

UCD IMPROVE Standard Operating Procedure #201

Sampler Maintenance by Site Operators

*Interagency Monitoring of Protected Visual Environments
Air Quality Research Center
University of California, Davis*

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IMPROVE SOP #201: SAMPLER MAINTENANCE BY SITE OPERATORS

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1. INTRODUCTION

1.1 IMPROVE Network

IMPROVE (Interagency Monitoring of Protected Visual Environments) is a cooperative program of the National Park Service, National Forest Service, Bureau of Land Management, Fish and Wildlife Service, Environmental Protection Agency, and state and tribal organizations. IMPROVE was established in 1985 to aid the creation of Federal and State implementation plans for the protection of visibility in Class I areas (156 national parks and wilderness areas) as stipulated in the 1977 amendments to the Clean Air Act.

The first IMPROVE samplers were deployed in 1988 at twenty sites. The number of sites has increased significantly over the years. For a current list of sites please visit:

<http://views.cira.colostate.edu/fed/DataWizard/Default.aspx>

Click on the “Sites” tab to see the site list. A map of the network is available here:

<http://views.cira.colostate.edu/fed/SiteBrowser/Default.aspx?sskeyse=10001&smmkeys=57>

Zoom out on the map to see sites beyond the Continental United States in Alaska, Hawaii, Virgin Islands, Canada, and South Korea. Click on any site to see photos and information about that site.

Every IMPROVE site employs an aerosol sampler to collect particulate matter samples below $2.5 \mu\text{m}$ ($\text{pm}_{2.5}$) and below $10 \mu\text{m}$ (pm_{10}). The version i improve aerosol sampler was used in the network from 1988 to 2000. In 2000, the version ii improve aerosol sampler was introduced, and the sampling protocol changed from twice a week to every third day. The sampling schedule was changed to be consistent with the EPA-designated schedule for the speciation trends network (STN), which operates in urban areas.

1.2 IMPROVE Aerosol Sampler Overview

A picture of an IMPROVE aerosol sampler is shown in Figure 1-1. The sampler consists of four modules used to collect aerosol samples, labeled A, B, C, and D. The third white box from the left, in the center of the picture is the controller. The controller contains the microcontroller with programmed schedule, the keypad, and other electronic equipment required to operate the sampler. Note that the four sampling modules have inlet pipes protruding from the top of them, while the controller does not. During a sampling period, each of the four modules collects a filter sample simultaneously. The four modules are used to collect four different types of samples.

- Module A collects $\text{PM}_{2.5}$ particles on Teflon filters. These filters are analyzed by four methods at UC Davis:
 - a. gravimetric analysis for $\text{PM}_{2.5}$ mass,
 - b. hybrid-integrating plate and sphere (HIPS) for optical absorption,

- c. proton elastic scattering (PESA) for hydrogen, and
- d. x-ray fluorescence (XRF) for elements: sodium (Na) to lead (Pb).
- Module B collects PM_{2.5} particles on nylon filters. A denuder before the nylon filter removes nitric acid and sulfur dioxide vapors. These filters are analyzed by ion chromatography for nitrate, chloride, sulfate and nitrite by Research Triangle Institute (RTI).
- Module C collects PM_{2.5} particles on quartz filters. These filters are analyzed for organic and elemental carbon using Thermal Optical Reflectance (TOR) by Desert Research Institute (DRI).
- Module D collects PM₁₀ particles on Teflon. These filters are analyzed by gravimetric analysis for PM₁₀ mass at UC Davis.

Figure 1-1. Photo of the IMPROVE aerosol sampling modules inside a shelter.



2. IMPROVE Aerosol Sampling

2.1 Sampler Shelters

The sampling modules are protected from direct sunlight by a shelter. The shelter will also protect the operator and filters during sample changes in rain or snow. The shelter will vary from an outdoor stand with a sunshield to a fully enclosed but well-ventilated shelter. The shelters at IMPROVE sites should not be heated or air-conditioned.

2.2 Operator Qualifications

A UC Davis technician will train the site operator. The operator must pay attention to details, perform the work in a timely manner, and communicate any problems to UC Davis. The operator should have a general familiarity with electrical connections, flow through pipes, and pumps to service the IMPROVE sampler.

2.3 Interferences

The IMPROVE network is designed to measure regional air quality. Therefore, the sites are located in remote areas. The sites should not be heavily influenced by local sources. If a new activity begins close to the site (if you can see or smell emissions when you are at the site), please inform UC Davis of the possible interference at once. Examples of activities that might influence the air quality samples are

- Fires
- Road or building construction
- Gas or diesel powered generator
- Increased traffic
- Mining operations or timber harvesting

The IMPROVE siting criteria are detailed in IMPROVE SOP 126 Site Selection.

The quality of the samples is dependent upon careful handling of the samples. Careless handling of the samples can lead to contamination.

- Do not leave the samples sitting out in the open air for longer than a few minutes.
- Do not touch the surfaces of the filters.
- Be careful not to drop the samples.
- Ship the used samples back to UC Davis as soon as possible.
- Protect the samples from water contamination when changing samples in the rain or snow.
- Store the samples at room temperature (i.e., do not leave the samples in a hot car, or in the sun).

2.4 Sampling Supplies

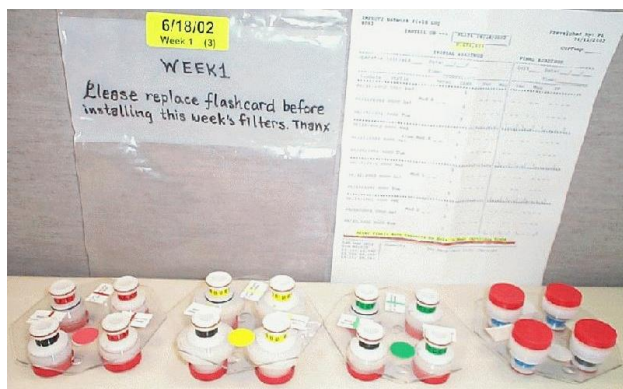
The laboratory at UC Davis prepares the sample cartridges for the IMPROVE sites. Every three weeks, UC Davis sends a “Blue Box” containing the necessary sampling supplies to each site (Figure 2-1). Usually, there will be two Blue Boxes at a site, one box in current use and the second box ready for the next period or ready to be shipped back to UC Davis. Inside each Blue Box are three re-sealable bags and a CompactFlash card for storing the electronic sampling data. Each bag contains the supplies for one week (Figure 2-2): four sample cartridges, one for each of the four modules, and the corresponding logsheet. The cassettes are color-coded for each module: red for module 1A, yellow for module 2B, green for module 3C, and blue for module 4D. A sampler which has a fifth module will use orange for module 5X. All cassettes are capped to protect the filters, and the red caps must be removed before the cassettes are installed in the modules. Each re-sealable bag is labeled with the date that the cartridges inside the bag are to be installed. The Blue Box will be labeled with the three sample install dates.

The Blue Box should be received 5 calendar days before the first sample-change day. If the appropriate box is not present before the change date, the operator should contact the UCD laboratory (530-752-1123). Once all the filter samples in a Blue Box have been used, the Blue Box should be shipped back to UCD by UPS, or FedEx, or USPS services. UC Davis provides shipping label to most site for returning the Blue Box.

Figure 2-1. Picture of a blue box showing the three filter bags.



Figure 2-2. Picture of the contents of one re-sealable bag – supplies for one week of sampling.



The filter samples are loaded into cassettes to form an airtight seal around each filter, and the cassettes are loaded into cartridges to allow sequential samples to be collected without operator intervention. Figure 2-3 is a picture of a sample cartridge and four cassettes. Each cartridge contains three or four cassettes but only two or three of the cassettes contain sample filters because only two or three samples are collected in any given week. **Error! Reference source not found.** lists the three cartridge configurations used for routine sampling. The unused cassettes contain pieces of paper or blank filters (blank filters do not require any special procedures of the operator).

Figure 2-4 shows a sampling calendar for September and October, 2015 to illustrate the 3-week repeating cycle.

Figure 2-3. Sample cartridge for the 2B module (yellow sticker) with four cassettes. Only three of the cassettes contain sample filters (indicated by the three labels).

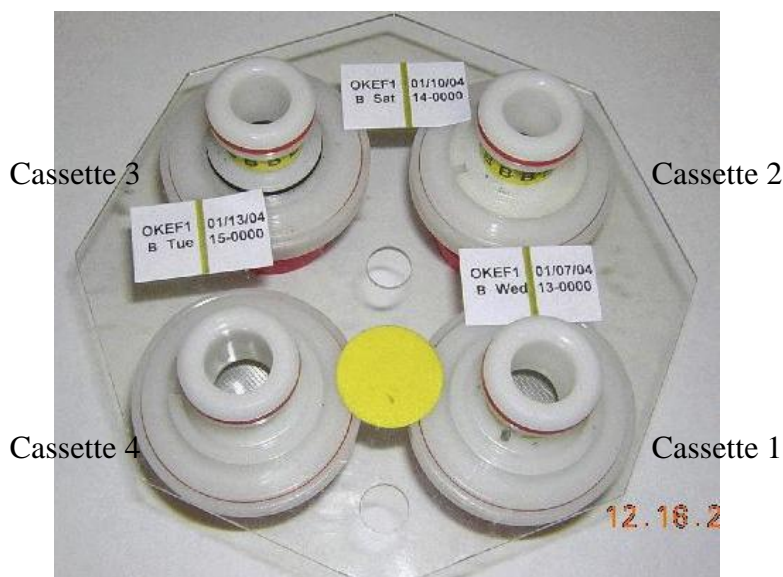



Table 2-1. Types of cartridges for 1-in-3 day sampling.


