entering the screen, the start option will appear as shown in Figure 4-20. Press the START softkey to begin the sequence. The tape and flow detectors are tested first, as shown in Figure 4-21.

Figure 4-20 The Self Test Start Screen

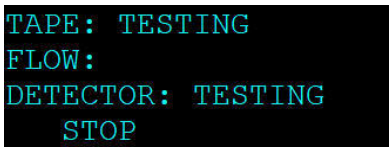


Figure 4-21 Tape and Detector Testing

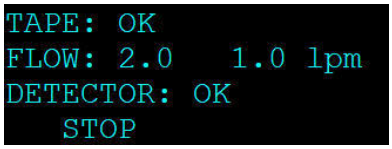


Figure 4-22 Flow Testing

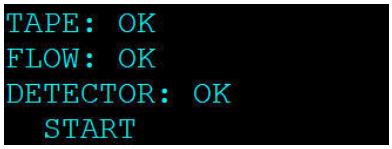


Figure 4-23 Self Test Complete

After about 25 seconds, the pumps should turn on and the flow tests should commence. If dilution is enabled, both dilution and sample flow rates will be displayed. If dilution is disabled, only sample flow will be reported. After the pump(s) have been running for about a minute, the flow rates should be stable as shown in the FLOW field (see Figure 4-22). The test should take about another minute from that point to complete. The results will be displayed and the option to run the test again will be provided (see Figure 4-23). Press the ESC key to return to the Test menu.

4.10.2 The TAPE TEST Screen

The TAPE TEST menu is used to manually advance the filter tape in order to spool up the end of a new roll of tape, or to test the tape motor and encoder. Press the MOVE softkey to advance the tape. The amount of travel, as measured by the encoder, is displayed in the TRAVEL field. Figure 4-24 shows a typical tape movement result.

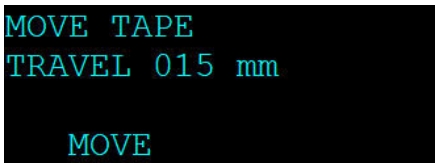


Figure 4-24 The Tape Test Screen

Each time the MOVE softkey is pressed, the displayed travel distance is reset to 000 mm before moving the tape and the new result is displayed.

4.10.3 The LEAK TEST Screen

See Section 6.5 for a detailed explanation of the LEAK TEST screen and its use.

4.10.4 The DIGITAL LINK Screen

The BC 1060 can log and record wind speed (WS), wind direction (WD) and relative humidity (RH) using an optional digital WS/WD/RH sensor, such as the AIO 2 or the MSO. This screen is used to verify communications with the sensor. If no sensor is connected, or if the link to the sensor is not properly established, the status will indicate BAD, as shown in Figure 4-25.

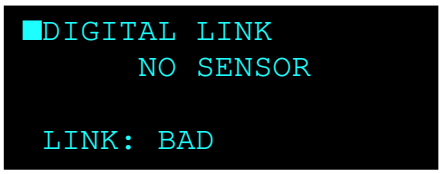


Figure 4-25 The BC 1060 Digital Link Screen

If a sensor is installed and communicating properly with the BC 1060, the status will be indicated on this screen as GOOD and the model of the sensor will be listed. Even if other parameters, such as ambient temperature or barometric pressure, are available on the digital sensor, the BC 1060 will only monitor and record the WS, WD, and RH channels.

4.11 The ADVANCED Menu

The ADVANCED menu provides access to advanced setup, calibration and test features. Settings are configured for most sampling environments and will only need to be accessed in special situations. Attempting to enter this menu displays the warning message shown in Figure 4-26

Figure 4-26 The Advanced Menu Warning

Contact the Met One Instruments, Inc. service department (see Section 1.2) for assistance with this menu.

4.12 The ABOUT Screen

This screen is used to view the BC 1060 firmware part numbers and revision levels. The BC 1060 uses two different types of firmware. Use the ▲▼ keys to toggle the second line of the ABOUT display between the two different types.

The instrument's serial number is displayed on the third line as shown in Figure 4-27.

Figure 4-27 The About Screen

5 BC 1060 AIRFLOW SYSTEM

The flow control system is a critical component of the BC 1060 measurement. A complete functional description is included to assist the user in understanding this system.

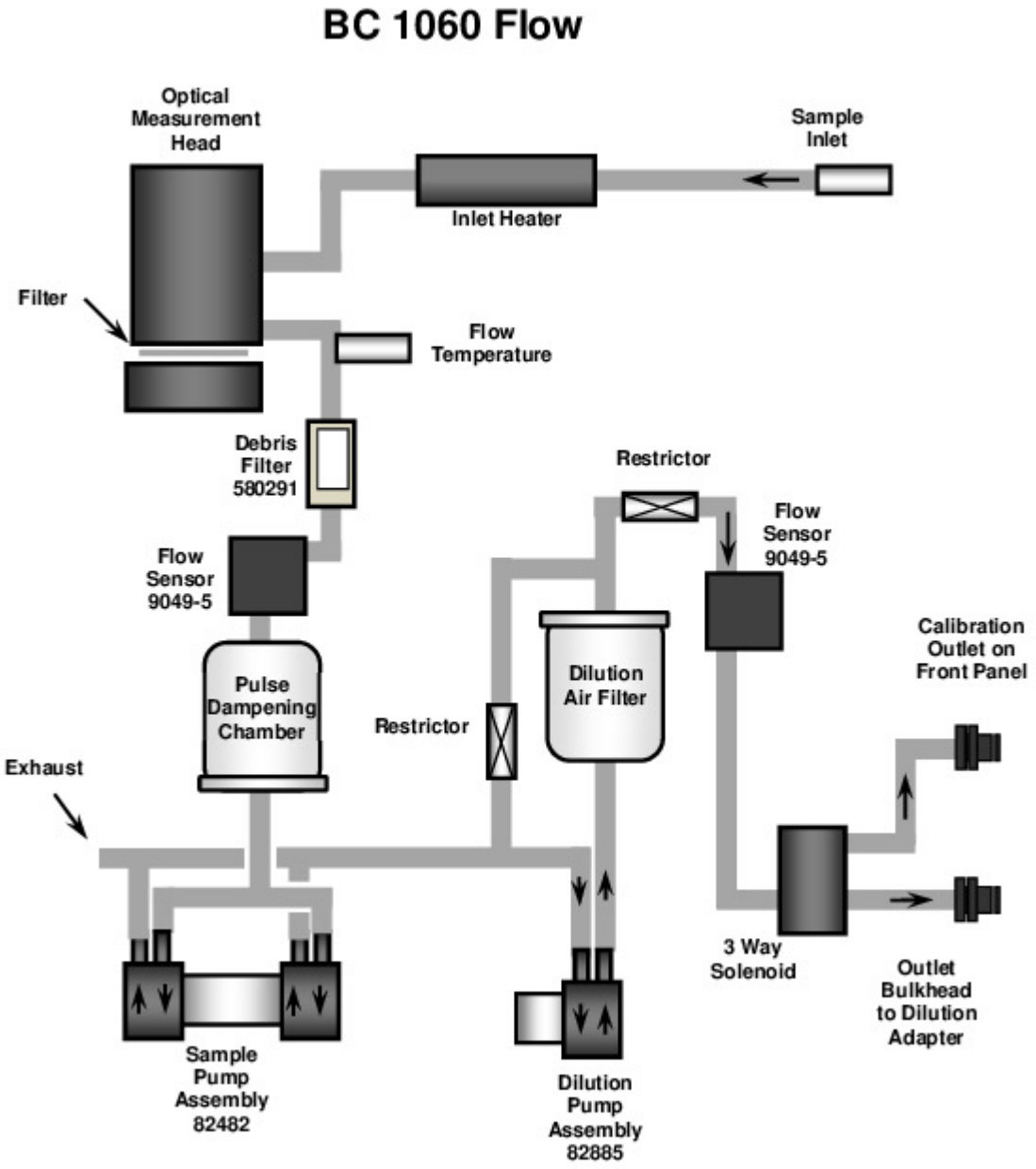


Figure 5-1 BC 1060 Flow Diagram

5.1 Airflow Control System Descriptions

The following flow control systems refer to the flow system shown in Figure 5-1.

Airflow During Normal Sampling:

1. Ambient air is drawn into the instrument at 2 LPM through a TSP inlet, then through the $PM_{2.5}$ or PM_1 size fractionator the dilution adapter then through a stiff support tube (for mounting). Flexible tubing connects to the back of the BC 1060.
2. The sample air is drawn through the inlet heater and into the optical measurement module and through the filter tape where ambient particulate is deposited onto a small diameter filter spot. The filter spot size is optimized for high sensitivity operation rather than for high concentration operation.
3. The sample air exits the bottom of the measurement module, passes through a small debris filter, and then flows through the mass airflow sensor where the flow rate measurement is made. The CPU converts the mass flow from the sensor into actual volumetric flow based on continuous inputs from the model 80866-1ambient temperature sensor. Barometric pressure is measured by a sensor located inside the electronics bay.
4. Next, the sample air passes through the flow controller (which controls the sample flow rate), through the pulse dampening chamber, then the pump. The air is exhausted inside the instrument, for purge air.

Filter Spot Changes:

1. In order to change the filter tape sample spot, the unit turns off the pump and then opens the measurement module. The tape take-up motor activates and advances the filter tape to a clean spot. The measurement module is moved back to the closed position on the tape and then the pump turns back on. This entire process takes less than 1-minute.
2. After the tape spot advances, optical carbon measurements will resume after 2 minutes.

5.2 Dilution Flow System Description

In monitoring environments with extremely high concentration levels, the high particulate level contained in the sample can result in excessive tape loading. This will result in frequent tape advances. Rapid depletion of the filter tape and potentially bad data are the most immediate detrimental side effects. Over time, there will be excessive buildup of particulate matter inside the instrument, too. This will result in additional maintenance being required and greater wear on internal components. To avoid these issues, the BC 1060 includes a built-in dilution system.

