IMPROVE
Standard Operating Procedure

SOP 201 Version 3 (SOP 201-3)
Sampler Maintenance by Site Operators

Crocker Nuclear Laboratory
One Shields Avenue
University of California
Davis, CA 95616-8569

(530) 752-1123
fieldops@crocker.ucdavis.edu

DOCUMENT HISTORY

Date Modified	Initials	Section/s Modified	Brief Description of Modifications
6/28/05	NPH	Entire document	Revised and reorganized SOP based on input from EPA and state agencies.

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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. At the end of 2003, 164 sites were operating. Figure 1-1 shows a map of the sites. These sites represent all 156 Class I areas, except Bering Sea NWR.

Every IMPROVE site employs an aerosol sampler to collect particulate matter samples below 2.5 μm ($PM_{2.5}$) and below 10 μm (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.

Figure 1-1. Aerosol sites in the IMPROVE Network in February 2005.

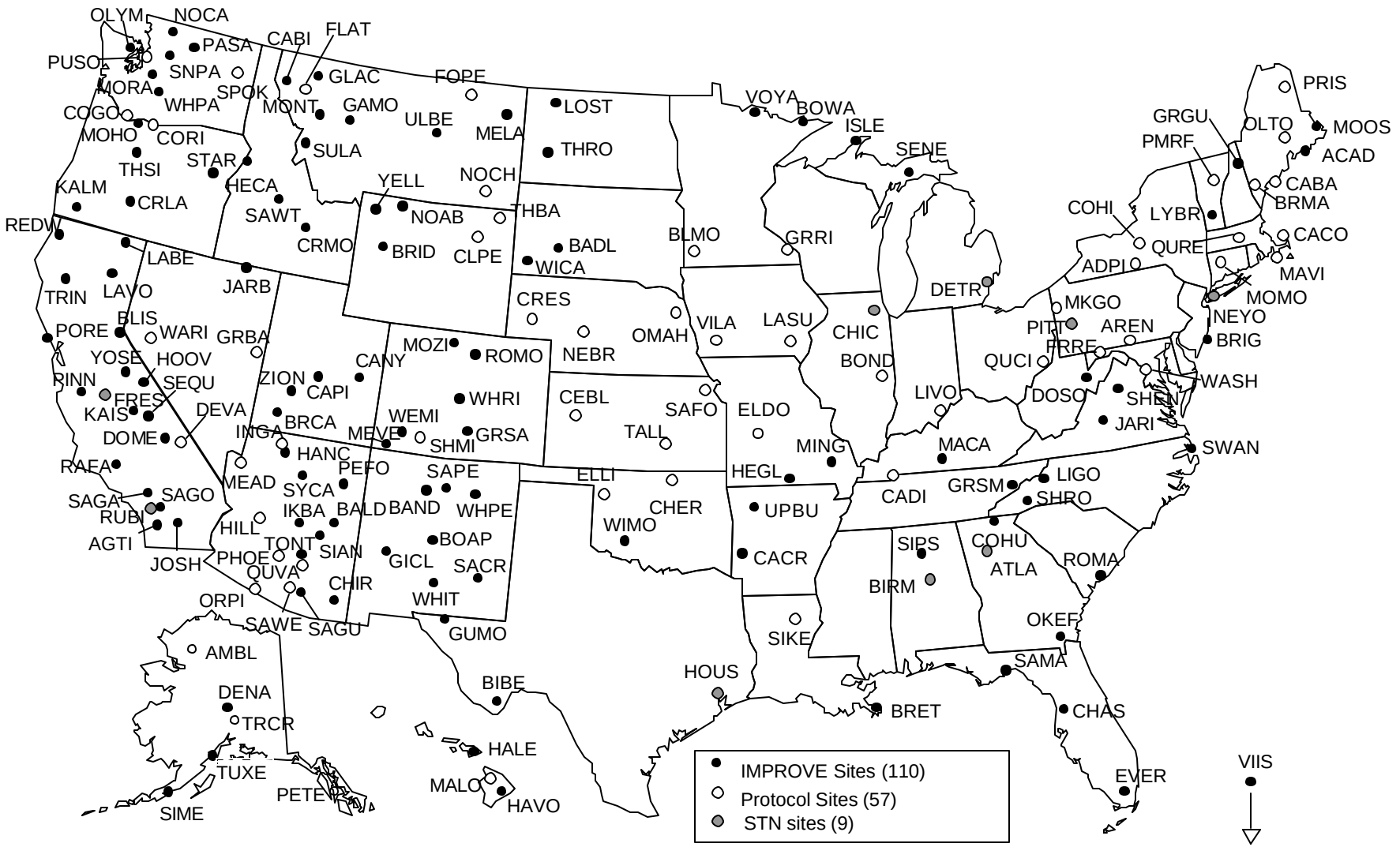


Table 1-1. List of site names, locations, and funding agencies as of February 2005.