Cartridge Type	Cassette 1	Cassette 2	Cassette 3	Cassette 4
Type 1	Thursday	Sunday	Unused or field blank	Unused
Type 2	Wednesday	Saturday	Tuesday	Unused
Type 3	Friday	Monday	Empty hole	Unused


Figure 2-4. Sampling calendar for November and December 2005 illustrating the repeating 3-week cycle.

September 2015							Cartridge Type
Tue	Wed	Thu	Fri	Sat	Sun	Mon	
1	2	3	4	5	6	7	1
8	9	10	11	12	13	14	2
15	16	17	18	19	20	21	3
22	23	24	25	26	27	28	1
29	30						2
October 2015							
Tue	Wed	Thu	Fri	Sat	Sun	Mon	
		1	2	3	4	5	2 continued
6	7	8	9	10	11	12	3
13	14	15	16	17	18	19	1
20	21	22	23	24	25	26	2
27	28	29	30	31			3

KEY

 Sample change day

 Sample collection day

 Sample change and collection day

2.4.1 Collocated “X” Module Sampling

Collocated (or duplicate) sampling is performed at a small number of sites. At these sites, five sampling modules are operated. The fifth module is a duplicate of one of the other four modules and is labeled as the “5X” module.

2.4.2 Special Studies

At times, special aerosol studies will be performed at some of the sites. These studies may require additional sampling equipment and supplies. The individual site operators will be contacted before any special studies are initiated at their sites.

2.5 Schedules

2.5.1 Sampling Schedule

IMPROVE filter samples are collected every three days on the EPA-designated schedule. The samples are collected over 24 hours, starting at midnight, according to the local Standard time. .

2.5.2 Sample Change Schedule

The sample cartridges should be changed every Tuesday as described in Section 5. If the operator cannot change the samples on Tuesday, contact UC-Davis (530-752-1123) for instructions on when to change the samples. Alternative days for sample changes are shown on the IMPROVE calendar and vary each week. It takes approximately fifteen minutes to change the sample cartridges every Tuesday. For two of every three Tuesday sample changes, the sampler will not be actively collecting samples. For one of every three Tuesday sample changes, the sampler will be actively collecting samples, and the sampling will have to be interrupted to change the filter cartridges. The procedures required to change the cartridges on sampling days are slightly more complicated than on the non-sampling days.

2.5.3 Maintenance Schedule

A maintenance crew from UC Davis will visit the site every other year to perform routine maintenance. The routine maintenance consists of

- Cleaning and refurbishing the sampler,
- Replacing parts when necessary,
- Making scheduled modifications to the sampler and controller program,
- Checking the existing calibrations of the sample modules,
- Re-calibrating the flow rates of the sample modules,
- Discussing procedures with the site operator, and
- Providing training for any site operators.

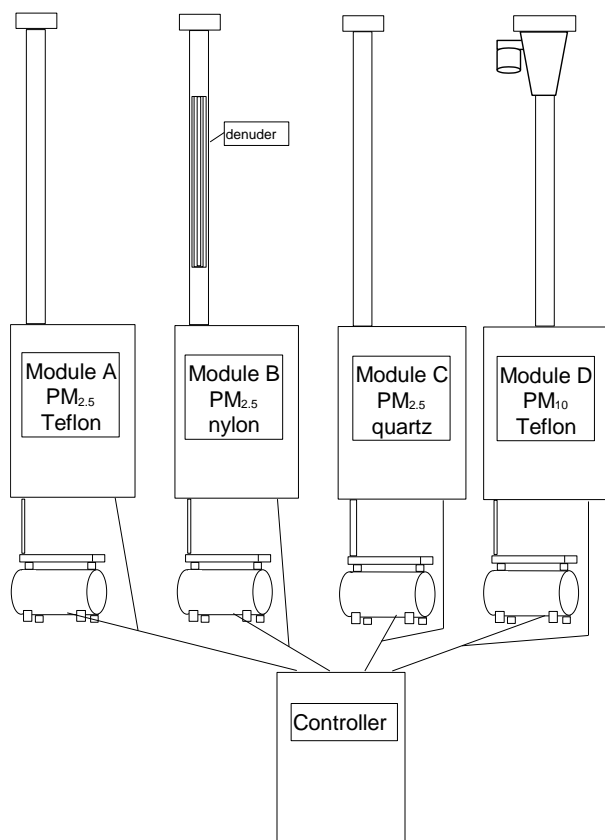
3. Version II IMPROVE Aerosol Sampler

The standard IMPROVE aerosol sampler configuration is shown in Figure 3-1. Most sites will have four modules plus a controller as shown in the figure. Each module has a dedicated pump. At steady state each pump requires 3.3 amperes (A) at 120 volts (V). The 1A, 2B, and 3C modules collect PM_{2.5} samples. The 1A and 3C modules are identical except that their flow rates are calibrated for different types of filters (as described in Section 1.2). The 2B module has a slightly different cartridge holder configuration to accommodate the larger diameter filters that are used in the 2B module. The 4D module collects PM₁₀ samples and has a very different

configuration to accommodate a PM₁₀ cyclone; the most noticeable operational difference is that the sample cartridges must be installed upside down compared to the other modules.

Selected sites will have a fifth module used to perform sampling for quality assurance purposes. The fifth module will be a duplicate of one of the other modules and will be referred to as a 5X module.

Figure 3-1. Standard IMPROVE aerosol sampler configuration.

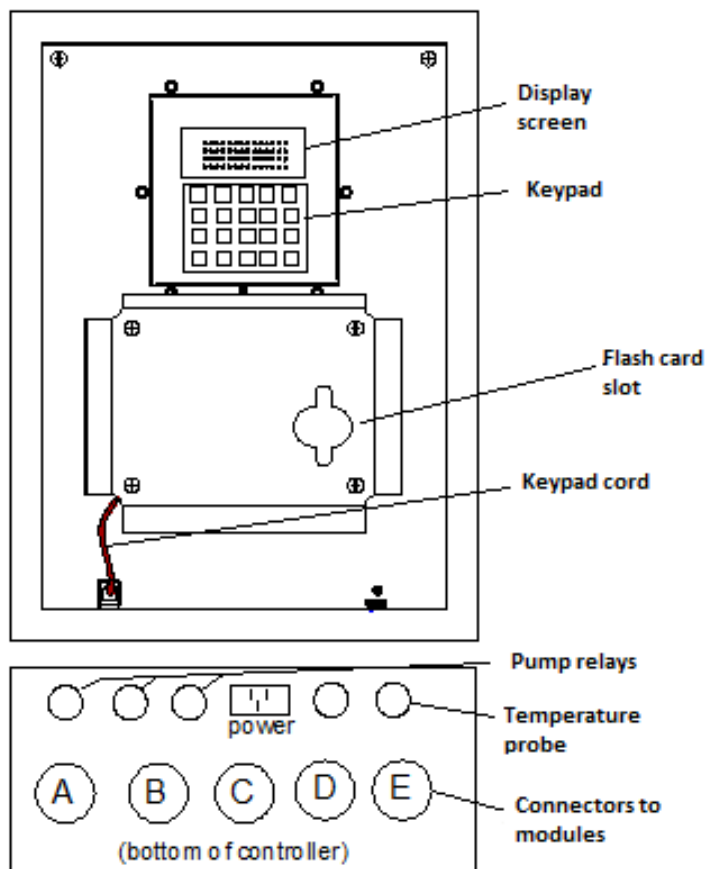


3.1 Sampler Controller

The sampler controller is used to control the sample collection and acquire data during sampling. The Version II controller consists of a TERN 20 MHz microcontroller, 12 bit analog to digital converter, a Two Technologies terminal with LCD screen, and a twenty-button keypad, plus appropriate electronic components. The controller is shown in

Figure 3-2. The lower portion of the figure shows the connectors on the bottom of the controller. The keypad and display terminal can be removed from the controller to be closer to the sampler modules; this is useful when the sampler is calibrated but not recommended during the weekly sample change. The controller can currently accommodate up to five filter sampling modules.

Figure 3-2. Controller module



The controller performs the following functions.

- Provides a status of current sampler operations to the site operator.
- Provides an interface for recording initial and final measurements of the filters during sample changes to the site operator.
- Provides options for selecting sampling protocols and filter types. This is normally performed by an UC Davis technician at the time of installation.
- Keeps the current date and time.
- Switches the filter solenoids and pump relays on and off.
- Records pressure transducers measurements. A standard configuration has 7 transducers. Measurement is done once a minute and averages are recorded on the flash card every 15 minutes. The averages are also recorded whenever there is a power outage or the operator starts the sample change.
- Records ambient temperature measurements. This is on the same schedule as that of the pressure transducers.
- Records the solenoid valve number that is open.

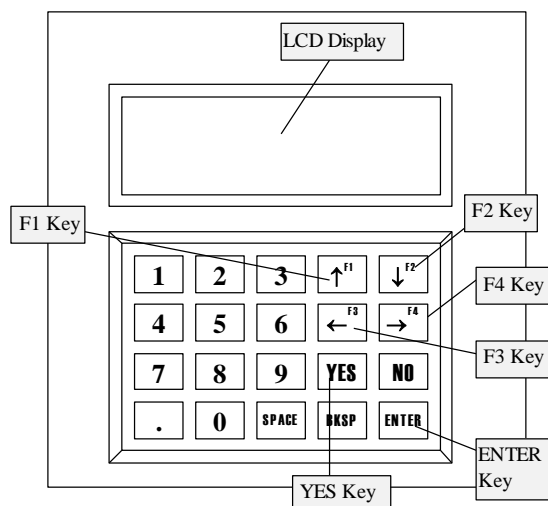
- Download all the measurements to the removable CompactFlash card.