A controlled portion of clean air is mixed with the incoming sample air. Using this feature, the incoming sample concentration levels can be diluted between 50 and 80%. This means that, because the volume of air is carefully controlled, accurate measurements can be made with a mere 20% of the full particulate concentration in extreme environments.

Airflow During Dilution Sampling:

1. Exhaust air is drawn through the dilution pump and directed through the dilution filter to ensure the dilution air is clean.
2. It then flows through the dilution flow meter at the target flow rate (between 1.0 and 1.6 LPM). The flow rate is controlled by adjusting the speed of the dilution pump.
3. During normal sampling, after exiting the flow meter, the three-way solenoid valve will direct the clean dilution air into the primary sample air intake path. Here it will mix with the sample air and be ingested back through the main sample path.

a. The three-way solenoid valve temporarily routes the dilution air to a bulkhead fitting in the transport plate for performing flow verifications and calibrations of the dilution system (see Section 6.4.4).

It is important to note that the sharp cut cyclone requires the proper 2 LPM flow rate to perform correctly. This is why the Dilution Adapter on the inlet system is mounted above (before, in the flow path) the inlet cyclone. This is because the sample flow will now include both the air flow from the sample inlet and the dilution air flow paths. Therefore, the 2 LPM flow rate will only be present *after* the dilution air is added to the sample air.

For example, if the dilution flow is set to the maximum value of 80%, the dilution flow rate will be 1.6 LPM. There will be a flow of clean air at 1.6 LPM being injected into the sample air flow path through the Dilution Adapter and before it enters the SCC. The sample flow rate must be adding 0.4 LPM to the dilution flow rate in order to maintain the necessary 2.0 LPM required by the SCC. Therefore, the sample airflow *upstream of the dilution adapter* is only 0.4 LPM.

By contrast, if the dilution flow were set to 50%, both the dilution flow and the sample flow rates would be 1.0 LPM. This relationship should be considered when determining the sample inlet location and routing the sample air flow path inlet tubing.

Configuration settings for the Dilution Flow System are found in the Advanced menu (Section 4.11). Contact the Met One Instruments service department for assistance. See Section 1.2.

6 MAINTENANCE and TROUBLESHOOTING

This section provides information about routine maintenance of the BC 1060, and for performing more detailed diagnostic tests if a problem is encountered. The instrument generates error messages on the display or in the data log if a failure or other problem is detected. Many times, there is a simple solution. Persistent errors often signify a failure that will require investigation.

6.1 BC 1060 Error & Alarm Event Descriptions

The BC 1060 contains a system of error and alarm codes that are used to alert the operator to problems with the unit. The errors appear on the display and are stored in the digital alarm log with the time and type of the error. Corresponding alarm codes are stored in the data array.

The Alarm field is reported in data files by a numeric code. If multiple alarms are generated for a single data record, the reported alarm value is the sum of the alarm codes. The general alarm events are described in Table 6-1. Certain alarm events may not be posted to the data array if an alarm condition terminates operation before the end of a sample. Please consult the Alarm Log for more detailed information when an error is encountered.

Code	Description	Causes	Corrective action
0	**No Alarm**	System fully functional	None
1	**Power Failure**	Caused by a power cycle or a microprocessor reset.	Power off/on event logged. Ensure unit is provided with stable power
2	**Digital Sensor Link Failure**	Digital sensor link failure after 10 seconds of no communication with the Digital Sensor, if installed.	1. Verify sensor cable is installed on the connector on the back of BC 1060 (Figure 3-3). 2. Verify cable is fastened securely to the sensor. 3. Possible problem with the Digital Sensor. Contact Met One Instruments service department for assistance (Section 1.2).
4	**Tape Move Failure**	Tape roll exhausted Tape break Tape loose, not turning encoder Encoder wheel turns, but not measuring tape movement	Install new roll of tape (Section 3.7) Re-attach tape (Section 3.7) Tighten tape (Section 3.7) Optical encoder fault. Contact Met One Instruments service department for assistance (Section 1.2).
8	**Maintenance**	Stop for maintenance during normal operation. Operation terminated because of an error condition.	"Stop Sample" logged. Not an error condition. See additional error messages in the Alarm log (Section 4.6) to determine cause.
16	**Flow Failure**	Failure when the flow is 10% out of regulation for more than one minute, or when the flow is 5% out of regulation for more than five minutes. 1. Inlet hose kinked or other blockage on inlet 2. Debris filter clogged 3. Bad pump 4. Bad flow sensor	1. Un-kink hose or remove blockage, Clean cyclone, clean TSP inlet, replace inlet tubing 2. Clean or replace debris filter (Section 6.6) 3. Replace pump* 4. Replace Flow Sensor* *See the BC 1060 Service Manual
32	**Automatic Tape Advance**	The tape was advanced because of tape loading.	Automatic tape advance logged. Not an error condition.
64	**Detector Failure**	Mis-installed tape Blocked Reference or Sample port Light leak Hardware Failure	Verify tape is installed correctly (Section 3.7). Clear obstructions in the ports below the tape (see BC 1060 Service Manual) Contact qualified service technician (Section 1.2).
128	**N/A**		
256	**Sensor Range**	A sensor is outside its designated limits. Check Alarm log for abbreviation WS, WD, AT, RH, BP, FLOW, DFLOW, LED T, or DET T.	1. AIO equipped: if WS, WD, AT, RH or BP, replace AIO. 2. If AT, replace 80866-1. 3. If FLOW, DFLOW, LED T, DET T contact qualified service technician (Section 1.2).

512	**Nozzle Move Failure**	Set when nozzle failed to move up or down.	1. Lift motor not turning: Verify connection in nozzle motor cable. 2. Lift motor turning, lift bearing not moving: Lift bearing slipping on shaft, or shaft broken. Refer to qualified service technician (Section 1.2). 3. Lift motor turning, lift arm moving, nozzle not moving: lift bearing broken. Refer to qualified service technician (Section 1.2). 4. "UP" and/or "DOWN" optical sensor not functioning. Refer to qualified service technician (Section 1.2)..
1024	**N/A**		
2048	**Calibration Audit**	A user Calibration Audit was being performed.	Calibration Audit activity logged. Not an error condition.
4096	**N/A**		
65536	**Tape Move**	System advances the filter tape.	Tape advance logged. Not an error condition.

Table 6-1 Alarm Triggers

Detector Alarm Events: The detector alarm events are detailed in Table 6-2. Any detector failure event will stop machine operation, force a tape advance, and then attempt to resume normal sampling. Detector *warnings* will be logged but will not interrupt operation. The IR and UV detector range is 0.0 to 2500 mV. The limits are as follows:

Saturation Limit = 2450 mV Detector Limit = 100 mV Zero Limit = 5 mV

Description	Causes
LED Failure	While an LED is ON, the signal and reference detector readings are below the Detector Limit.
Signal Detector Failure	While LED 1 is ON, the signal detector reading is below the Detector Limit and reference detector reading is above the Detector Limit.
Reference Detector Failure	While LED 1 is ON, the signal detector reading is above the Detector Limit and reference detector reading is below the Detector Limit.
Signal Zero Warning	When the signal zero is above the Zero Limit.
Reference Zero Warning	When the reference zero is above the Zero Limit.
Signal Saturation Failure	When any LED Signal reading is above the Saturation Limit.
Reference Saturation Failure	When any LED Reference reading is above the Saturation Limit.

Table 6-2 Causes for Detector Alarms

Sensor Outside Range Alarm Events: This alarm occurs if one of the sensor parameters registers a value outside of its measurement range, indicating a possible sensor failure. It is intended to filter out and catch full scale readings which can occur from the ambient sensors.

Sensor	Minimum	Maximum
AT Sensor	-40.0 C	60.0 C
BP Sensor	300 mbar	1100 mbar

Table 6-3 Set Points for Out of Range Alarms

6.2 Basic Problem Causes/Solutions Table

The following table contains information on some of the more common BC 1060 problems that may be encountered, and some steps to identify and remedy the problems. Met One Instruments welcomes user suggestions for new items to include in this section of future manual revisions.

Problem:	**The instrument doesn't appear to be turning on or starting.**
Cause/Solution:	• Make sure the power supply and power cord are properly connected to a good electrical outlet. • If the instrument is ON, the hum of the internal heater circulation fan should be audible. • The display should come up any time power is applied. • The BC 1060 should start sampling within 10 minutes after power-up. • After using the STOP SAMPLE function, sampling will resume after 30 minutes.

Problem:	**Flow failures or low flow.**
Cause/Solution:	• Make sure that the tape is properly advancing the dirty spots. See Section 4.5 or 4.10.2 • DEFAULT the flow sensor calibrations and re-calibrate the flow. If corrupted flow calibration parameters are entered into the flow calibration, it may appear that the flow system is not working. See Section 6.4. • Verify the AT and BP sensor function. Failed ambient sensors will affect the flow. See Section 6.4 . • Check the internal debris filter. If it is clogged, remove and clean (or replace) the filter element. See Section 6.6. • The sample pump itself will eventually wear out and need to be replaced. It should last at least two years under normal conditions. Check the other possibilities first. See Section 8 for replacement part and the BC 1060 Service Manual for instructions.

Problem:	**Leak check failures**
Cause/Solution:	• There is always a small amount of leakage at the filter tape interface. • Make sure the upper and lower nozzles are completely clean. • Check the push-to-connect tubing fittings inside the instrument. • The filter tape can be replaced with a small rubber sheet with a small hole positioned under the nozzle. This will eliminate the tape as the leak point to help isolate the leak source. • Note: nothing down-stream of the flow sensor is leak tested during the standard leak test procedure.

Problem:	**Optical system alarms and failures**
Cause/Solution:	• A Detector Failure will occur if no filter tape is installed in the measurement module. • Detector Failure will occur if an LED has failed, if either the Reference or Signal Detectors have failed or if there is a ZERO failure (high background). First, ensure tape is properly installed. • Check for obstruction in the ports below the tape above the detector windows as detailed in the BC 1060 Service Manual or return to the factory for servicing (Section 1.2).