IMPROVE SITES

National Park Service

ACAD	Acadia, ME
BADL	Badlands, SD
BAND	Bandelier, NM
BIBE	Big Bend, TX
BRCA	Bryce Canyon, UT
CANY	Canyonlands, UT
CAPI	Capitol Reef, UT
CHIR	Chiricahua, AZ
CRLA	Crater Lake, OR
CRMO	Craters of the Moon, ID
DENA	Denali, AK
EVER	Everglades, FL
GLAC	Glacier, MT
GRSA	Great Sand Dunes, CO
GRSM	Great Smoky Mtns., TN
GUMO	Guadalupe Mtns., TX
HALE	Haleakala, HI
HANC	Hance (Grand Canyon), AZ
HAVO	Hawaii Volcanoes, HI
ISLE	Isle Royale, MI
JOSH	Joshua Tree, CA
LABE	Lava Beds, CA
LAVO	Lassen Volcanic, CA
MACA	Mammoth Cave, KY
MEVE	Mesa Verde, CO
MORA	Mount Rainier, WA
NOCA	North Cascades, WA
OLYM	Olympic, WA
PEFO	Petrified Forest, AZ
PINN	Pinnacles, CA
PORE	Point Reyes, CA
REDW	Redwood, CA
ROMO	Rocky Mountain, CO
SAGU	Saguaro, AZ
SEQU	Sequoia, CA
SHEN	Shenandoah, VA
THRO	Theodore Roosevelt, ND
TONT	Tonto, AZ
VIIS	Virgin Islands, USVI
VOYA	Voyageurs, MN
WICA	Wind Cave, SD
YELL	Yellowstone, WY
YOSE	Yosemite, CA
ZION	Zion, UT

Fish and Wildlife Service

BOAP	Bosque del Apache, NM
BRET	Breton, LA
BRIG	Brigantine, NJ
CHAS	Chassahowitzka, FL
LOST	Lostwood, ND
MELA	Medicine Lake, MT
MING	Mingo, MO
MOOS	Moosehorn, ME
OKEF	Okefenokee, GA
ROMA	Cape Romain, SC
SACR	Salt Creek, NM
SAMA	Saint Marks, FL
SENE	Seney, MI
SIME	Simeonof, AK
SWAN	Swanquarter, NC
TUXE	Tuxedni, AK
ULBE	UL Bend, MT
WIMO	Wichita Mtns., OK

Forest Service

AGTI	Agua Tibia, CA
BALD	Mount Baldy, AZ
BLIS	Bliss, CA
BOWA	Boundary Waters, MN
BRID	Bridger, WY
CABI	Cabinet Mountains, MT
CACR	Caney Creek, AR
COHU	Cohutta, GA
DOME	Dome Land, CA
DOSO	Dolly Sods, WV
GAMO	Gates of the Mtns., MT
GICL	Gila, NM
GRGU	Great Gulf, NH
HECA	Hells Canyon, ID
HEGL	Hercules-Glades, MO
HOOV	Hoover, CA
IKBA	Ike's Backbone, AZ
JARB	Jarbridge, NV
JARI	James River Face, VA
KAIS	Kaiser, CA
KALM	Kalmiopsis, OR
LIGO	Linville Gorge, NC
LYBR	Lye Brook, VT
MOHO	Mount Hood, OR
MONT	Monture, MT
MOZI	Mount Zirkel, CO
NOAB	North Absaroka, WY
PASA	Pasayten, WA
RAFA	San Rafael, CA
SAGA	San Gabriel, CA
SAGO	San Gorgonio, CA
SAPE	San Pedro Parks, NM
SAWT	Sawtooth, ID
SHRO	Shining Rock, NC
SIAN	Sierra Ancha, AZ
SIPS	Sipsey, AL
SNPA	Snoqualmie Pass, WA
STAR	Starkey, OR
SULA	Sula, MT
SYCA	Sycamore Canyon, AZ
THSI	Three Sisters, OR
TRIN	Trinity, CA
UPBU	Upper Buffalo, AR
WEMI	Weminuche, CO
WHIT	White Mountain, NM
WHPA	White Pass, WA
WHPE	Wheeler Peak, NM
WHRI	White River, CO