The control program is written and compiled at UC Davis in C/C++ on a personal computer. The program is uploaded to an EPROM, which is inserted into the microcontroller. More detailed instructions will be provided to the site operator/s if a software upgrade is ever necessary.

Fifteen-minute average temperature and pressure transducer measurements are stored on a removable CompactFlash card. The CompactFlash card is replaced every three weeks. The used card is sent back to UC Davis, and the data are uploaded to a database. The CompactFlash card has the capacity to store much more than three weeks of sampling data if necessary.

The terminal is shown in greater detail in **Error! Reference source not found.** The LCD has 4 lines of 20 characters each. The six keys used to activate the menu are pointed out in the figure. The **ENTER** key is generally used to jump to the next main step. The **→F4** or **←F3** keys are used to move to the next or previous screens. In most cases, the LCD will list the available options for navigation.

Figure 3-3. Controller terminal



The controller program has two modes: AUTO MODE and MENU MODE. The program normally is in the AUTO MODE whether the sampler is running or not. In the AUTO MODE, the LCD will display the current status of the sampler modules. Section 3.1.1 details the current status screens. All sampler functions are set up using menus and submenus in the MENU MODE, as discussed in Section 3.1.2.

To move from the AUTO MODE to the MENU MODE, press the **ENTER** key. This will switch the display from a current status screen to the main menu. After using a menu, make certain that the controller has returned to the AUTO MODE. After completing the standard filter change, the program will automatically return to the AUTO MODE. For other menus, press the **ENTER** key to return to the AUTO MODE.

3.1.1 AUTO MODE: Current Status Screens

When the sampler is in AUTO MODE, the current status of the sampler is displayed. The display shows whether the sampler is collecting, idling, or waiting for samples. In the figures below, several example displays are shown.

In the first example, Figure 3-4, the first line displays the current date and time. For this example, the date is January 2nd, 2000. The time is 4 pm or 16:00. After the time, the day of the week is listed, in this case Saturday. The second line indicates that the 2nd filter in each module is sampling and that the current temperature reading is 25° C. The third line is the header for the elapsed times that are displayed in the fourth line in minutes. In this example, Filter 1 sampled for 1440 minutes (24 hours), Filter 2 for 960 minutes (16 hours) and Filter 3 and 4 have not sampled.

Figure 3-5 is the same as Figure 3-4, except that it is displaying that the sampler is currently recording sensors. At this time, the sampler is recording the flowrate, temperature, and other parameters and will not accept any keystrokes from the keypad. This screen will only appear momentarily.

Figure 3-6 shows that the sampler is idle. It is not a sampling day. The date displayed is June 4th, 2003. It is 8am. The day of the week is Tuesday.

The status screen in Figure 3-7 indicates that the sampler has collected all the samples for the week and will remain idle until the operator changes the cartridges and collects the exposed and clean filter readings. The date is November 1st, 2000 at 10am, standard time.

Figure 3-4. Current status, filter on.

01/02/00	04:00p	SAT
Fil 2	ON,	Temp= 25C
Fil1 Fil2 Fil3 Fil4		
1440 960	0	0

Figure 3-5. Current status, recording sensors.

01/02/00	04:00p	SAT
Fil 2	ON,	Temp= 25C
Fil1 Fil2 Fil3 Fil4		
Recording sensors		

Figure 3-6. Current status, idle screen.

06/04/03	08:00	TUE	
A	B	C	D
OFF	OFF	OFF	OFF

Figure 3-7. Current status, sampling complete

11/01/00	10:00	SAT
SAMPLING COMPLETED		
WILL CONTINUE AFTER		
FILTER CHANGE		

3.1.2 Menu Mode

The MENU MODE has a main menu and several sub-menus. The main menu can be accessed by pushing the **ENTER** key while the sampler is displaying the current status. When the **ENTER** button is pushed the display in Figure 3-8. Main menu screen will appear, with four available options.

Figure 3-8. Main menu screen.

F1=Filter Readings
F2=Change Date&Time
F3=Advanced Menu
ENTER=AUTO MODE

- F1** - Pressing the **↑F1** key will bring up the Filter readings menu. Press **↑F1** when you need to take the readings of the exposed and clean cassettes on a sample change day. This will be described in detail in Section 5.2.
 - F2** - Pressing the **↓F2** key will bring up the menu to change the current date and time. This option is described below.
 - F3** - Pressing the **←F3** key will bring up the advanced menu, which allows the user to change the sampler protocols. This menu should not be accessed unless authorized by UC Davis personnel. This menu is described below.
- ENTER** - Pressing the **ENTER** key will return the sampler to AUTO MODE and display the current status screen.

Change Date and Time

To change the current date and/or time, press the **↓F2** key in the main menu. Figure 3-9 shows the menu for changing the Greenwich Mean Time (GMT). By pressing the **↑F1** and **↓F2** keys the operator can adjust the value up or down. Pressing the **←F3** key changes the value's sign.

Figure 3-10. shows the menu for changing the date and time. By pressing the **←F3** and **→F4** keys, the operator can move the cursor to change the month, day, year, hour or minute. The day of the week will automatic change based on the month, day, and year.

If you enter an invalid date, the screen shown in Figure 3-11 will appear. An invalid date is one that does not exist in the month (e.g., 2/30 or 9/31).

Figure 3-9. Change date and time screen.

Enter GMT time zone
Offset, then press
enter. F3: +/-
-8:00 hours

Figure 3-10. Change date and time screen.

```
12/01/00 08:00 SAT
F1&F2 adjusts values
F3&F4 to move cursor
Press ENTER to write
```

Figure 3-11. Invalid date error screen.

```
INVALID DATE
PUSH ENTER TO CHANGE
```

3.2 PM_{2.5} Sampling Modules

The inside of a Version II IMPROVE aerosol sampler PM_{2.5} module is shown in Figure 3-12. The flow diagram for the IMPROVE PM_{2.5} module is shown in **Error! Reference source not found.** Approximate pressure readings in units of inches of mercury are listed in the figure.

Figure 3-12. PM_{2.5} module from the Version II IMPROVE aerosol sampler.

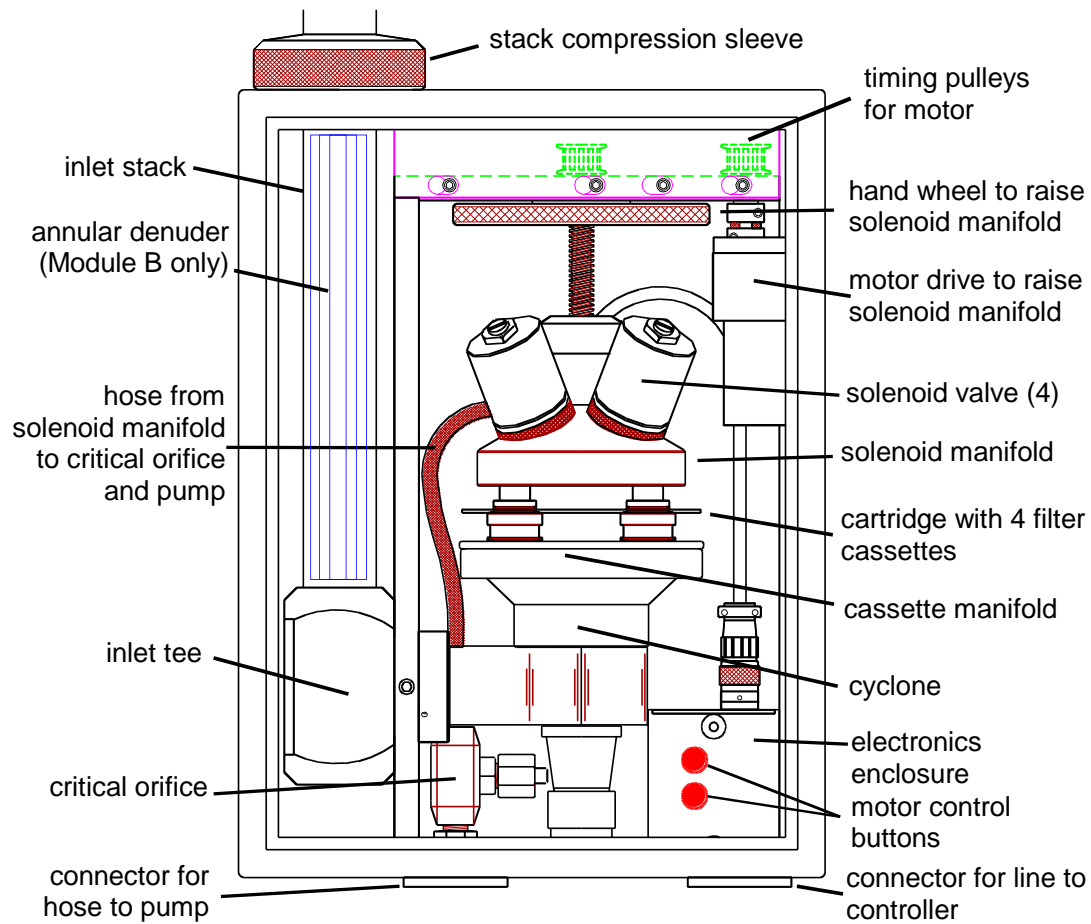
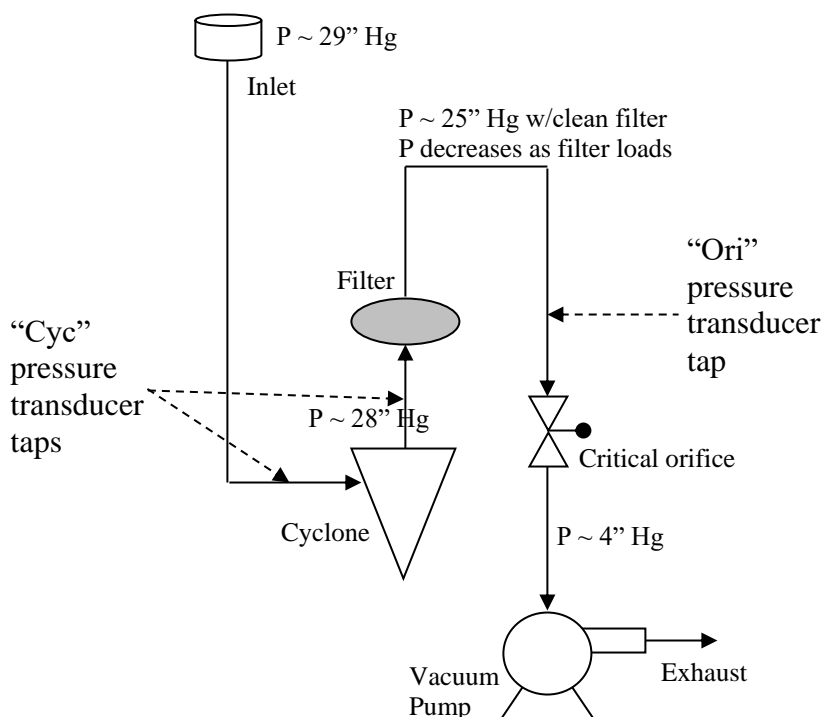