Problem:	Calibration Audit failures
Cause/Solution:	• A Calibration Audit Failure can occur if the filter tape is moved during the Calibration Audit procedure. Care should be exercised to not move or damage the tape when performing the calibration audit. • A Calibration Audit Failure can occur if the Calibration Audit Membrane (83011) is inserted incorrectly. The Membrane should be fully seated and the open holes on the LEFT. • A Calibration Audit Failure can occur if the ND filter membrane in the 83011 span check membrane is damaged. A replacement 83011 membrane can be purchased from the Met One Instruments Service Department.

Table 6-4 Common Problems and Solutions

6.3 Suggested Periodic Maintenance Intervals

Table 6-5 shows the Met One Instruments recommended periods for routine maintenance items. Some of these items will need to be performed more or less often depending on local conditions. Local monitoring program administrators may need to review these items and establish SOPs appropriate for local applications.

Maintenance Item	Minimum Period	Manual Section
Replace filter tape	As Required (2-12 Months Typical)	3.7
Temperature, pressure, and flow audits	1 Months	6.4.1, 6.4.2, 6.4.3, 6.4.4
Span check	3 Months	6.4.6
Clean inlet particle traps (cyclone)	3 Months	6.7
Leak test	3 Months	6.5
Flow, temperature, and pressure full calibrations	3 Months	6.4.1, 6.4.2, 6.4.3, 6.4.4
Clean cyclone	3 Months	6.7
Replace cyclone O-rings	As Required	6.7
Clean the debris filter	1 Year	6.6
Replace dilution system cartridge filter	3 Years	See the BC 1060 Service Manual
Replace main pump	As Required	
Replace dilution system pump	As Required	
Replace dilution system flow sensor	As Required	
Factory service	As Required	0

Table 6-5 BC 1060 Maintenance Schedule

6.4 Temperature, Pressure, and Flow Audits and Calibrations

The BC 1060 has a system of calibration menus which allow the operator to audit or calibrate various system parameters for optimal performance. It is recommended that airflow control parameters (AT, BP, FLOW, and DILUTION) be audited monthly and calibrated quarterly during continuous operation. The exact frequency may vary depending on local conditions and the data validation requirements established by the sampling program administrator.

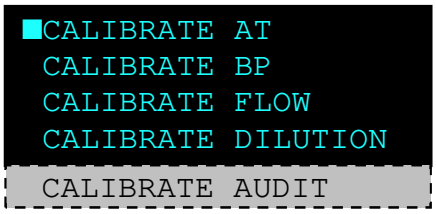


Figure 6-1 The BC 1060 Calibrate Menu

Note: The BC 1060 temperature and pressure calibrations should always be checked before any flow calibrations are performed, since the flow calculation is dependent on these parameters. The model 80866-1 ambient temperature sensor must be fully functional and connected properly.

The CALIBRATE MENU option is located in the main BC 1060 menu. The password, if used (see Section 4.8.5), is required to enter the menu. The CALIBRATE MENU is shown below:

6.4.1 Ambient Temperature Calibration

The CALIBRATE AT screen is used for field audits or calibrations of the ambient temperature measurement of the BC 1060.

The DEFAULT softkey should be pressed to clear out all previous field calibrations and restore the factory calibration for the sensor. Use this prior to beginning the calibration process.

The AT parameter is the current reading from the 80866-1 temperature sensor. The STANDARD field is where the correct value from the traceable temperature standard should be entered, if necessary. To correct the AT reading, enter the value shown on the reference sensor in the STANDARD field (see Section 4.3) and then press the CALIBRATE softkey.

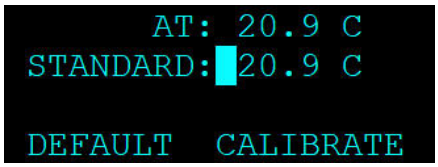


Figure 6-2 The BC 1060 AT Calibration Screen

The AT value should change to match the STANDARD value when the CALIBRATE softkey is pressed.

Audit Only Temperature Checks: see Section 6.4.5.

6.4.2 Barometric Pressure Calibration

The CALIBRATE BP screen is used for field audits or calibrations of the ambient barometric pressure measurement of the BC 1060.

The DEFAULT softkey should be pressed to clear out all previous field calibrations and restore the factory calibration for the sensor. Use this prior to beginning the calibration process.

The BP parameter is the current reading from the internal pressure sensor. The STANDARD field is where the correct value from the traceable pressure standard should be entered, if necessary. To correct the BP reading, enter the value shown on the reference sensor in the STANDARD field (see Section 4.3) and then press the CALIBRATE softkey.

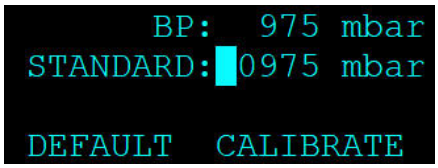


Figure 6-3 The BC 1060 BP Calibration Screen

The BP value should change to match the STANDARD value when the CALIBRATE softkey is pressed.

Audit Only Pressure Checks: see Section 6.4.5.

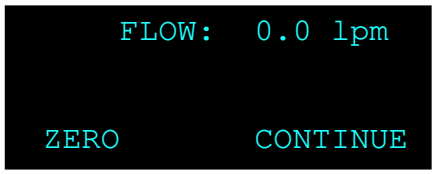
6.4.3 Flow Sensor Calibration

Note: The BC 1060 temperature and pressure calibrations should always be checked before any flow calibrations are performed, since the flow calculation is dependent on these parameters. The model 80866-1 ambient temperature sensor must be fully functional and connected properly.

The CALIBRATE FLOW screen is used for field audits or calibrations of the sample flow measurement of the BC 1060. The temperature, BP and leak status must be checked before performing any flow calibrations. See Sections 6.4.1, 6.4.2, and 6.5 for more details on these prerequisites.

Note: The dilution pump will remain OFF when calibrating the sample flow. See Section 6.4.4 for calibration of the dilution flow sensor.

Flow calibrations require a traceable flow audit calibration device, and a traceable standard for temperature. The BGI TetraCal and similar particulate sampler flow calibrators work well. Attach the flow meter to the BC 1060 sample inlet.



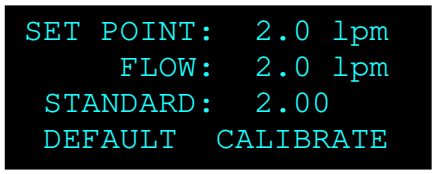


Figure 6-4 The BC 1060 Flow Calibration Screens

All flow values are in Q_a actual volumetric conditions.

The screen will first display the zero flow mode with the pump OFF. The measured flow will be displayed at the top of the screen.

To access the DEFAULT menu item, enter the CALIBRATE FLOW menu. The cursor will be flashing next to the ZERO softkey. Press the ENTER key to open the ZERO field for editing. Use the arrow keys to scroll down to DEFAULT. Press ENTER again. The flow control offset and slope can now be set to factory defaults by pressing the DEFAULT softkey.

Press the ENTER key, change the DEFAULT softkey back to ZERO, and press ENTER again to return to the zero flow calibration screen. Press the ZERO softkey to zero the flow sensor. Then press CONTINUE to proceed to the main flow calibration screen and automatically turn the pump ON.

The SET POINT parameter is the target flow rate that the BC 1060 will attempt to maintain. The FLOW parameter is the current flow reading from the BC 1060 flow sensor. The instrument should automatically regulate to the SET POINT value within a few moments.

The DEFAULT softkey may be pressed to clear out all previous field calibrations and restore the factory calibration for the sensor if difficulties are encountered.

The STANDARD field is where the correct flow value from the traceable flow meter should be entered if the flow does not match within ± 5% of the traceable standard. To correct the FLOW reading, enter the value shown on the reference meter in the STANDARD field (see Section 4.3) and then press the CALIBRATE softkey. The FLOW value should change to match the STANDARD value when the CALIBRATE softkey is pressed. The monitor will then attempt to regulate the FLOW value to match the SET POINT.

Audit-Only Flow Checks: see Section 6.4.5. No flow calibrations are changed if the ZERO and CALIBRATE softkeys are not pressed.

6.4.4 Dilution Flow Sensor Calibration

The CALIBRATE DILUTION screen is used for field audits or calibrations of the dilution flow measurement of the BC 1060 Dilution Flow System. If the Dilution Flow System is not being used, it is not necessary to perform this calibration. The sample flow sensor should be calibrated before calibration of the dilution flow sensor. See Section 6.4.3 for more details.

This flow calibration requires a traceable flow audit calibration device. The standard must be able to accept a pressurized flow rate. A vacuum style of flow measurement will not work for this flow. During Dilution Flow Calibration, the Dilution air is temporarily routed to the ¼" push-to-connect fitting mounted on the transport plate, just above the Measurement Module. Attach the flow meter standard to the ¼" push-to-connect fitting on the BC 1060 front panel (see Figure 6-5).

REMEMBER: Air flows OUT of this port NOT in.