IMPROVE PROTOCOL SITES

National Park Service

AMBL	Ambler, AK
DEVA	Death Valley, CA
GRBA	Great Basin, NV
INGA	Indian Gardens, AZ
MALO	Mauna Loa, HI
TRCR	Trapper Creek, AK
WASH	Washington, DC

US EPA

AREN	Arendtsville, PA
BOND	Bondville, IL
CADI	Cadiz, KY
COHI	Connecticut Hill, NY
LIVO	Livonia, IN
MKGO	MK Goddard, PA
PHOE	Phoenix, AZ
PUSO	Seattle, WA
QUCI	Quaker City, OH
SIKE	Sikes, LA

Tribes

CHER	Cherokee, OK
FLAT	Flathead, MT
FOPE	Fort Peck, MT
MAVI	Martha's Vineyard, MA
NOCH	Northern Cheyenne, MT
OLTO	Old Town, ME
OMAH	Omaha, NE
PRIS	Presque Isle, ME
SAFO	Sac and Fox, KS
SPOK	Spokane, WA
WARI	Walker River, NV

Forest Service

COGO	Columbia Gorge, WA
CORI	Columbia River Gorge, WA
PETE	Petersburg, AK
SHMI	Shamrock Mine, CO

States

ADPI	Addison Pinnacle, NY
BLMO	Blue Mounds, MN
BRMA	Bridgton, ME
CABA	Casco Bay, ME
CACO	Cape Cod, MA
CEBL	Cedar Bluff, KS
CLPE	Cloud Peak, WY
CRES	Crescent Lake, NE
ELDO	El Dorado Springs, MO
ELLI	Ellis, OK
FRRE	Frostburg Reservoir, MD
GRRI	Great River Bluffs, MN
HILL	Hillside, AZ
LASU	Lake Sugema, IA
MEAD	Meadview, AZ
MOMO	Mohawk Mtn., CT
NEBR	Nebraska Natl. Forest, NE
ORPI	Organ Pipe, AZ
PMRF	Proctor Research, VT
QURE	Quabbin Reservoir, MA
QUVA	Queen Valley, AZ
SAWE	Saguaro West, AZ
TALL	Tallgrass Prairie, KS
THBA	Thunder Basin, WY
VILA	Viking Lake, IA

SPECIAL IMPROVE SITES

Sites with Collocated QA Modules

BIBE	Big Bend, TX
BLMO	Blue Mounds, MN
EVER	Everglades, FL
FRRE	Frostburg Reservoir, MD
GAMO	Gates of the Mtns., MT
HEGL	Hercules-Glades, MO
HOOV	Hoover, CA
HOUS	Houston, TX
JARB	Jarbridge, NV
JOSH	Joshua Tree, CA
LAVO	Lassen Volcanic, CA
MACA	Mammoth Cave, KY
MELA	Medicine Lake, MT
MEVE	Mesa Verde, CO
OLYM	Olympic, WA
PHOE	Phoenix, AZ
PMRF	Proctor Research, VT
QURE	Quabbin Reservoir, MA
SAFO	Sac and Fox, KS
SAMA	St. Marks, FL
SAWE	Saguaro West, AZ
SENE	Seney, MI
SWAN	Swanquarter, NC
TRCR	Trapper Creek, AK
WICA	Wind Cave, SD

STN Collocated Sites

ATLA	Atlanta, GA
BIRM	Birmingham, AL
CHIC	Chicago, IL
DETR	Detroit, MI
FRES	Fresno, CA
HOUS	Houston, TX
NEYO	New York NY
PITT	Pittsburgh, PA
RUBI	Rubidoux, CA

1.2 IMPROVE AEROSOL SAMPLER OVERVIEW

A picture of an IMPROVE aerosol sampler is shown in Figure 2. The sampler consists of four modules used to collect aerosol samples, labeled A, B, C, and D. The fifth white box in the center of the picture is the controller. The controller contains the timer, 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 $PM_{2.5}$ particles on Teflon filters. These filters are analyzed by four methods at UC Davis:
    a. gravimetric analysis for $PM_{2.5}$ mass,
    b. hybrid-integrating plate and sphere (HIPS) for optical absorption,
    c. proton elastic scattering (PESA) for hydrogen, and
    d. x-ray fluorescence 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 PM_{10} particles on Teflon. These filters are analyzed by gravimetric analysis for PM_{10} mass at UC Davis.