Figure 3-13. Flow Diagram For The IMPROVE PM_{2.5} Module.



3.2.1 PM_{2.5} Module Inlet and Cyclone

The ambient air enters through a screened inlet on top of the stack. The screen removes bugs, rain, and particles larger than approximately $15 \mu\text{m}$. The air stream then passes through a cyclone that removes particles larger than $2.5 \mu\text{m}$. The cyclone is located inside the module, as shown in Figure 3-12. The cyclone is 50% efficient at removing particles with aerodynamic diameters larger than $2.5 \mu\text{m}$ at the nominal flow rate of 22.8 L/min . A 5% decrease in flow rate, from 22.8 to 21.7 L/min , increases the cut point to $2.9 \mu\text{m}$.

Module 2B (nylon) has a carbonate-coated annular denuder to remove nitric acid (HNO_3) and sulfur dioxide (SO_2). The denuder consists of four concentric 61-cm aluminum tubes. The calculated efficiency for removing HNO_3 is greater than 99.7%. The denuder is located inside the inlet tube of module 2B.

A temperature probe is inserted in the inlet of one of the three PM_{2.5} modules (typically module 3C but it doesn't matter). The temperature probe is situated in the air stream just prior to the cyclone. The temperature is measured every minute and the average temperature is recorded on the CompactFlash card every 15 minutes.

3.2.2 Critical Orifice Flow Control

A critical orifice located between the filter and the vacuum pump shields the flow system from pump fluctuations and resultant flow rate fluctuations. Critical flow will be maintained as long as the pressure behind the orifice is 53% or less of the pressure upstream of the orifice (behind the filter). A properly operating pump will maintain critical

flow under most conditions. Critical flow will be lost when a pump begins to fail or, more commonly, when the filter loading is heavy (i.e., the air is very polluted). Heavy filter loadings cause large pressure drops across the filter which result in the pressure in front of the critical orifice being too low to maintain critical flow.

A needle valve serves as the critical orifice in the Version II IMPROVE PM_{2.5} aerosol samplers. The valve is adjusted by an authorized technician during each annual maintenance visit to achieve the desired nominal flowrate. A machined 0.062” ruby orifice serves as the critical orifice in the version II IMPROVE PM₁₀ aerosol samplers, with the needle valve serving to fine tune the flow rate.

A constant volumetric flow rate of 22.8 L/min must be maintained to keep a 2.5 µm cut point. Two factors can cause the flow rate to vary from the nominal: a change in pressure drop across the filter or a change in ambient temperature. Each of these factors varies throughout the course of every sampling period, the pressure drop due to gradual loading of the filter with particles and the temperature due to natural variability. Although flow rates vary by less than 1 L/min during a typical 24-hour period due to temperature fluctuations, they sometimes vary more, especially when a filter begins to clog. The critical orifice does not protect against these flow variations; its only purpose is to dampen pump fluctuations.

3.2.3 PM_{2.5} Module Flow Rate Measurement

The sample flow rate is monitored using pressure transducers. The controller will read and record the transducer measurements every minute and record the averages every 15 minutes. The transducer measurements are calibrated for flow rate using an orifice flow check device that has been calibrated to a primary flow standard at UC Davis. Duplicate flow measurements are made in the PM_{2.5} modules.

The first flow rate measurement is the primary measurement used for the air quality data and is referred to as the “CYC” measurement. The “CYC” flow rate is related to the pressure drop of air as it passes through the cyclone. The two pressure transducers used to measure the pressure drop are placed in the inlet tee and immediately after the cyclone. The cyclone approximates a venturi-type meter. The flow rate equation is expressed in terms of parameters determined during the flow rate calibration at the site. The equation also includes a pressure function based on the elevation of the site, F(elev), and a temperature function based on the average ambient temperature during sample collection. The elevation factor is 1.00 for sites near sea level and increases to 1.20 at 10,000 feet, as listed in Appendix I: Elevation factors. The temperature function is equal to 1.00 at 20°C and varies from 0.95 at -9°C (17°F) to 1.05 at 50°C (122°F). The equation for flow rate based on the first set of transducers is

$$Q_m = 10^a M^b * F(\text{elev}) \sqrt{\frac{T + 273}{293}},$$

where

Q_m = actual volumetric flow rate (L/min) from the “CYC” reading,

M = “CYC” reading on the controller screen,

F(elev) = the pressure function based on the elevation of the site (see Appendix III),

T = average ambient temperature during sampling (°C), and

a and b = empirical calibration constants normalized to 20°C and sea level pressure.

The second flow rate is referred to as the “ORI” measurement. The “ORI” flow rate is related to the air pressure immediately before the critical orifice. The equation for flow rate based on the second transducer is

$$Q_v = (c - d * V) * F(\text{elev}) \sqrt{\frac{T + 273}{293}},$$

where

Q_v = actual volumetric flow rate (L/min) from the “ORI” reading,

V = “ORI” reading on the controller screen,

F(elev) = the pressure function based on the elevation of the site,

T = average ambient temperature during sampling (°C), and

c and d = empirical calibration constants normalized to 20°C and sea level pressure.

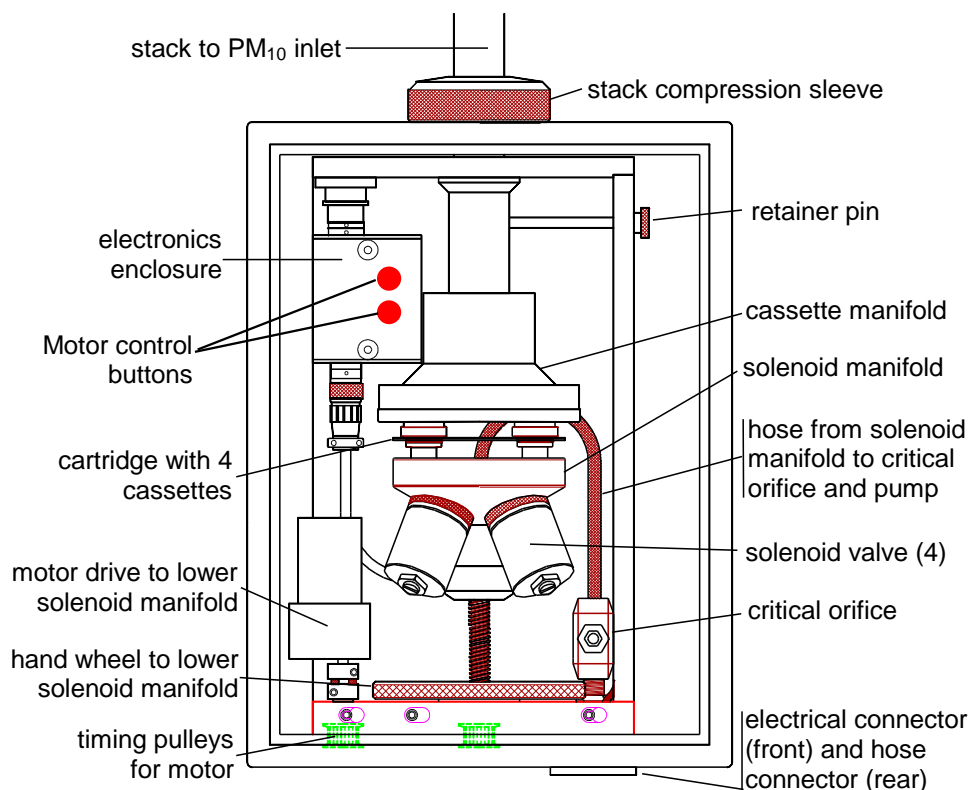
3.2.4 PM_{2.5} Module Filter Cassettes and Cartridges

The filter cassettes and cartridges are manufactured specifically for the IMPROVE sampler. They are made of acetal homopolymer with stainless steel screens. The two halves of the cassette snap together and are sealed with an o-ring. A special tool is required to separate and assemble the two halves. This process is only done at the UC Davis central laboratory when the filters are unloaded and reloaded. The individual cassettes are always installed in cartridges, with four cassettes per cartridge. Most cassettes are secured in the cartridges by a snap ring and cannot be removed easily. Some cassettes are to be moved from one cartridge and to a second cartridge in the field; these cassettes are held in by an o-ring and can be removed and inserted relatively easily. Each cartridge has a center hole and a small alignment hole. When the cartridge is placed on the cyclone manifold, alignment pins on the manifold prevent the cartridge from being rotated a quarter or half turn. Each cassette is labeled with the site, module, and the sample collection date. When the cartridges are loaded into the PM_{2.5} modules, the labels on the cartridges will always be oriented downward.