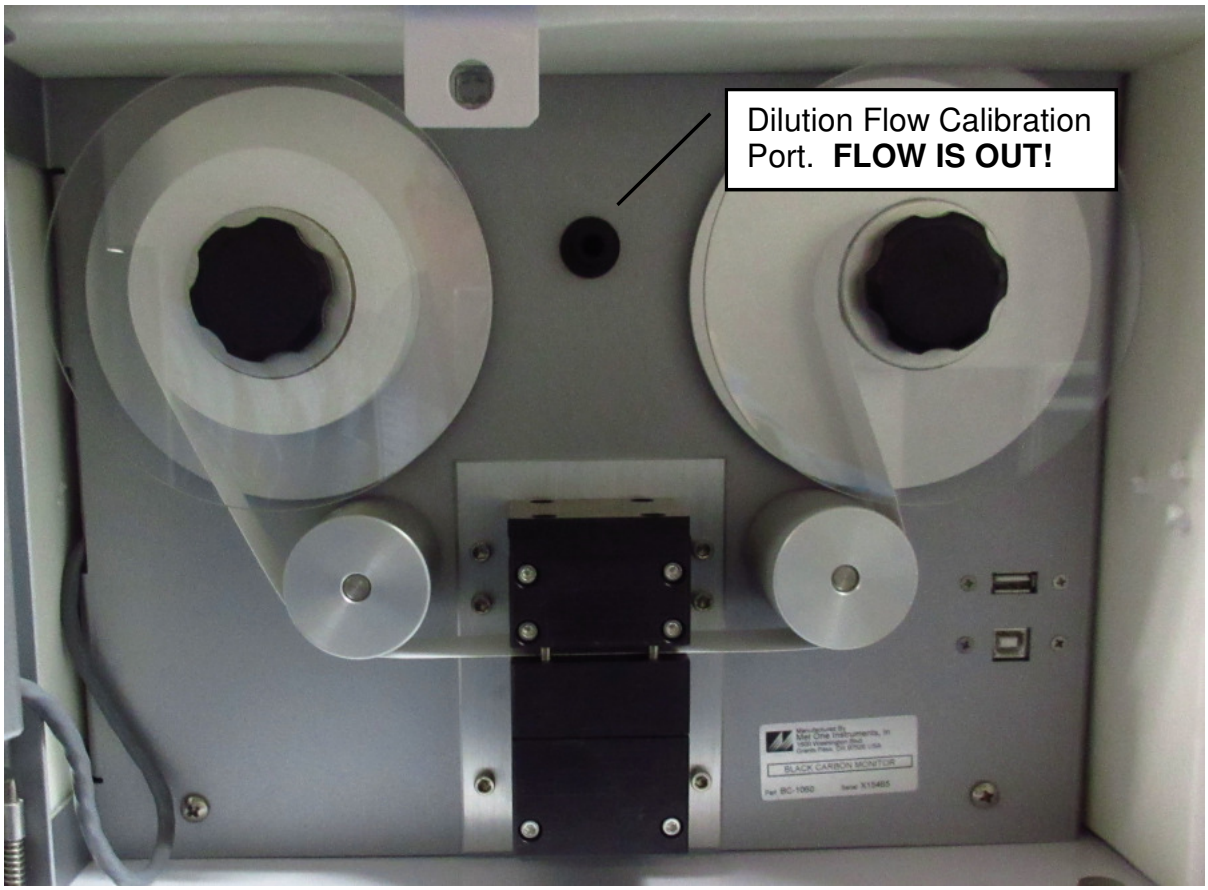


Figure 6-5 Dilution Flow System Calibration Port

If Dilution Flow is configured to be OFF, the WARNING screen shown in Figure 6-6 will be displayed. Press the CONTINUE softkey to display the Dilution System Enable screen (MENU > ADVANCED MENU > SETUP > FLOW). Enable Dilution Flow and press ESC to return to the Dilution Flow Calibration screen.

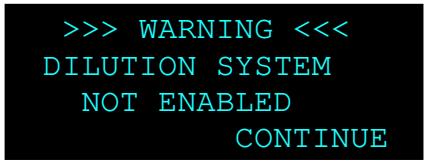


Figure 6-6 Dilution System Warning Screen

All flow values are in actual volumetric conditions. Figure 6-7 shows the various screens that will be displayed during the dilution flow rate calibration.

Figure 6-7 The BC 1060 Dilution Flow Calibration Screens

The screen will first display the current dilution flow set point and turn on the pump. If performing a flow audit, simply allow the flow to stabilize and verify the flow rate is correct and matches the flow standard. Press CONTINUE to advance to the 1.0 lpm flow rate. Allow the flow to stabilize and then verify it is correct and matches the flow standard. Press CONTINUE to advance to the 1.6 LPM flow rate. Allow the flow to stabilize and then verify it is correct and matches the flow standard. Record the results as required by your SOP. Press CONTINUE twice more to exit to the Calibration menu. If a calibration needs to be performed, press the ENTER key to enter the CALIBRATE DILUTION menu again and begin the calibration process.

The calibration of the dilution flow is a two-point calibration consisting of the minimum (1.0 LPM) and the maximum (1.6 LPM) flow rates. After entering the CALIBRATE DILUTION menu, the current dilution flow rate setting will be displayed and the pump will start and regulate to the set point. Allow the flow to stabilize and press CONTINUE.

The SET POINT parameter is the target flow rate that is to be maintained. The DILUTION parameter is the current flow reading from the dilution flow sensor. The instrument should automatically regulate to the SET POINT value within a few moments.

The STANDARD field is where the correct flow value from the traceable flow meter should be entered if the flow does not match within ± 5% of the traceable standard. To correct the DILUTION reading, enter the value shown on the reference meter in the STANDARD field (see Section 4.3) and then press the CALIBRATE key to calibrate. Repeat as necessary. Press CONTINUE to advance to the high flow set point.

The instrument should automatically regulate to the SET POINT value. Allow the flow to stabilize. The STANDARD field is where the correct flow value from the traceable flow meter should be entered if the flow does not match within ± 5% of the traceable standard. To correct the DILUTION

reading, enter the value shown on the reference meter in the STANDARD field (see Section 4.3) and then press the CALIBRATE key to calibrate. Repeat as necessary.

Press the CONTINUE softkey to advance to the final audit screen. The current dilution flow rate and measured flow will be displayed again. Verify they match and also match the standard and then press the EXIT softkey to return to the Calibrate menu.

If difficulty is encountered during the calibration process, the default key can be used. If the flow cannot be calibrated accurately after several attempts, press the DEFAULT key to clear out all previous field calibrations. Once reset, repeat the Dilution Flow System flow calibration process.

Audit-Only Flow Checks: see Section 6.4.5.

6.4.5 Temperature, Pressure, and Flow Audits

To audit any of the AT, BP, Flow or Dilution parameters, without making any calibration changes, enter the corresponding calibration menu and allow the reading to stabilize. Verify the value is correct and matches the flow standard. Record the results and press ESC on the front panel to exit to the Calibration menu.

6.4.6 The CALIBRATE AUDIT Menu – Performing Optical Span Tests

The CALIBRATE AUDIT menu is used to perform the optical span calibration verification test on the instrument using a neutral density filter. This will introduce a known and consistent amount of optical attenuation into the measurement system. The 83011 Span Check Filter tool will be required to perform this test.

Note: No changes to the instrument calibration are made with this process. This is a span check only.

Press the MENU key on the front panel display. Highlight the CALIBRATE MENU item and press the ENTER key on the keypad. Scroll to the CALIBRATE AUDIT option and press the ENTER key again.

When entering the CALIBRATE AUDIT menu, the Measurement Module should be in the OPEN position. If it is not, or if the state is unknown, press the MOVE button (see Figure 6-8) to open the measurement module and advance the tape one position.

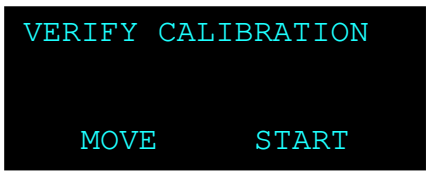


Figure 6-8 Entering the CALIBRATE AUDIT Menu

Press the START button to advance to the Zero measurement. Verify the filter tape is installed and press the CONTINUE softkey. The measurement module will close and the zero measurement will begin as shown in Figure 6-9 Performing the Zero Test.

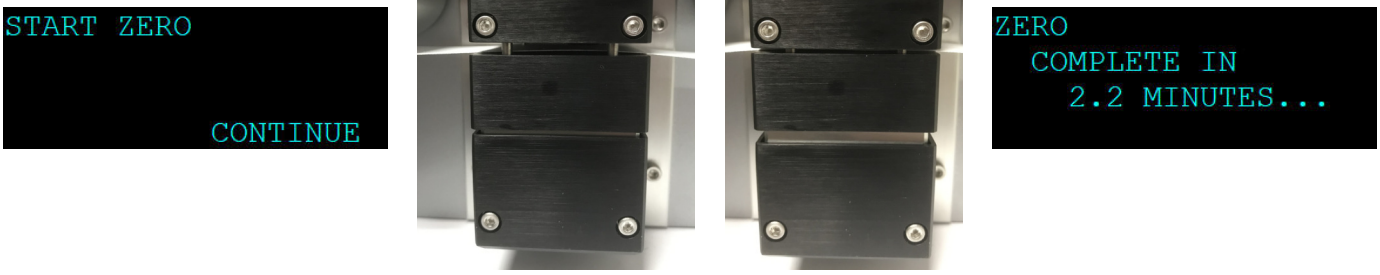


Figure 6-9 Performing the Zero Test

Once the zero test is complete, the span test must be performed using the 83011 neutral density (ND) filter. The measurement module will open and the screen will display instructions to insert the ND Filter as shown in Figure 6-10.

Hold the 83011 ND Filter so that the label is UP (filter element is on the right-hand side) and insert it above the tape. Be certain it is fully inserted and seated squarely against the pins at the front of the measurement module. See Figure 6-13.

CAUTION: Be very careful not to move the tape as this will affect the measurement!