Figure 1-2. 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. The length of the inlet stacks will be 1.83 m at all sites.

2.2 OPERATOR QUALIFICATIONS

A UC Davis technician will train the site operator. The operator needs to 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. 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 car 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 flash 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 A, yellow for module B, green for module C, and blue for module D. 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 10 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. Reverse the label on the outside of the Blue Box and send it in the U.S. mail.

Figure 2-1. Picture of a blue box showing the three bags and the flashcard at the top.

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 the 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. Table 2-1 lists the three cartridge configurations used for routine sampling. The unused cartridges 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 November and December 2005 to illustrate the 3-week repeating cycle.

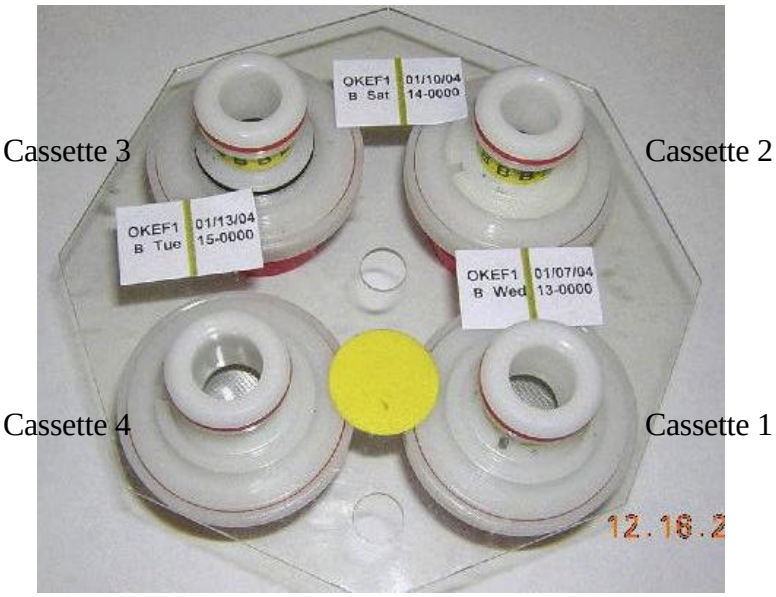


Figure 2-3. Sample cartridge for the B module (yellow sticker) with four cassettes. Only three of the cassettes contain sample filters (indicated by the three labels).

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

November 2005							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
December 2005							
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

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

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 "X" module. An additional Blue Box will be shipped to these sites every three weeks containing only the supplies for the X 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 time convention (i.e., standard time or daylight saving time, as appropriate). The sampler will automatically change to and from daylight saving time, when necessary. Appendix I lists the sampling dates for 2004 through 2008.

2.5.2 Sample Change Schedule

The sample cartridges must 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. It takes approximately fifteen minutes to change the sample cartridges every Tuesday. For two of every three Tuesday sample changes, the sampler will be 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 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 new 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, which requires 3.3 amperes (A) at 120 volts (V). The A, B, and C modules collect $PM_{2.5}$ samples. The A and C modules are identical except that their flow rates are calibrated for different types of filters (as described in Section 1.2). The B module has a slightly different cartridge holder configuration to accommodate the larger diameter filters that are used in the B module. The D module collects PM_{10} samples and has a very different configuration to accommodate a PM_{10} 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 an X module.