3.3 PM₁₀ Sampling Module

A Version II PM₁₀ module is shown in Figure 3-14. Note that the PM₁₀ module manifold is oriented in the opposite direction as the PM_{2.5} module manifold.

Figure 3-14. PM₁₀ module from the Version II IMPROVE sampler.



3.3.1 PM₁₀ Module Inlet and Cyclone

The ambient air enters through an inlet on top of the stack. Two different inlets are used in the IMPROVE network. The first inlet was manufactured by Wedding TP10 and uses cyclonic flow to eliminate particles larger than 10 μm from the sample stream. The Wedding inlet requires a flow rate of 19 LPM. The second inlet is manufactured by Sierra-Anderson and uses impaction to eliminate particles larger than 10 μm from the sample stream. The Sierra-Anderson inlet requires a flow rate of 16.9 LPM. Both inlets are 50% efficient at removing particles with aerodynamic diameters larger than 10 μm at the respective nominal flow rates.

3.3.2 PM₁₀ Module Flow Rate Measurement

The sample flow rate is monitored using pressure transducers. The controller will read and record the transducer measurements every minute and record the averages every 15 minutes. The transducer measurements are calibrated for flow rate using an orifice flow check device that has been calibrated to a primary flow standard at UC Davis. One flow measurement is made in the PM₁₀ module.

The flow rate is referred to as the “ORI” measurement. The “ORI” flow rate is related to the pressure drop of air as it passes through the filter. The flow rate equation is expressed in terms of parameters determined during the flow rate calibration at the site. The equation

also includes a pressure function based on the elevation of the site, F(elev), and a temperature function based on the average ambient temperature during sample collection, as described in Section 3.2.3. The equation for flow rate based on the second set of transducers is

$$Q_v = (c - d * V) * F(\text{elev}) \sqrt{\frac{T + 273}{293}},$$

where

Q_v = actual volumetric flow rate (L/min) from the “ORI” reading,

V = “ORI” reading on the controller screen,

$F(\text{elev})$ = the pressure function based on the elevation of the site (see Appendix III),

T = average ambient temperature during sampling (°C), and

c and d = empirical calibration constants normalized to 20°C and sea level pressure.

3.3.3 PM₁₀ Module Filter Cassettes and Cartridges

The same cassettes and cartridges are used in the PM₁₀ module as the PM_{2.5} modules, which were described in Section 3.2.4. The only difference is that they are inserted upside down compared to those for the PM_{2.5}. For the PM₁₀ module (4D), the labels and blue dot on the cartridge will be facing down when they are installed in the sampler.

4. SAMPLER INSTALLATION

Prior to the installation of an IMPROVE sampler, the local support agency must establish power and erect a shelter at the site to prepare for installation of the sampler. UC Davis will provide the power requirements and shelter dimensions. UC Davis will ship the sampler to the site. A field technician from UC Davis will install the sampler. The installation consists of

- Placing the controller and filter modules on a wall of the shelter and cutting holes in the ceiling for the inlets,
- Installing the module inlets,
- Connecting the cables between the controller, filter modules, and pumps,
- Connecting the vacuum hoses between the modules and the pumps,
- Selecting the sampling parameters,
- Calibrating the flow rates of the sample modules,
- Attaching the sample changing instructions to the inside of the controller door,
- Training the site operators, and
- Installing the initial set of sample cartridges with the site operators.

5. TUESDAY SAMPLE CHANGES

The sample cartridges should be changed every Tuesday. Alternative days for sample changes are shown on the IMPROVE calendar and vary each week. It takes approximately fifteen minutes to change the sample cartridges every Tuesday. Care must be taken during the change to protect the samples from contamination by rain or snow.

5.1 Preparation

The Blue Box should be received 5 calendar days before the first sample-change day. If the appropriate box is not present the Thursday before the sample-change date, the operator should contact the UCD laboratory (530-752-1123).

Before going to the site, the operator must check the dates on the Blue Box(es). The operator needs the Blue Box(es) with the bags for both the current install date and the previous install date. For example, if the first date on the new Blue Box is today's date, the operator should bring both this Blue Box and the previous Blue Box. The used samples are returned to the previous Blue Box, and the new samples are installed from the new Blue Box.

Figure 5-1. Field logsheet for sample cartridges with three cassettes (i.e., three sampling days).

Code: 2572		INSTALL ON --> UPRU: 11/21/2017		FCH 2572.04.01				
IMPROVE Network Field Log								
INITIAL READINGS			FINAL READINGS					
Operator Initials: <i>PC</i>		Sampler's Date: <i>11/21/17</i>		Initials: <i>PC</i> Sampler's Date: <i>11/28/17</i>				
Sampler's Time: <i>1:42 PM</i>				Sampler's Temp: <i>13 C</i>				
Sampler's Time: <i>8:54 PM</i>								
SamDate	Day	MxOri	Cass	Ori	Cyc	Ori	Cyc	ET
11/24/2017	Fri	Mod 1A <i>37</i>	1	<i>11</i>	<i>21</i>	<i>12</i>	<i>21</i>	<i>1425</i>
11/27/2017	Mon		2	<i>11</i>	<i>21</i>	<i>13</i>	<i>20</i>	<i>1440</i>
11/21/2017	Tue		3	<i>(12)</i>	<i>(20)</i>	<i>12</i>	<i>21</i>	<i>1427</i>
11/24/2017	Fri	Mod 2B <i>40</i>	1	<i>14</i>	<i>20</i>	<i>14</i>	<i>20</i>	<i>1425</i>
11/27/2017	Mon		2	<i>13</i>	<i>20</i>	<i>15</i>	<i>19</i>	<i>1440</i>
11/21/2017	Tue		3	<i>(14)</i>	<i>(20)</i>	<i>14</i>	<i>20</i>	<i>1427</i>
11/24/2017	Fri	Mod 3C <i>40</i>	1	<i>14</i>	<i>20</i>	<i>15</i>	<i>20</i>	<i>1425</i>
11/27/2017	Mon		2	<i>14</i>	<i>20</i>	<i>15</i>	<i>20</i>	<i>1440</i>
11/21/2017	Tue		3	<i>(14)</i>	<i>(20)</i>	<i>14</i>	<i>20</i>	<i>1427</i>
11/24/2017	Fri	Mod 4D <i>40</i>	1	<i>19</i>	<i>04</i>	<i>19</i>	<i>04</i>	<i>1425</i>
11/27/2017	Mon		2	<i>19</i>	<i>04</i>	<i>19</i>	<i>04</i>	<i>1440</i>
11/21/2017	Tue		3	<i>(19)</i>	<i>(04)</i>	<i>19</i>	<i>04</i>	<i>1427</i>
Remove Flash Card After Final and Return Box ASAP								
Always Orient each Cartridge Plate as per Instructions on each Door								
Lab Use Only		Comments		For Help Call (530) 752-1123				
1A	4D	<i>Forest Fires Very Hazy (11-28)</i>						
47 231	47 513							
49 662	47 411							

Two of the three logsheets in every Blue Box will have three sampling days listed, while one of the three logsheets will only have two sampling days listed.

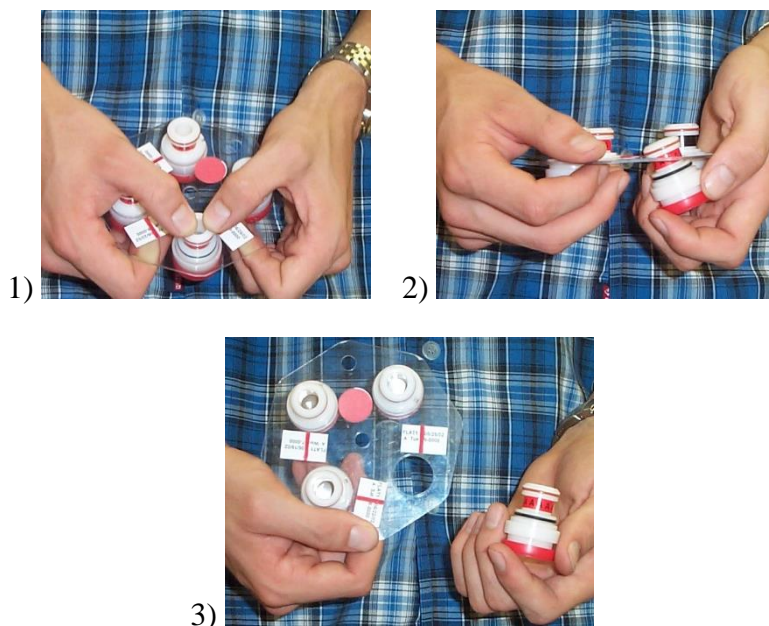
5.2 Sample Change Procedures

The basic steps in the sample change procedures are: 1) collect the final (exposed) flow rate readings for each used cassette; 2) remove the exposed cartridges; 3) install the clean cartridges; 4) collect the initial flow rate readings for each new cassette. This procedure must be repeated for all four sampling modules: 1A, 2B, 3C, and 4D.