Figure 6-10 The Span Test Start Screen

Figure 6-11 The Span Test in Progress Screen

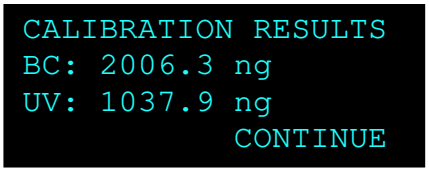


Figure 6-12 The Span Test Completed Screen

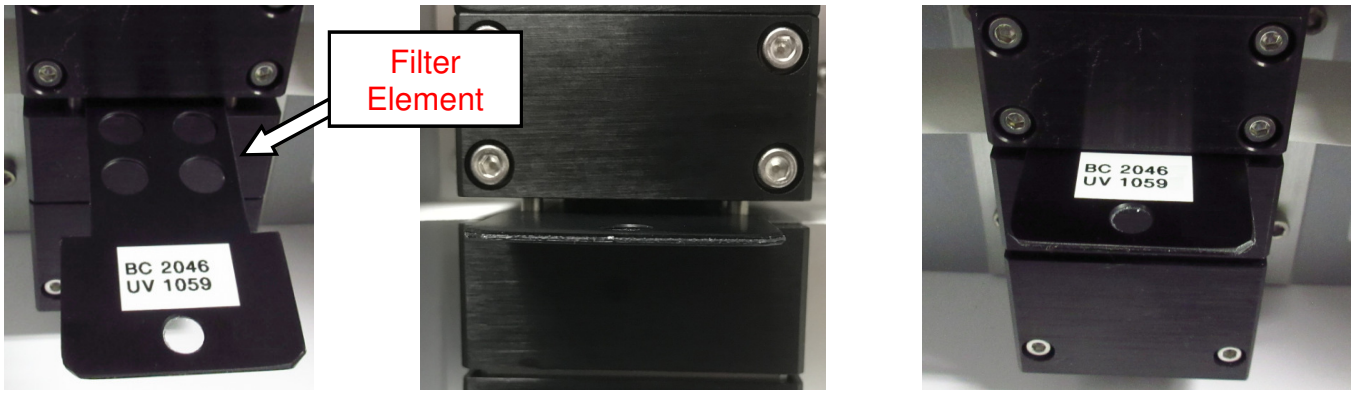


Figure 6-13 Inserting the Neutral Density Span Membrane

The measurement module will close and the display will show the completion time remaining (see Figure 6-11) for the span filter portion of the test. At the end of the test, the measurement module will open and the results will be displayed as shown in Figure 6-12.

The values should be within ± 5% of the values indicated on the label of the 83011 ND Filter. Record the results and then press the CONTINUE button.

The measurement module will open and the display will indicate when it is safe to remove the ND filter as shown in Figure 6-14.

Remove the filter and then press the EXIT button to return to the CALIBRATE menu.

Figure 6-14 The Calibration Audit Exit Screen

Should the values fail to be within ± 5%, the most likely reason is inadvertent tape movement during the test. The test should be repeated, paying particular attention to maintaining the tape stationary. If the test still fails, contact the Met One Instruments, Inc. service department for assistance. See Section 1.2 for contact details.

6.5 Flow System Leak Checks

NOTE: Leak check should be performed with the tape installed.

The tape interface nozzles in the optical measurement module should be checked and cleaned on a routine basis, in order to prevent flow leaks at the filter tape interface. This requires removing the filter tape. With the measurement module open, the parts can be inspected and cleaned with a cotton-tipped applicator if needed. Be sure to replace the tape prior to beginning the leak check.

The BC 1060 flow contains an easy to maintain flow system (see Figure 5-1). To perform a leak test, remove the cyclone from the sample inlet and place the vinyl cap (pn: 770025) over the inlet tube. Navigate to the TEST MENU > LEAK TEST menu as shown in Figure 6-15. The FLOW value is the output from the internal flow sensor.

Press the PUMP ON softkey. This will turn on the pump at a fixed control point while the vinyl cap is in place. The FLOW value should be 0.5 LPM or less for the leak test to be considered passing.

Figure 6-15 The BC 1060 Leak Test Menu

Once complete, press the PUMP OFF key to turn off the pump. **Slowly release the vacuum** in the system (by easing off the vinyl cap) ***before*** exiting this screen. The warning screen shown in Figure 6-15 will be displayed when exiting the Leak Test screen. Exiting the Leak Test screen before releasing the vacuum will cause the vacuum to be released rapidly. This can damage the tape and suck debris into the sample chamber which may require returning the monitor to the factory for service.

Reconnect the Cyclone and other inlet components to the inlet sample tube and resume sampling operations.

6.6 Debris Filter Changes

The BC 1060 contains a filter in the flow system, as described in Section 5.1.

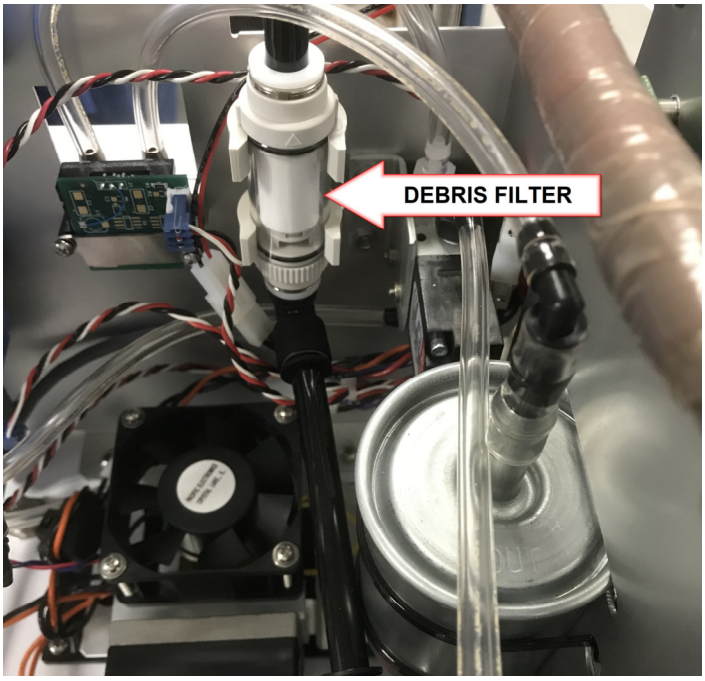


Figure 6-16 Debris Filter Location

This internal filter (see Figure 6-16) keeps filter tape debris out of the flow sensor and is not usually exposed to ambient particulate. It can be cleaned by turning the end of the housing to open it, then blowing any debris off of the element and reassembling. The element can be replaced if excessively dirty.

6.7 Inlet and Cyclone Cleaning

The BC 1060 inlet cyclones all need to be cleaned periodically. Met One recommends cleaning the inlet cyclone particle trap at least once per month in normal conditions. The main cyclone cavity should be disassembled and cleaned every three months during continuous use.

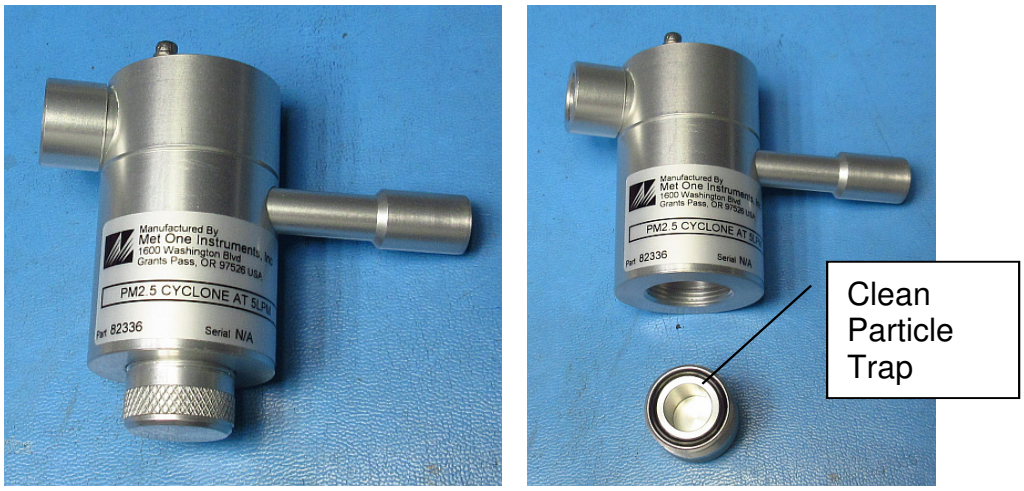


Figure 6-17 Unscrew and clean particle trap

Clean the cyclone particle trap by unscrewing the cap from the cyclone body, then wipe it out with a cloth or blow it clean with compressed air. Check the O-ring and lubricate if necessary. If the O-ring is damaged, replace it using part number 720079 found in the 8658-2 replacement O-ring kit.

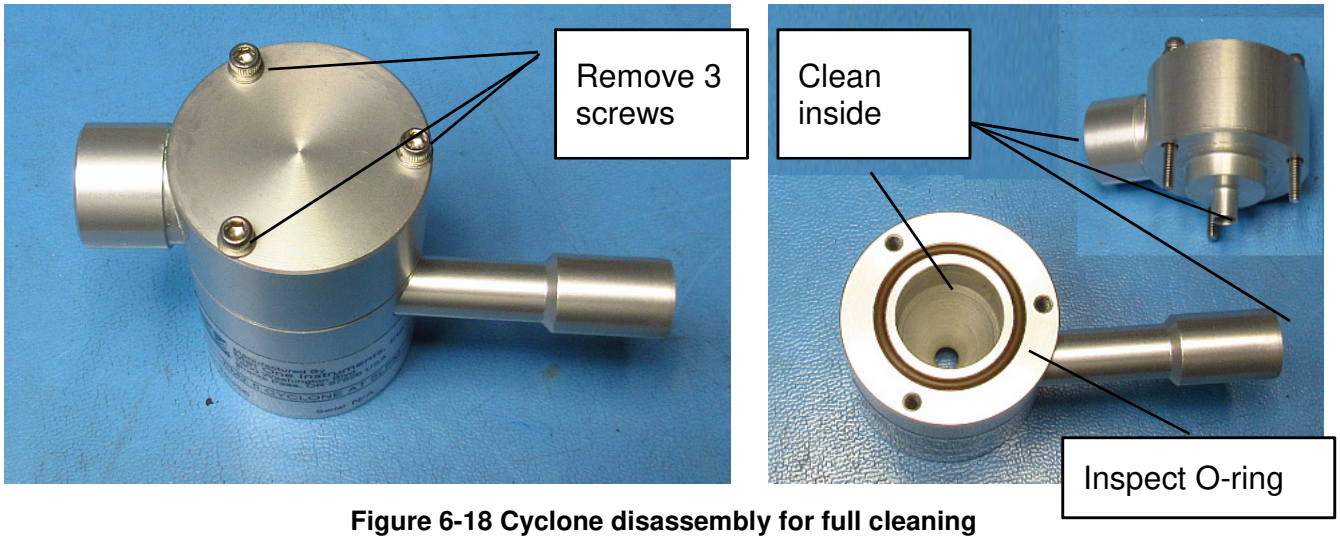


Figure 6-18 Cyclone disassembly for full cleaning

Full cleaning of the cyclone requires accessing the conical chamber inside. All of the inside surfaces must be cleaned. Isopropyl alcohol and cotton-tipped applicators work well.