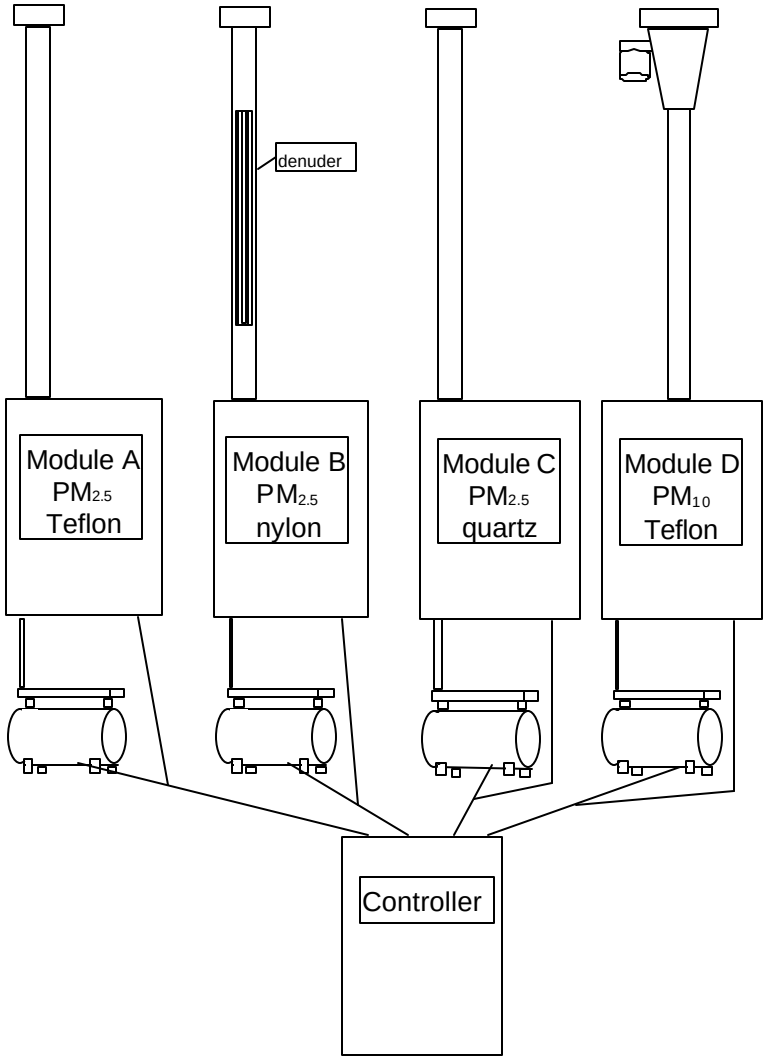


Figure 3-1. Standard IMPROVE aerosol sampler configuration.

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 16-bit controller, 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. When left in the controller, the cord is contained in the storage pocket. The controller can currently accommodate up to five filter sampling modules.

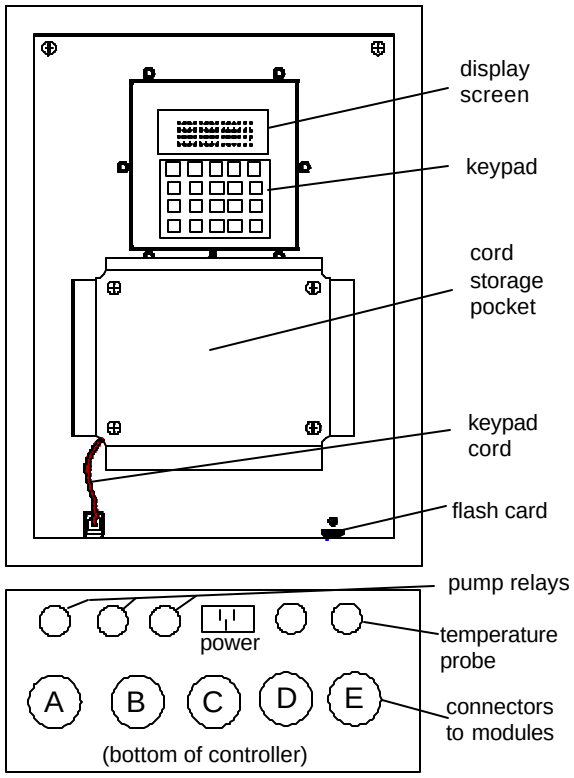


Figure 3-2. Controller module

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 flash 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 controller microprocessor. 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 flash card. The flash card is replaced every three weeks. The used flash card is sent

back to UC Davis, and the data are uploaded to a database. The flash card has the capacity to store much more than three weeks of sampling data if necessary.

The terminal is shown in greater detail in Figure 3-3. 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.