For two of every three Tuesday sample changes, the modules will not be actively collecting samples. For one of every three Tuesday sample changes, the modules will be actively collecting samples, and the sampling will have to be interrupted to change the filter cartridges. The procedures required to change the cartridges on sampling days are slightly more complicated than on the non-sampling days.

On the active sampling days, the operator will have to transfer the cassettes in position 3, which are in the midst of sampling, from the old to the new cartridges. This transfer must be done for each of the four modules because all four modules are sampling simultaneously. The position 3 cassettes have a black O-ring around them and are the only ones that can be removed without a special tool. Figure 5-2 shows the removal of the position 3 cassette from a cartridge. This cassette must be loaded into the open hole in position 3 of the new cartridge. After the cassette is transferred to the new cartridge, the new cartridge is installed in the sampler. After the initial readings are taken, the sampler will resume collection on the filters in position 3. If the roof does not provide adequate protection from the elements, you should remove all four of the exposed cartridges, move to a protected location, switch the position 3 cassettes from the old cartridges to the new, and then return to the sampler to install the new cartridges.

Figure 5-2. Photos illustrating the removal of position 3 cassette (note black o-ring on removable cassette) from the cartridge.



The sample change procedures are detailed below. The procedures listed under the letter “a” are for non-active sampling days, and the procedures listed under the letter “b” are for active sampling days. There will be a series of informational screens with the upper lines showing “One moment please” throughout this procedure when the pumps are being turned on or when the readings are being recorded on the flash card. The display will automatically switch to the next screen after several seconds.

1. Open the controller module door.
2. Fill in your initials, the date, and the time on the logsheet (Figure 5-1).
3. Make sure that the date and time on the controller module are correct. If they are off by more than 5 minutes, note the problem on the logsheet and refer to Section 3.1.2 to enter the correct date and time. If this is a sampling day, wait until the following week to correct the time.
4. Also, note any unusual activities that occurred during sampling days on the logsheet (e.g., fires, road paving, power outage, etc.)
5. Initiate the sample change sequence by pressing the ENTER key followed by the ↑F1 key to collect the final filter readings. Press the YES key to continue with the filter readings **(Error! Reference source not found.)**.
6. Press the number corresponding to your initials. Enter your initials using keys ↑F1/↓F2 to toggle value and ←F3/ →F4 or press ENTER to exit. (
7. Figure 5-4).
8. Record the temperature measurement, “Temp=” (25C in Figure 5-5), in the blank labeled “CurTemp” on the top right of the logsheet.
9. Hit Enter.

Figure 5-3. Continue screen.

Filter Reading PRESS YES to Continue NO to Cancel
--

Figure 5-4. Select initials screen.

Select # edit/add Primary: 1-JPM Backups: 2-BNP 3-TRM Press ENTER to exit
--

Figure 5-5. Current temperature screen.

```

USED WEEK:02/04/2003
Logsheet Temp=25C
02/11/03 10:17am TUE
Hit ENTER when ready

```

10. Record the Final Readings (Ori, Cyc, and ET) for each used cassette. Figure 5-6 shows the pressure readings (**Ori & Cyc**) and elapsed time (**ET**) for the first cassette (**FIL 1**) in Module A.
11. Press the →**F4** key to go to the next filter (and the ←**F3** key to move to the previous cassette). A standard sampler will have 8 or 12 filters (2 or 3 per module).
12. When all the Final Readings are collected, check that all blank fields on the log sheet are filled in.
13. Note any problems or mistakes made during the sample change procedures (e.g., dropped cartridge or cassette, touched filter with finger, etc.).
14. Also note any unusual events that occurred near the site (e.g., fires, construction, painting, power outages, lightening strikes, fireworks, high traffic, etc.).
15. If all the readings are acceptable, press the →**F4** key (Figure 5-7). To redo the readings, press the ←**F3** key.
16. Put the completed logsheet in its original re-sealable bag (i.e., the re-sealable bag and the top of the logsheet should be labeled with the same date).
17. Get out the new bag of filters labeled with the “**USE WEEK**” date displayed on the controller. Figure 5-8 shows that the bag label for the week is 2/11/03.
18. Hit **ENTER** when you have the appropriate bag of filters.

Figure 5-6. Flow rate readings screen.

```

Mod1 (A)
Cass   Ori  Cyc  ET
(FIL1) 13   25 1440
      F3-Bkwd F4-Fwd

```

Figure 5-7. Continue screen.

```

F3-GO BACK to take
      EXPOSED readings
F4-Continue with
      CLEAN readings

```

Figure 5-8. Exchange cartridges screen.

```

USE WEEK:02/11/2003
Logsheet Entry T=95V
02/11/03 10:17am TUE
Hit ENTER when ready

```

19. Start with module 1A, which is color-coded red.

If this is not a sampling Tuesday, the sampler should not be running when you arrive at the site.

- a1. Figure 5-9 shows the screen that will be displayed on a non-sampling Tuesday.
- b1. Remove the cartridge of used cassettes from the module by raising the sampling manifold using the red motor control button and pulling out the cartridge.
- c1. Put the red caps on the cassettes and return the used cartridge to its original re-sealable bag.
- d1. Remove the red caps from the new cassettes, and install the new cartridge in the module — align the new cartridge in the lower manifold with the pins through the holes in the cartridge.
- e1. Lower the manifold using the red motor control button (stop pressing the red button when the motor starts to strain).
- f1. For the PM_{2.5} modules (1A,2B, and 3C), the labels and the red, yellow, or green dot will be facing up (Figure 5-10). For the PM₁₀ module (4D), the labels and the blue dot will be facing down (Figure 5-11).

Figure 5-9. Non-sampling Tuesday sample change.

STANDARD change Remove EXPOSED
↑↓
cartridges & insert the CLEAN cartridges
Press ENTER if done

Figure 5-10. PM_{2.5} cassette orientation.

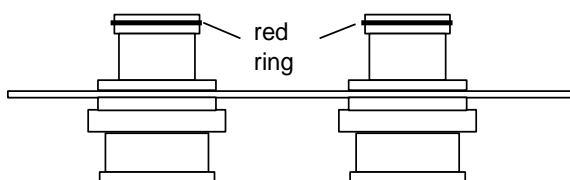
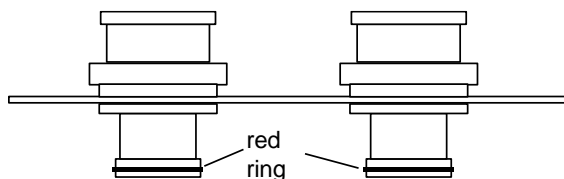


Figure 5-11. PM₁₀ cassette orientation.



----- OR -----

If this is a sampling Tuesday, the sampler should be running when you arrive at the site.

- a2. Figure 5-12 shows the screen that will be displayed on a sampling Tuesday.
- b2. The old cartridge will have a black O-ring around the cassette in position 3, and the new cartridge have an empty space in position 3.
- c2. Remove the used cartridge from the sampler by raising the sampling manifold using the red motor control button and pulling out the cartridge.
- d2. Move the position 3 cassette of the used cartridge to the empty position in the new cartridge. (Do not move the cassette label from the old cartridge to the new cartridge.)
- e2. Install the new cartridge in the module — align the new cartridge in the lower manifold with the pins through the holes in the cartridge, and lower the manifold using the red motor control button.
- f2. Put the red caps on the used cassettes, and return the cartridge to its original re-sealable bag.
- g2. For the PM_{2.5} modules (1A,2B, and 3C), the stickers and the red, yellow, or green dot will be oriented upwards. For the PM₁₀ module (4D), the labels and the blue dot will be facing down.

Figure 5-12. Active sampling Tuesday sample change.

NON-STANDARD change Remove EXPOSED cartridges and move CASSETTE with BLACK
↑↓
O-RING to the CLEAN cartridges & insert the CLEAN cartridges Press ENTER if done

- 20. Repeat Step 18 for modules 2B (yellow), 3C (green), and 4D (blue), making sure to install the appropriately colored cartridge in each module.
- 21. Press the **ENTER** key when all the new cartridges are installed.
- 22. If today's bag is the first in a new Blue Box, the controller will prompt the operator to change the flash card (Figure 5-13). Otherwise, skip to step 22.
 - a. Remove the flash card from the controller by grasping it and pulling it out of the controller.
 - b. Place the flashcard in the small ziploc bag in the old Blue Box.

- c. Remove the flash card from the new box and place it in the controller. (If there is no flash card in the new box, leave the old one in the controller and write a note on the old logsheet.)
- d. Press the **ENTER** key.

Note: If the warning shown Figure 5-14 appears when a flash card is installed in the controller, try removing the CompactFlash card, and reinstalling it. If the warning is still displayed, install the old card and note the problem on the logsheet or call UC Davis (530) 752-1123.

Figure 5-13. Replace flash card screen.

Replace controller's
memory card with the
one in the blue box.
Hit **ENTER** when done.

Figure 5-14. No memory card warning.

Warning: No mem card
Insert card then hit
YES to continue.
Press **NO** if no card.

23. The screen shown in Figure 5-15 shows the Initial Readings for the new filter in the first cassette position in Module 1A.
24. Record the Initial Readings (MxOri, Ori, and Cyc) for each new cassette on the new logsheet. Note that only one MxOri reading is necessary for each module, and only one space is provided on the logsheet for each module. **Two errors may be encountered during the initial readings.**

Error 1: If the flow rate through the cyclone is significantly less than the nominal flow rate, the message shown in Figure 5-16 will appear. There are two common reasons for this error. First, the cassette manifold was not lowered into place. Lower the manifold using the motor control button down until the motor sounds strained. Then press the **←F3** key. Second, a cassette may be missing from the cartridge. Every third week, when the change day coincides with the sampling day, the current filter must be moved from the old cartridge to the new cartridge. This message will appear if the cassette was not transferred. In either case, correct the problem and press the **←F3** key. If you have corrected the problem, the screen shown in Figure 5-15 will appear. If this does not work, and the installation appears to be correct, it is possible to override this check and proceed with the sample change by pressing the **→F4** key. If a warning cannot be resolved, please call UC Davis at (530) 752-1123 for assistance. Once pressing the **→F4** key the program will proceed to Figure 5-15. Note that the low flow message may appear for all in the cartridge.