Inspect the O-ring in the top of the cyclone body. Replace if damaged (720081 from 8658-2 O-ring kit).

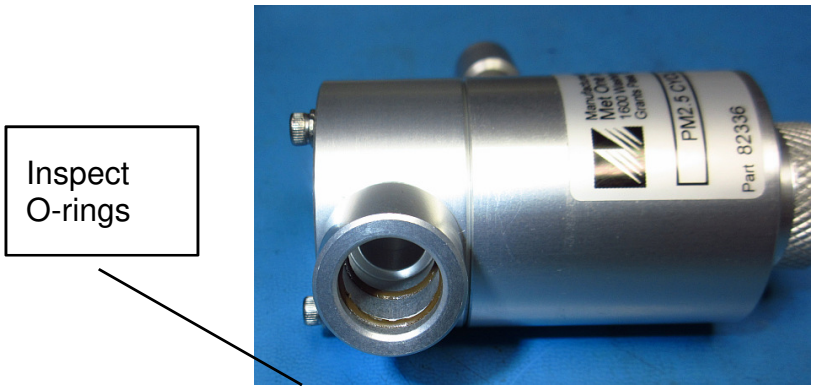


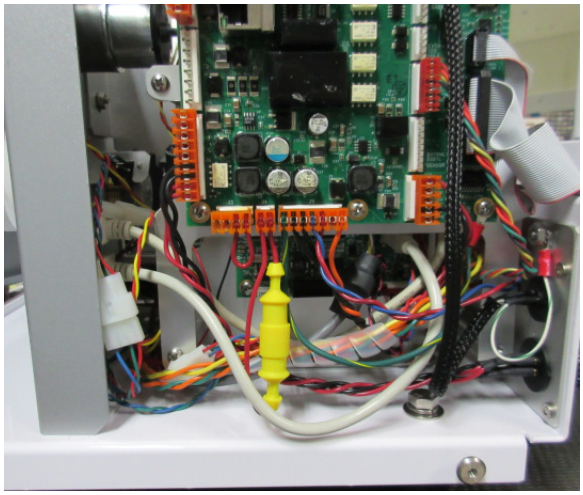
Figure 6-19 Unscrew and clean particle trap

Inspect O-rings in cyclone inlet. If damaged, replace (720087 from 8658-2 O-ring kit).

6.8 Internal Fuse

The BC 1060 is equipped with an inline fuse on the 12 VDC power circuit. If this fuse fails all instrument function will cease.

Remove BC 1060 cover. Fuse is located on right side of instrument in the 81561 Fuse Assembly, connected to J4 of the 81860 PCBA. Replace fuse with 590854 Fuse or equivalent (8A 250 V Slo-Blow 5 x 20mm).



6.9 Factory Service Interval

The BC 1060 recommended factory service interval is once every two years.

Factory service primarily consists of optical system cleaning, optics/detector checks, and a calibration check (and recalibration if needed) against a factory standard. As-found calibration checks can also be requested. Contact the Met One technical service department to schedule service. A Return Authorization number must be obtained before the unit is returned. See Section 1.2 for contact details.

7 DATA RETRIEVAL and COMMUNICATIONS

This section describes the methods used to retrieve data from the BC 1060 carbon monitor. The unit has a single serial data output which can be routed through the RS-232 data port or the USB serial converter port. This is used for all data transfer and may be used with a local computer, digital data logger or with a remote network connection. Access to the data through the serial ports is easy using a terminal emulation program (see Section 7.4).

The User data file can store over 83,000 records. At a 1 minute Sample Rate, the BC 1060 can store 57 days of data. See Table 7-1 for data storage time period at the available Sample Rates.

Note: Large data files take a long time to download, especially at low baud rates. Download the data on a regular basis and use the fastest baud rate that the connected data collection hardware can support. The User Data file, if full, will take approximately 22 minutes to download at the fastest baud rate or via USB download.

Sample Rate, minutes	Days of Storage
1	57
5	288
10	577
15	866
30	1732
60	3465

Table 7-1 BC 1060 Data Storage

7.1 Collecting BC 1060 Data Using a USB Flash Drive

To download directly to USB drive, insert a user-supplied USB flash drive in the USB port located behind the front door, in the bottom right of the tape transport. This USB port is not used for any other purpose.

From the main menu, select and enter the **COPY TO USB DRIVE** menu. Use the ▼▲ keys to select the PAST field, then press the ENTER key. Use the ▼▲ keys to set the desired number of days back to retrieve data (001 to 999 days), or leave it set to ALL to retrieve all data. Press ENTER again when done.

This downloads the User Data file, the Settings file, and the Alarm file. The User Data file contains the corrected concentrations, ambient temperature, barometric pressure (and wind speed, wind direction and relative humidity if equipped with a digital Sensor). The Factory Data file contains additional diagnostic data. Contact Met One Instruments for more information (see Section 1.2 for contact information).

Press the COPY softkey to transfer the files to the USB flash drive. Do not remove the drive until the copy is finished! When the COPY process is complete "100% COMPLETE" will be displayed. See Figure 7-1 for an example of the export screen process.

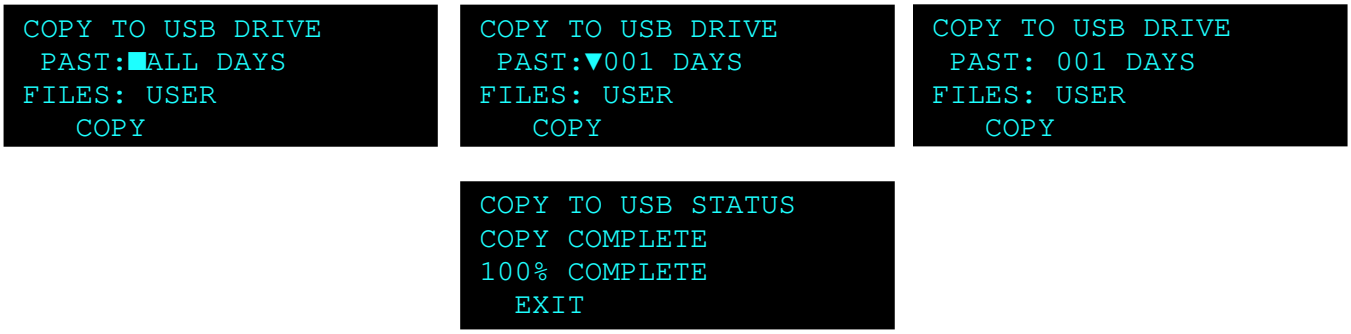


Figure 7-1 The BC 1060 Flash Drive Export Screens

7.2 BC 1060 Cloud Data

The BC 1060 can be paired with the Comet Cloud Services Modem 2 (CCS 2) to upload data to the cloud. The data will be displayed as charts and in tabular format and can be viewed by any web-enabled device (computer, smart-phone, etc). Contact Met One Instruments for more details (Section 1.2).

7.3 BC 1060 Data Outputs and Data Examples

The BC 1060 outputs data files, SETTINGS files, and ALARM files. The raw format of these stored files is *.txt text (ALARM and SETTINGS) files or *.csv comma separated values format (data file) for import into a spreadsheet program.

When downloaded to USB flash drive, the file naming convention described in Table 7-2 is used.

File	File Name
Alarm	ALxxxxxx
Settings	STxxxxxx
User Data	DTxxxxxx

Where xxxxxx is the timestamp when the data was retrieved.

Table 7-2 BC 1060 File Naming

The SETTINGS File (STxxxxxx):

The settings file contains most of the setup menu parameters for the BC 1060. This file should be reviewed periodically to ensure that no settings have been incorrectly changed. It also serves as a good data validation record. An example of a BC 1060 settings text file is shown in Figure 7-2.

The settings file also contains encrypted Factory Settings at the end of the Settings file report.

```
BC 1060 Settings Report
2019-02-01 06:26:43

      Firmware, 82601, R1.1.0
          CPLD, 81699, R1.0.1
 Serial Number, X15465
      Location, 1
          Baud, 9600
 Sample Period, 1 MIN
    Time Stamp, ENDING
    Load Level, 10
   Load Carbon, UVPM
    Alarm Conc, OFF
  Alarm Set Pt, 100.0
   Flow Set Pt, 2 LPM
 Dilution Ctrl, OFF
  Dilution Pct, 50
 50% Threshold, 7500
 80% Threshold, 15000
    N Spot Avg, 5
    Brightness, 128
      USB Days, 1
     USB Files, ALL
   UV K-Factor, 1.000
   BC K-Factor, 1.000
  UV K-Loading, 0.710
  BC K-Loading, 1.170
     FT Set Pt, 40.0
    Box Set Pt, 40.0
     UV Set Pt, 17.42
     BC Set Pt, 6.55
Digital Sensor, ON

  Name, Offset,  Slope
  FLOW,  0.000,  1.000
 DFLOW,  0.000,  1.000
    AT,  0.000
    BP,  0.000

Factory Settings
DQogICAgICBQYXNzd29yZCwgMA0KICAgICAgIElTZXR0bGUsIDENCiAgICAgIElB
dmVyYWdlLCA5DQogICAgICBDLUZhY3RvciwgMi42MTANCiAgICAgICAgVVYgQWJz
```

Figure 7-2 Settings Report

The ALARM LOG File (ALxxxxxx):

The BC 1060 alarm log contains the date, time, and type of each alarm or error encountered during data collection.

```
Alarm Report
2019-02-01 06:26:43
Location, 1, X15465

Time,Alarm
2019-01-31 09:43:58,MAINTENANCE
2019-01-31 09:46:02,MAINTENANCE
2019-01-31 10:11:20,SENSOR RANGE,AT,-50.9
2019-01-31 10:21:57,POWER OUTAGE
2019-01-31 10:22:08,MAINTENANCE
2019-01-31 10:22:57,SENSOR RANGE,AT,-50.9
2019-01-31 11:58:30,MAINTENANCE
2019-01-31 11:58:30,SENSOR RANGE,AT,-50.9
```

Figure 7-3 Alarm Log

The User Data File (DTxxxxxx):

The top of the BC 1060 User Data file contains the header information for the file, including the name of the report, the time stamp at which the report was requested, the location id and the serial number of the device.