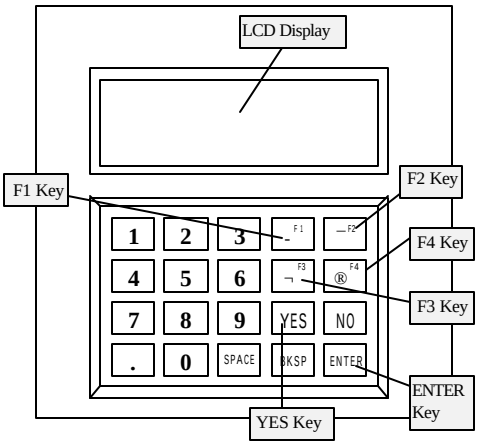


Figure 3-3. Controller terminal

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.

```
01/02/00 04:00p* SAT
Fil 2 ON, Temp= 95V
Fil 1 |Fil 2 |Fil 3
24hrs | 16hrs| 0hrs
```

Figure 3-4. Current status, filter on

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. The star after the time shows that local time is in daylight saving time. 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 95 millivolts. The voltage reading is converted to temperature at UC Davis. The third line is the header for the elapse times that are displayed in the fourth line in hours. In this example, Filter 1 sampled for 24 hours, Filter 2 for 16hrs and Filter 3 have not sampled.

```
01/02/00 04:00p  SAT
Fil 2 ON, Temp= 95V
Fil 1 |Fil 2 |Fil 3
Recording sensors
```

Figure 3-5. Current status, recording sensors

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.

```
06/04/03 08:00 * TUE

  A   B   C   D
 OFF OFF OFF OFF
```

Figure 3-6. Current status, idle screen

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 and the site is observing daylight saving (indicated by the *). The day of the week is Tuesday.

```
11/01/00 10:00   SAT
     SAMPLING
     COMPLETED
```

Figure 3-7. Current status, sampling complete

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 cassettes and collects the exposed and clean filter readings. The date is November 1st, 2000 at 10am, standard time.

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.

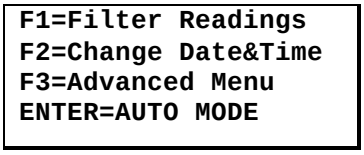


Figure 3-8. Main menu screen.

F1 - 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 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 week will automatic change based on the month, day, and year.

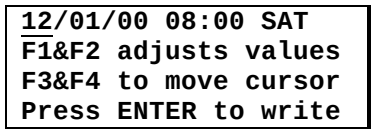


Figure 3-9. Change date and time screen.

If you enter an invalid date, the screen shown in Figure 3-10 will appear. An invalid date is one that does not exist in the month (e.g., 2/30 or 9/31).

Figure 3-10. Invalid date error screen.

3.2 $PM_{2.5}$ SAMPLING MODULES

The inside of a Version II IMPROVE aerosol sampler $PM_{2.5}$ module is shown in Figure 3-11. The flow diagram for the IMPROVE $PM_{2.5}$ module is shown in Figure 3-12. Approximate pressure readings in units of inches of mercury are listed in the figure.