Figure 5-15. Clean filter readings screen.

Mod1 (A)			
Cass	MxOri	Ori	Cyc
(FIL 1)	40	12	32
F3-Bkwd		F4-Fwd	

Figure 5-16. Low flow through cyclone warning.

<p>WARNING: LOW FLOW or UPSIDEDOWN cartridge check Module1 (A) for proper installation</p>
--

<p>Press: F3-To re-check installed filters F4-Ignore warning</p>

Error 2: If the cartridge is installed upside down, the message in ‘

Figure 5-17 will appear. Re-install the cartridge in the correct direction, as shown on the diagram on the module door, and press the ←F3 key. If this corrects the problem, the screen shown in Figure 5-15 will appear. If this does not correct the problem and the installation appears to be correct, it is possible to override this check and proceed with the sample change by pressing the →F4 key. The program will proceed to Figure 5-15. Note that this warning will probably be displayed for all the filters in the cartridge.

25. Use the →F4 key to move to the next cassette.

26. When the Initial Readings are all collected, check that all blanks on the left side of the logsheet are filled in. If complete, press the →F4 key (to redo the readings, press the ←F3 key).

27. The information for the clean filters will now be recorded on the flash card, and a series of temporary informational screens (“One moment please.”) will indicate the status. Then, the sampler will return to the AUTO MODE, and a current status screen will be displayed.

- a. If this is not an active sampling day, the sampler remains off. The sensors will be read and the current status screen of Figure 5-19 will automatically appear ‘

Figure 5-17. Cartridge upside down warning.

<p>WARNING: Cartridge may be UPSIDE DOWN check Module1 (A) for proper installation</p>

Press:
F3-To re-check
installed filters
F4-Ignore warning

Figure 5-18. Final filter readings screen.

F3 – GO BACK to take
CLEAN readings
F4 – FINISH

Figure 5-19. Current status, idle screen.

06/04/03 08:00 * TUE
A B C D
OFF OFF OFF OFF

----- OR -----

- b. If this is a sampling Tuesday, the sampler will resume sampling on Filter 3. A series of informational screens will appear indicating that the pumps are being started and the sensors are being recorded. Then, a current status screen similar to Figure 5-20 will appear.

Figure 5-20. Current status, filter on.

01/02/00 04:00p * SAT
Fil 3 ON, Temp= 25C
Fil1 Fil2 Fil3 Fil4
0 0 720 0

28. Make certain that a current status is showing on the screen before you leave.
29. Close the doors of the modules.
30. If you have any problems during a sample change, contact UC Davis at (530) 752-1123.
31. If this is the last (third) bag of samples in the Blue Box, return the box to Davis as soon as possible. Simply adhere the mailing UPS/U.S.P.S. label, stapled to the Week 3 Logsheet, to the Blue Box, and send the box through the UPS/USPS.

6. TROUBLESHOOTING GUIDE

When a problem is identified with the sampler, first note the issue on the logsheet. Contact the UC Davis sample handing laboratory to diagnose the problem at (530) 752-1123 (FAX (530) 752-4217, e-mail improvehelpdesk@ucdavis.edu). If at all possible, call from the site to facilitate troubleshooting and prevent the loss of samples.

6.1 Common Sampler Problems

1. *Missed Tuesday sample change.*

- a. If there are remaining sampling days in the week, remove the exposed filters as would normally be done and put in the clean filters that were to have been installed on the last change day. Make a note on the logsheet.
- b. If the week is completely missed, remove the exposed filters as normal but do not put in the filters for the missed week (keep the missed samples in the shipping box). Install the cartridges labeled for the current week. On the logsheet for the unused cartridges, note that they were not used and the reason for not using them.

2. *The display is blank.*

- a. Power may be off.
 - i. Check the main circuit breaker; turn it off and on if you are unsure if it has tripped.
 - ii. Reboot the power to the controller by disconnecting its power cord for a few seconds and reconnecting it.
 - iii. Check the Tripplite (or equivalent) surge suppressor that the sampler is plugged into (this may be located inside the pump enclosure). There should be a two green lights on the surge suppressor.
 - iv. Check the power cord for the sampler. This black or grey cord runs from the base of the control module to the power surge suppressor. If it is unplugged, reconnect it.
 - v. If you are still not sure if power is on:
 - (a) Unplug one of the pumps from its outlet box.
 - (b) Disconnect the silver connector of the black vacuum hose from the top of the pump.
 - (c) Plug the pump power cord directly into the power surge suppressor. The pump will start if there is power.
 - (d) Reconnect the vacuum hose and plug the pump back into the duplex outlet box.
- b. Sometimes the LCD screen freezes in cold weather. If this is a possibility at the site, remove the keypad by disconnecting the phone jack on the back of it. Allow it to warm up, either by putting it in a warm place or your jacket if possible.

3. *The elapsed time is zero for one or multiple days.*

Check the following to determine why sampling did not occur on the scheduled day.

Describe the problem on the logsheet. If you cannot determine the cause of the problem call UC Davis at (530)752-1123 as soon as possible.

- i. Check that the date and time on the controller screen are correct. Adjust if necessary as described in 3.1.2 Menu Mode.
- ii. If possible, check whether there was a power outage for the entire day.

- iii. Look at the Module 1A filter that has an elapsed time of zero. Does the filter look white like a new filter or does it look like there is a sample on the filter?

4. *Pump will not start.*

- i. Check that the pumps are all plugged in (the outlet box that the pump is plugged into may have a switch on it but this does not control the pump power).
- ii. Test the pump that is not starting by doing the following:
 - (a) Unplug the pumps that are in question from their outlet box (relay box).
 - (b) Plug the pump cord directly into a working A/C outlet. If the pump starts, the problem is with the outlet box.
 - (c) If the pump does not start, the problem is with the pump.
 - (d) Plug the pump back into the duplex outlet box.
 - (e) Call UC-Davis and describe the results of the test.
- iii. Extreme cold may prevent pumps from starting. Remove the pump to a warm location (or come back when the weather is warmer) and test. If cold weather is found to be the problem, try one of the following solutions:
 - (a) Run pumps continuously by plugging them into unswitched outlets (power strip or wall outlet).
 - (b) Keep pumps warm by placing an automotive electric blanket or other heat source under the pumps.

5. *Pump starts slowly.*

Note the slow starting pump on the logsheet and contact UC-Davis. If the weather is extremely cold see Section 4.iii above. If the pump is slow to start in normal temperatures, it needs repairs. Contact UC-Davis and a new pump will be shipped to the site to replace the malfunctioning pump.

6. *The motor drive for the cartridge manifold is not working.*

The motor can be disengaged, and the hand wheel can be used to manually raise and lower the cartridge manifold. The motor drive for the PM_{2.5} module is shown in Figure 3-12 and for the PM₁₀ module is shown in Figure 3-14. For the PM_{2.5} module, push down on the top of the drive while pulling the bottom outwards. Then swing the motor to the left to lock it in the disengaged position. The hand wheel may now be used to raise or lower the solenoid manifold. The procedure is the same for the PM₁₀ module (4D) except the motor is upside down compared to the PM_{2.5} modules. The PM₁₀ module (4D) motor must be pulled up and pushed to the right to disengage. Notify UC Davis of the motor problem by calling (530-752-1123) or making a note on the logsheet.

6.2 Sampler Configuration

Press the **ENTER** key on the controller keypad to access the main menu. Press the **←F3** key to access the Advanced Menu. The advanced menu should not be accessed unless authorized by UC Davis. Enter the code **1123** to access controller parameters.

```
Authorized use only
Please enter code:
****
```

Once accessed, the operator will be able perform calibrations on the sampler by pressing the **↑F1** key. Pressing the **↓F2** key will allow the operator to check and change, if necessary, the sampler configuration including the Serial Number, time average, sample change day, and module type.

```
F1=Calib
F2=Site Config.
F3=Operator Initials
ENTER = Main Menu
```

Old UCCODE #: Check that the proper 4-digit site code is displayed on this screen. Enter the 4-digit site code assigned by UCD.

```
Old UCCODE: 1138
F1&F2 = Toggle Value
F3&F4 = Move Cursor
Press ENTER to save
```

Module types: This screen is used to specify the number and type of modules operating at the site. If the current information is correct, press **ENTER** to save. Otherwise, enter the correct information and press **ENTER** to save.

```
PORT/MOD Select
PORT: 1 2 3 4 5
MOD: A B C D X
Press ENTER to save
```

X Module Type: This screen is used to select what particle size the X module (if present) will select for.

```
X Module Type
CURRENT X MOD=PM 2.5
F1=PM 2.5 F2=PM 10
PRESS F1orF2 SELECT
```

Time average: Enter the time interval, which the data will be reported to the serial flash card. Typically the value will be 15 minutes.

```
CFLSH AVG (min): 15
F1&F2 = Toggle Value
F3&F4 = Move Cursor
Press ENTER to save
```

Change day: This is the day that the sample changes are performed. This will always be set to Tuesday unless otherwise specified by UCD.

```
Change Day:  TUE
F1&F2 = Toggle Value

Press ENTER to save
```

Blue Box sequence: This screen allows the user to specify the cartridge sequence of the Blue Boxes. There are two choices: F1) the Blue Boxes, when received from UC Davis, have three cassettes in the first week and two cassettes in the second and third weeks (Sequence 322), or F2) the Blue Boxes have two cassettes in the first week, three cassettes in the second week, and two cassettes in the third week (Sequence 232).

```
BLUE BOX Sequence
CURRENTORDER3-2-2
F1=3-2-2 F2=2-3-2
PRESS F1or F2 SELECT
```

Controller ID: This screen allows the user to specify the inventory number assigned to current controller. The ID is found on the interior left wall of the controller, or on the inner door.

```
CONTRLR ID# C1243
F1&F2=Toggle Value
F3&F4 = Move Cursor
Press ENTER to save
```

Firmware: The final screen summarizes the configuration and displays the firmware version number.

```
Info:CNTRLR ID C1243
INV#:1138
CFLSH AVG: 15 min
FWARE: V.07.0P.00
```

APPENDIX I: ELEVATION FACTORS

Table AI-1. Elevation factors for a range of elevations. The elevations are listed in units of both meters (m) and feet (ft) above mean sea level. The pressure in units of millimeters of mercury is also listed for each elevation.