Below the file header is the csv column header names which describe the data from each field. Below is a description for each header. See Figure 7-4 for an example.

Time is the date and timestamp for the data record. See Section 4.8.2 for details.

UVPM(ng/m3) is the reported carbon concentration for the near UV channel.

BC(ng/m3) is the reported black carbon concentration for the near IR channel.

BIO(ng/m3) is the concentration of UVPM minus BC, this channel is also known as Biomass or delta carbon.

Flow(lpm) is the average sample flow rate for the last sample period.

DFlow(lpm) is the average dilution flow rate for the last sample period.

WS(m/s) and **WD(Deg)** are the average wind speed and wind direction values from the optional WS/WD sensor. Reported as zero if no digital sensor is connected/enabled.

AT(C) is the average ambient temperature for the last sample period.

RH(%) is the average ambient relative humidity for the last sample period as reported by the optional digital sensor. Reported as zero if no digital sensor is connected/enabled.

BP(mbar) is the average barometric pressure for the last sample period from the internal BP sensor.

Status is the alarm status (see Section 6.1).

Note: The concentrations in the User Data report are corrected for tape loading by fixed, average correction factors set in the Advanced Menu. Contact the Met One Instruments, Inc. service department for more details. See Section 1.2.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Data Report											
2	2/1/2019 6:26											
3	Location	1	X15465									
4												
5	Time	UVPM(ng/m3)	BC(ng/m3)	BIO(ng/m3)	Flow(lpm)	DFlow(lpm)	WS(m/s)	WD(Deg)	AT(C)	RH(%)	BP(mbar)	Status
6	1/31/2019 6:27	37	20.1	16.8	2	0	0	0	21.6	0	972.6	0
7	1/31/2019 6:28	35.3	23.4	12	2	0	0	0	21.6	0	972.6	0
8	1/31/2019 6:29	49.5	16.9	32.6	2	0	0	0	21.6	0	972.6	0
9	1/31/2019 6:30	30.7	31.4	-0.7	2	0	0	0	21.6	0	972.6	0

Figure 7-4 User Data File Report

7.4 Downloading Data Using Terminal Utility Programs

The BC 1060 supports a system of ASCII based terminal commands and Escape commands that can be used to manually collect data records or to remotely change some of the settings in the instrument through the serial port. These commands can be manually sent to the instrument through HyperTerminal or similar terminal programs such as PuTTY or TeraTerm. They can also be programmed into a digital data logger or similar automated system. Most of these functions are intended primarily for use with advanced or remote data collection systems and are not usually used for routine data collection purposes. There are two modes through which the 7500 protocol commands can be used:

The default RS-232 settings are as follows:

Baud Rate: 9600

Data Bits: 8

Parity: None

Stop Bits: 1

Flow Control: None

7.4.1 User Communication

In the User Communication (or Terminal) mode, commands are issued by entering a letter or number command and then pressing the Enter, <cr>, key. The <Esc> key is not used when sending commands in this mode.

Press the Enter key three times to enter User Communication mode. An asterisk character appears confirming that the BC 1060 has entered the mode and that the instrument is ready for a new command. Commands will be echoed back from the instrument and an asterisk will appear after a command has completed.

To issue one of the commands listed in Table 7-3, type the command listed and press the Enter key. The command will run and display the requested information or current setting, as appropriate.

For example, to view the current date setting type the letter D followed by the Enter key. The current date will be reported. The sequence would appear like this:

```
D<cr>

Date: 2019-01-18 :□
```

The unit will report the current date and wait for a new date to be entered. Enter the correct date in the format “YYYY-MM-DD<enter>”. If the date is correct, press the <enter> and the unit will respond with **“Invalid Date!”** and make no change.

Entering the command “D YYYY-MM-DD” on a new line will also change the date.

To change a setting, the typical sequence is to type the command, press the space bar one time, enter the new value in the same format that is displayed when checking the setting, and then pressing the Enter key.

Continuing the example above, to change the date setting type the letter D, space, and then the current date in YYYY-MM-DD format followed by the Enter key. A confirmation of the new date will be reported. The sequence would appear like this:

```
D 2016-02-28<cr>
```

```
D 2016-02-28<cr><lf>
```

Pressing <Esc> or Q<cr> will exit terminal mode.

For a detailed listing of all commands and their formats, consult the BC 1060 7500 document (contact the Met One Instruments service department. See Section 1.2).

7.4.2 Computer Communication

In the Computer Communication mode, character echo is suppressed. This means if commands are issued in this mode using a keyboard, the characters *will not be displayed on the screen* as the keys are pressed. The command format includes a checksum to verify data integrity.

The mode is entered whenever an <Esc> character is sent to the instrument. Commands are issued using the following format:

```
<Esc>Cmd p1 p2*cs<cr>
```

Computer commands are prefaced with an <Esc> character followed directly by a command (Cmd). After the command there can be zero or more parameter field (p1 and p2) where each field is separated by a space. The end of the message is signaled by the Checksum Delimiter character (*) followed by the checksum itself (cs). Finally, the command is terminated with a carriage return (<cr>).

A computer command example requesting the Model/Part/Revision numbers would look like this:

```
<Esc>RV*1234<cr>
```

All command responses are terminated with a checksum. The above command response would have this format:

```
BC 1060, 82401, R1.0.0
CPLD, 81699, R1.0.0
```

COMMAND	DESCRIPTION
H	Help Menu
1	Request settings report
2	Request All data report
3	Request New data report
4	Report Last Data
7	Request alarm event report
C	Clear data log file – $
D	Get/Set date part of the real time clock – $
T	Get/Set time part of the real time clock – $
CA	Clear alarm log file – $
DS	Report data log channel descriptors
DT	Get/Set the date and time of the real time clock – $
ID	Get/Set location ID or address – $
OP	Get/Set operation state – $
PR	Print report – 0-Settings, 1-User, 2-Alarm, 3-Factory Diagnostic
QH	Report Data Record Header
RRT	Report Remaining Tape
RV	Report Model/Part/Revision
RQ	Get last data record (Data ONLY. No header)
SB	Get/Set baud rate – $
SS	Get Met One serial number
ST	Get/Set sample time – $
SPW	Get/Set user password – $
FTSP	Get/Set flow temperature set point – $
TLOAD	Get/Set tape advance loading – $
TCARBON	Get/Set tape advance loading carbon type – $
DFCTL	Get/Set dilution control – $
DFPCT	Get/Set dilution flow percentage – $
K x	Get/Set User K factor for each channel, k 1 = UVPM, k 2 = BC

Table 7-3 Available Terminal Mode and Escape Commands

For commands that have fixed options, entering the command followed by a "?" will report the available choices. For instance, typing "SB ?" would display a list of the available baud rates for the monitor.

For a listing of all commands and their formats along with additional in-depth Computer Communication details, consult the BC 1060-7500 document. Contact the Met One Instruments service department. See Section 1.2.

Table 7-4 shows the commands associated with editable settings, along with the default value for the setting and the settable range:

DESCRIPTION	RANGE	DEFAULT	COMMAND
Location ID	1 – 999	1	**ID**
Serial port baud rate	2=1200, 3=2400, 4=4800, 5=9600, 6=19200, 7=38400, 8=57600, 9=115200	5	**SB**
Sample Period	0=1min, 1=5min, 2=10min, 3=15min, 4=30min, 5=60min	0	**ST**
Time Stamp	0=Ending, 1=Beginning	0	**TS**
Number of days of data to copy to USB drive	0 = All data, 1 - 999 days	0	**UD**
Files to copy to USB drive	0=User data, 1=All data	0	**UF**
User password	0 – 9999	0	**SPW**

Table 7-4 User Editable Settings

7.5 Flash Firmware Upgrades

The BC 1060 has the capability for flash firmware upgrades. This allows the field operator to reprogram or update the instrument operating system through the front panel USB port using the Firmware Update Utility program. A Met One Instruments technician may supply the firmware update files by e-mail if a bug fix is released, or if additional features are added to the firmware program.

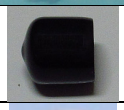
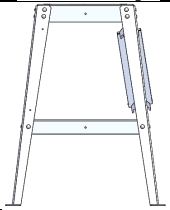
Ensure that the power source to the BC 1060 and the computer will not be interrupted during the update process! This may cause the firmware to become inoperative. If this happens the unit will have to be returned to the factory. Make sure the USB cable connection cannot come loose during the update.

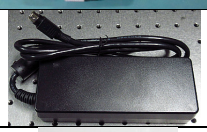
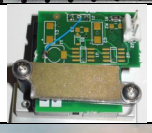
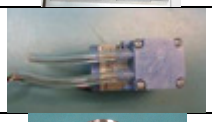
The following must be performed to update the firmware:

1. It is advisable to download and save the data log and alarm log from the instrument before proceeding. Note: The firmware update process does not clear the instrument memory.
2. A PC or laptop with a USB port must be available and the USB drivers for the BC 1060 installed. Install the Firmware Update Utility program onto the computer by following the prompts after following the e-mail link to the Met One FTP site.
3. Connect the instrument USB serial port to the computer. Make sure that BC 1060 is set to the **9600 baud** rate.
4. Run the Firmware Update Utility. From the computer “Start” menu, go to: Programs/Met One/BC 1060/BC 1060 Master Program Installer (or similar directory). The program may prompt to press ENTER to begin the update.
5. A “Done!” message will be displayed at the end of the update process. Execution time is approximately five to fifteen minutes.