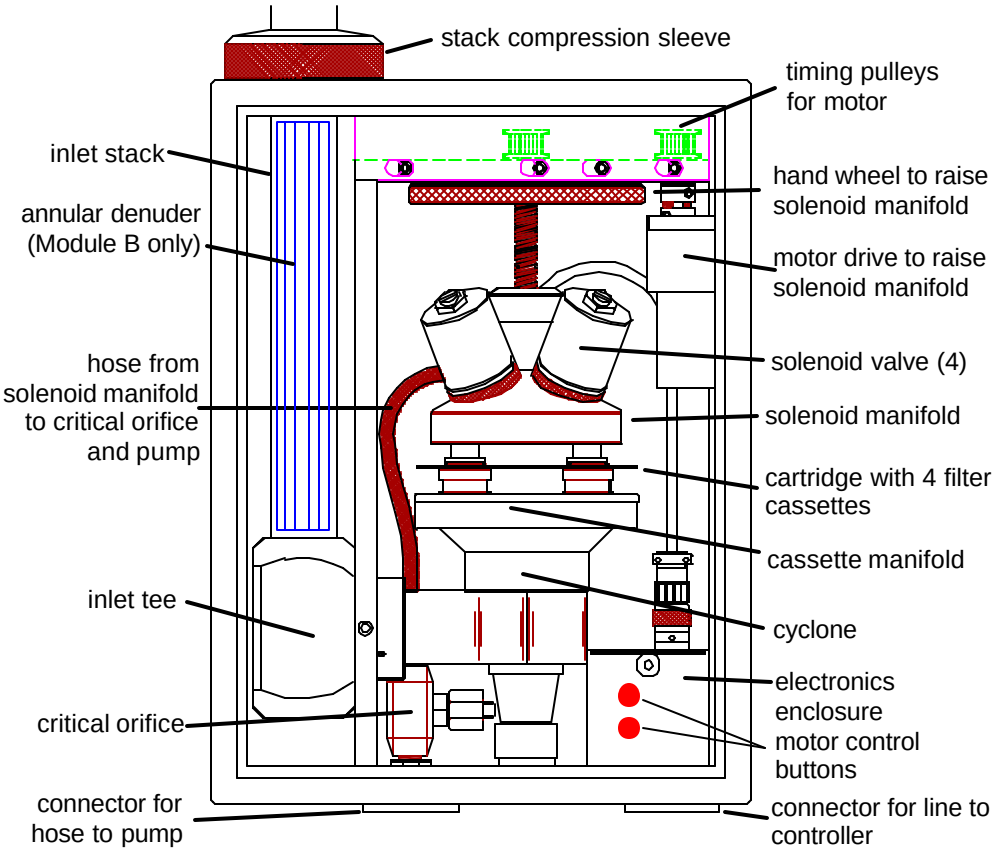


Figure 3-11. $PM_{2.5}$ module from the Version II IMPROVE aerosol sampler.

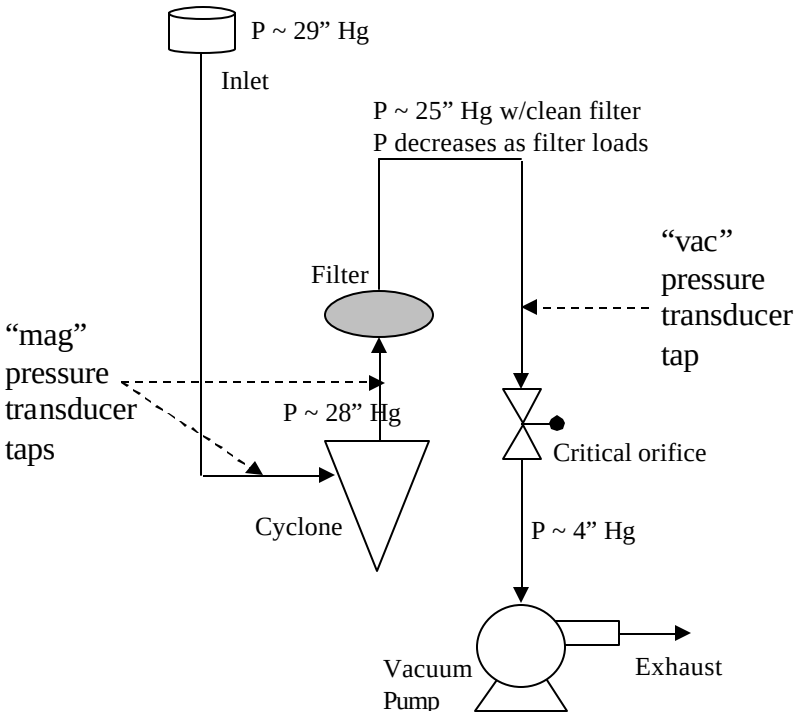


Figure 3-12. Flow diagram for the IMPROVE $PM_{2.5}$ module.

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 µm. The air stream then passes through a cyclone that removes particles larger than 2.5 µm. The cyclone is located inside the module, as shown in Figure 3-11. The cyclone is 50% efficient at removing particles with aerodynamic diameters larger than 2.5 µm 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 µm.

Module B (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 B.

A temperature probe is inserted in the inlet of one of the three $PM_{2.5}$ modules (typically module C 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 flash 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 aerosol sampler. The valve is adjusted by an authorized technician during each annual maintenance visit to achieve a the desired nominal flowrate.

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 audit 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 "mag" measurement. The "mag" 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 II: 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

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

where Q_m = actual volumetric flow rate (L/min) from the "mag" reading,

M = "Mag" 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 "vac" measurement. The "vac" flow rate is related to the air pressure immediately before the critical orifice. The equation for flow rate based on the second transducer is

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

where Q_v = actual volumetric flow rate (L/min) from the "vac" reading,
V = "Vac" 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 PM_{10} SAMPLING MODULE

A Version II PM_{10} module is shown in Figure 3-13. Note that the PM_{10} module manifold is oriented in the opposite direction as the $PM_{2.5}$ module manifold.