Elevation (m)	Elevation (ft)	F(elev)	P (mmHg)	Elevation (m)	Elevation (ft)	F(elev)	P (mmHg)	Elevation (m)	Elevation (ft)	F(elev)	P (mmHg)
0	0	1.000	29.90	1200	3,936	1.075	25.88	2400	7,872	1.158	22.32
50	164	1.003	29.72	1250	4,100	1.078	25.73	2450	8,036	1.161	22.18
100	328	1.006	29.55	1300	4,264	1.081	25.57	2500	8,200	1.165	22.04
150	492	1.009	29.37	1350	4,428	1.085	25.41	2550	8,364	1.168	21.90
200	656	1.012	29.20	1400	4,592	1.088	25.26	2600	8,528	1.172	21.76
250	820	1.015	29.02	1450	4,756	1.091	25.10	2650	8,692	1.176	21.63
300	984	1.018	28.85	1500	4,920	1.095	24.95	2700	8,856	1.180	21.49
350	1,148	1.021	28.68	1550	5,084	1.098	24.80	2750	9,020	1.183	21.35
400	1,312	1.024	28.51	1600	5,248	1.101	24.65	2800	9,184	1.187	21.22
450	1,476	1.027	28.34	1650	5,412	1.105	24.49	2850	9,348	1.191	21.09
500	1,640	1.030	28.17	1700	5,576	1.108	24.34	2900	9,512	1.195	20.95
550	1,804	1.033	28.00	1750	5,740	1.112	24.19	2950	9,676	1.198	20.82
600	1,968	1.036	27.83	1800	5,904	1.115	24.05	3000	9,840	1.202	20.69
650	2,132	1.040	27.67	1850	6,068	1.119	23.90	3050	10,004	1.206	20.56
700	2,296	1.043	27.50	1900	6,232	1.122	23.75	3100	10,168	1.210	20.43
750	2,460	1.046	27.34	1950	6,396	1.126	23.60	3150	10,332	1.214	20.30
800	2,624	1.049	27.17	2000	6,560	1.129	23.46	3200	10,496	1.218	20.17
850	2,788	1.052	27.01	2050	6,724	1.133	23.31	3250	10,660	1.221	20.04
900	2,952	1.055	26.84	2100	6,888	1.136	23.17	3300	10,824	1.225	19.91
950	3,116	1.059	26.68	2150	7,052	1.140	23.02	3350	10,988	1.229	19.79
1000	3,280	1.062	26.52	2200	7,216	1.143	22.88	3400	11,152	1.233	19.66
1050	3,444	1.065	26.36	2250	7,380	1.147	22.74	3450	11,316	1.237	19.53
1100	3,608	1.068	26.20	2300	7,544	1.150	22.60	3500	11,480	1.241	19.41
1150	3,772	1.072	26.04	2350	7,708	1.154	22.46	3550	11,644	1.245	19.28
1200	3,936	1.075	25.88	2400	7,872	1.158	22.32	3600	11,808	1.249	19.16

APPENDIX II: MODULE DOOR QUICK REFERENCE SHEETS

Version II IMPROVE Sampler
 (Firmware 7.0P)
 designed and built by
 Crocker Nuclear Laboratory
 University of California, Davis

UC Davis Sample Laboratory: Telephone (530) 752-1123
 or e-mail: improvehelpdesk@ucdavis.edu

Changing IMPROVE particle cartridges

On the controller's keypad press ENTER, ↑F1, and YES keys to access Filter Readings

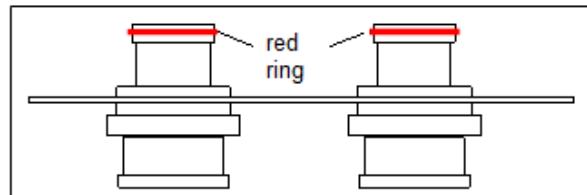
- | | |
|--|---|
| <ol style="list-style-type: none"> 1. Press the number corresponding to your initials.
 <i>** If your initials are not one of the options: Pick #1 and MAKE A NOTE ON THE LOGSHEET</i> 2. Record the temperature measurement, and the controller date and time in the blanks at the top right of the log sheet. 3. Record the ORI, CYC readings and Elapse time for each exposed filter on to the log sheet. Press →F4 to move to the next filter. 4. To retake exposed readings, press ←F3. If okay, press →F4. 5. If today is the end of Week 3, the controller will prompt operator to change the memory (flash) card <i>*Only change the Compact Flash Card when this screen appears.</i> Otherwise leave the card in until instructed to change it. 6. Change the cartridges in each module. 7. Follow the instructions displayed on the keypad. Record the displayed information into the blanks at the top left of next weeks log sheet. 8. Record MxORI, ORI and CYC readings for each clean filter on to the logsheet. Press →F4 to move to the next filter. 9. To retake the final readings, press ←F3. If okay, press →F4. | <ol style="list-style-type: none"> 1 OPERATOR initials
 Primary:1-***
 Backups:2-*** 3-*** 2 USED WEEK: MM/DD/YY
 Logsheets Temp = ## °C
 MM/DD/YY hh:mm am DAY
 Hit ENTER when ready 3 Mod 1 (A)
 Cass Ori Cyc ET
 (FIL 1) 10 12 1440
 F3-Bkwd F4-Fwd 4 F3- GO BACK to take
 EXPOSED readings
 F4- Continue with
 CLEAN readings 5 Replace controller's
 Flash card with the
 One in the blue box.
 Hit enter when done. 6 GET FILTERS
 WITH BAG DATED
 MM/DD/YYYY
 Hit ENTER when ready 7 ENTER ONTO LOGSHEET
 MM/DD/YY HH:MM
 INITIALS: ***
 Hit ENTER when ready 8 Mod 1 (A)
 Cass MxOri Ori Cyc
 (FIL 1) 40 12 14
 F3-Bkwd F4-Fwd 9 F3-GO BACK to take
 CLEAN filter
 readings
 F4-FINISH |
|--|---|



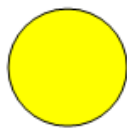
Version II IMPROVE Sampler Module A—Red Dot on Cartridge

Crocker Nuclear Laboratory
University of California, Davis

Cassette Orientation
Labels and Red O-ring UP



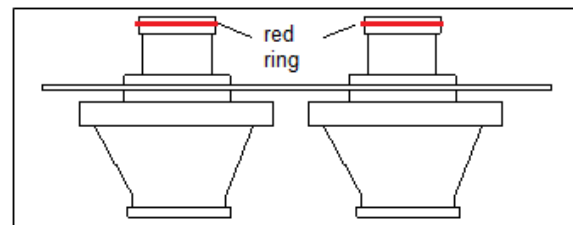
All cartridges must have four cassettes.
Never install a cartridge with a hole.
Get cassette with black O-ring from last week.



Version II IMPROVE Sampler Module B—Yellow Dot on Cartridge

Crocker Nuclear Laboratory
University of California, Davis

Cassette Orientation
Labels and Red O-ring UP



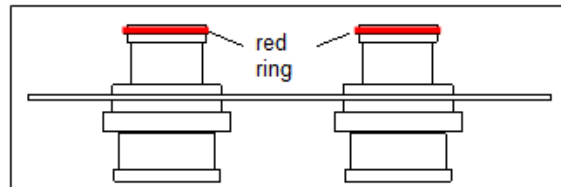
All cartridges must have four cassettes.
Never install a cartridge with a hole.
Get cassette with black O-ring from last week.



Version II IMPROVE Sampler Module C—Green Dot on Cartridge

Crocker Nuclear Laboratory
University of California, Davis

Cassette Orientation
Labels and Red O-ring UP



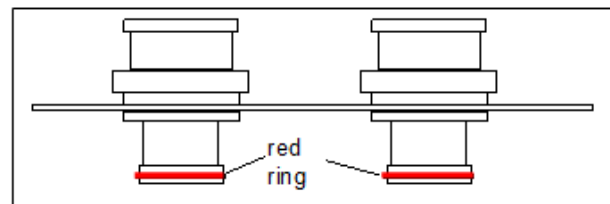
All cartridges must have four cassettes.
Never install a cartridge with a hole.
Get cassette with black O-ring from last week.



Version II IMPROVE Sampler Module D (PM₁₀ inlet)—Blue Dot on Cartridge

Crocker Nuclear Laboratory
University of California, Davis

Cassette Orientation Reversed
Labels and Red O-ring DOWN



All cartridges must have four cassettes.
Never install a cartridge with a hole.
Get cassette with black O-ring from last week.