8 ACCESSORIES and PARTS

The following parts are available from Met One Instruments for maintenance, replacement, service, and upgrades. If unsure about a part, please contact the technical service department. Some of these parts may require technical skills or special instructions before use or installation.

Description	Part Number	Graphic
Filter Tape Roll	**460211**	
Span Check Membrane	**83011**	
Debris Filter Assembly	**580356**	
Debris Filter, Replacement Filter Element Only	**580292**	
Fuse, 8A	**590854**	
Inlet Support Tube	**82977**	
Sharp Cut Cyclone, PM 1, 2 LPM	**SCC 111**	
Sharp Cut Cyclone, PM 2.5, 2 LPM	**SCC 112**	
Dilution Adapter with Elbow	**82238** **580273**	
Cap, Vinyl, 1/2" ID x1/2" Long, Black	**770025**	
TSP Inlet	**9441**	
Straight Fitting, Reducer (Mates inlet to Sample Tubing)	**580198**	
Tubing, 1/8” ID x ¼” OD, Black Tygon	**960207**	
Tubing, 1/4” ID x 3/8” OD, PUR tubing	**960215**	
Rooftop Extension Kit	**BCX-801**	
Optional Mounting Stand	**BCX-901**	
Ambient Temperature Sensor shield	**820471**	

Ambient Temperature Sensor	**80866-1**	
Power Supply, AC/DC Switching Adapter, 12V, 8.5A (Mounts inside Power Enclosure Assembly and includes 400100 US Power Cord)	**82522**	
Flow Sensor Assembly	**9049-5**	
Pump Module, Dilution Flow	**82885**	
Pump Module, Sample Flow	**82482**	
Solenoid, 3 Way, Dilution Flow System	**82886**	
Filter, Dilution Flow System	**82887**	
Inlet cyclone O-Ring replacement kit	**8658-2**	
Serial Cable, RS-232	**82459**	
Fan, Box Heater Circulation	**590080**	
USB Cable	**500784**	
Comet	**80248**	

9 PRINCIPLE OF OPERATION

Rosen, et. al.[i] established the relationship between the attenuation of laser light through quartz filters onto which ambient particulate samples containing soot had been collected and the concentration of "graphitic carbon" of the same samples thereby establishing the viability of optical BC monitoring techniques as determined by Raman scattering.

Gundel, et. al.[ii] later demonstrated reasonable linear correlation over a wide concentration range between measured attenuation of graphitic carbon collected onto quartz filters and "BC" concentrations determined by thermo-optical methods leading to an estimate of its "specific attenuation" σ.

BC concentration in the BC 1060 is determined by measuring the change in optical transmission as BC-containing particulate matter accumulates onto a filter and then converting this transmission data into BC concentration. In the Met One Instruments BC 1060, filter tape is used which extends the possible period of unattended operation to several months under most conditions.

In the BC 1060, transmission of light coming from light emitting diodes is measured across filter tape onto which sampled aerosol containing BC is being accumulated. Reference transmission across a clean portion of the filter tape is simultaneously measured. As BC accumulates onto the filter tape light transmission across the portion of the tape onto which BC is accumulating relative to the reference transmission will decrease.

9.1 Mass Calculation

There is not a universally agreed to soot reference material "SRM" that could be used to calibrate filter-based thermal-optical EC or filter-based BC analyzers such as the BC 1060.[iii] Since a precise definition of soot does not exist, its exact quantification cannot be made. Instead, filter-based BC monitors such as the BC 1060 report BC concentrations based on a presumed relationship between measured optical attenuation through the filter tape as BC accumulates and ambient BC levels based on historical measurement data collected by thermo-optical methods, which are themselves only semi-quantitative. The default calibration settings on the BC 1060 are derived from those. The mass attenuation cross section "MACS" and its wavelength dependence are derived from the empirical relationship shown in Equation 1 based on absorption onto quartz filter media and thermo-optical measurements.[iv] [v]

Equation 1: MACS Relationship

$$\sigma(m^2 g^{-1}) = \frac{14{,}625}{\lambda(nm)}$$

BC is calculated by measuring the changes in transmission of light through the portion of the filter accumulating particulate matter relative to the transmission of light through a portion of the filter not accumulating particulate matter. The relative measured intensity, I_t is defined as the measured signal at time t through the filter accumulating the PM divided by the measured signal at time t of light through the reference as shown in Equation 2.

Equation 2: Measured Relative Intensity

$$I_t = \frac{S_B(t) - S_Z(t)}{R_B(t) - R_Z(t)}$$

$S_B(t)$ is the measured signal at time "t" with the illumination source on through the sampled filter spot. $S_Z(t)$ is the measured signal at time "t" with the illumination source off through the sampled filter spot. $R_B(t)$ is the measured signal at time "t" with the illumination source on through reference

portion of the filter and $R_Z(t)$ is the measured signal at time "t" with the illumination source off through the reference portion of the filter.

Equation 3: Attenuation

$$ATN(t) = -ln\left[\frac{I_t}{I_0}\right]$$

$ATN(t)$ as defined in Equation 3 is calculated from the change in measured optical transmission through the filter that occurs over the time period Δt as PM accumulates. The filter-based aerosol absorption coefficient of the collected particulate matter is defined in Equation 4. A is the cross sectional area of the filter spot, Q is the volumetric flow rate, and $\frac{\Delta ATN}{\Delta t}$ is the measured change in attenuation during time Δt.

Equation 4: Aerosol Absorption Coefficient

$$b_{ATN} = \frac{A}{Q}\frac{\Delta ATN}{\Delta t}$$

The filter-based aerosol absorption coefficient of the collected particulate matter is known to differ significantly from the true aerosol absorption coefficient of black carbon. Weingartner, et. al. describe an empirical formula used to connect the two in Equation 5.

Equation 5: True Aerosol Absorption Coefficient

$$b_{abs} = b_{ATN}\frac{1}{C \cdot R(ATN)}$$

C is the part of the difference between the true aerosol absorption coefficient and the filter-based aerosol absorption that is constant and depends only on the filter medium. $R(ATN)$ is the part of the difference between the true aerosol absorption coefficient and the filter-based absorption coefficient that is not constant, but instead is attenuation-dependent.

BC concentration is determined by dividing true aerosol absorption coefficient by the mass attenuation cross section as is shown in Equation 6.

Equation 6: Mass Calculation

$$M_{BC} = \frac{b_{abs}}{\sigma_{abs}} = \frac{b_{ATN}}{\sigma_{abs} \cdot C \cdot R(ATN)} = \left[\frac{A}{Q \cdot \sigma_{abs} \cdot C \cdot R(ATN)}\right]\frac{\Delta ATN}{\Delta t}$$

In the BC 1060, the spot size A, the flow rate Q, the mass absorption coefficient σ_{abs}, and the filter tape constant C, are constants. Therefore the BC concentration M_{BC} is calculated by multiplying the change in attenuation over time $\frac{\Delta ATN}{\Delta t}$, as is measured by the BC 1060 by the inverse of $R(ATN)$ and a proportionality constant $\left[\frac{A}{Q \cdot \sigma_{abs} \cdot C}\right]$.

9.2 Instrument Calibration

The Met One Instruments BC 1060 has as its default calibration values the historically used mass absorption cross sections "MACS" shown in Equation 1 but adjusted for the change in filter media. This is shown in Equation 7 and Equation 8. Note that $C_{quartz} = 2.14$.

Equation 7: Filter Media Influence on MACS

$$\sigma(m^2 g^{-1}) =\cdot \sigma_{abs} \cdot C_{quartz} = \frac{14{,}625}{\lambda(nm)}$$

and

Equation 8: True Aerosol MACS used in BC 1060

$$\sigma_{abs}(m^2 g^{-1}) = \frac{6{,}834}{\lambda(nm)}$$

σ_{abs} is set to 7.770 m^2/g for 880 nm illumination. In order to calculate the true aerosol absorption coefficients for other illumination wavelengths a 1/λ wavelength dependence is presumed.

The true aerosol mass absorption coefficients σ_{abs} used in the BC 1060 are shown in the table below. For the glass fiber tape used by the BC 1060 C = 2.61.

MACS Values for BC 1060

λ(nm)	σ_{abs} (m^2/g)
370	18.48
880	7.77

9.3 Filter Media and Loading Effects

The convenience of using filter-based methods to measure BC is somewhat offset by several measurement artifacts caused by interaction between sampled BC and the filter media, non-linearity of response between measured absorption and BC concentration at high BC filter loadings, scattering of non-absorbing particulate matter and other issues. Non-linearity of response is often referred to as the "filter loading" effect and is more apparent in highly time resolved data where high BC concentrations are being tracked. The filter-loading effect becomes more pronounced as the amount of material accumulated on a given spot increases, thus increasing ATN. To help mitigate the effects of filter-loading, the tape move criteria has been set to a default of 0.3 (or 30%).

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[i] Rosen, H., Hansen, A. D., Gundel, L., and Novakov, T., "Identification of the optically absorbing component in urban aerosols." Appl. Opt. 17:3859-3861 1978.

[ii] Gundel, L., Dod, R., Rosen, H., and Novakov, T., "The relationship between optical attenuation and black carbon concentration for ambient and source particles." The Science of the Total Environment, **36**:197-202 1984.

[iii] Baumgardner, D., Popovicheva, O., et. al., "Soot reference materials for instrument calibration and intercomparisons: a workshop summary with recommendations." Atmos. Meas. Tech. **5**: 1869-1887, 2012.

[iv] Gilardoni, S., Vignati, E., Wilson, J., "Using measurements for evaluation of black carbon modeling" *Atmos. Chem. Phys.* **11**:439-455 2011.

[v] Jennings, S. G., Pinnick, R. G., "Relationships between visible extinction, absorption and mass concentration of carbonaceous smokes", Atmospheric Environment **14**:1123-1129 1980.