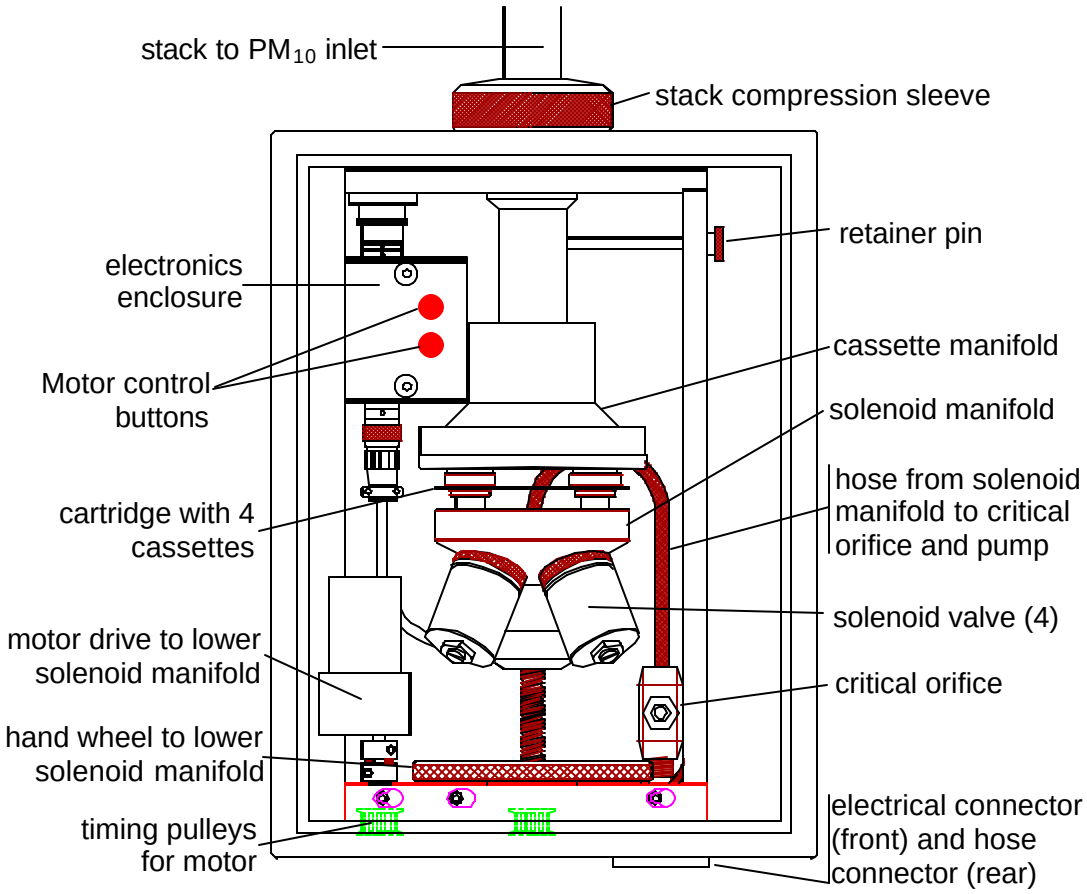


Figure 3-13. PM_{10} module from the Version II IMPROVE sampler.

3.3.1 PM_{10} 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 elminate 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 PM_{10} 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 audit device that has been calibrated to a primary flow standard at UC Davis. One flow measurement is made in the PM_{10} module.

The flow rate is referred to as the "vac" measurement. The "vac" 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

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

where Q_v = actual volumetric flow rate (L/min) from the "vac" reading,
V = "Vac" 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
c and d = empirical calibration constants normalized to 20°C and sea level pressure.

3.3.3 PM_{10} Module Filter Cassettes and Cartridges

The same cassettes and cartridges are used in the PM_{10} 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 PM_{10} module (D), 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.

Approximately six months after installation, the site operator will be asked to check the flow rate calibration. UC Davis will send detailed instructions and the appropriate equipment to perform the flow check.

5. TUESDAY SAMPLE CHANGES

The sample cartridges must be changed every Tuesday. 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 10 days before the first sample-change day. If the appropriate box is not present within two days of 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.

IMPROVE Network Field Log **Preweighed by:PL**

2566 **08/03/2004**

INSTALL ON --> **SIPS1 08/24/2004**

0,014,957 **CurTemp_____**

INITIAL READINGS **FINAL READINGS**

Operator's Initials_____ **Date:____/____/ ____** **Time:_____** **Init____** **Date:____/____/ ____** **Time:_____**

SamDate	StrTim		MxVac	Cass	Vac	Mag	Vac	Mag	ET
08/25/2004	0000 Wed			1	__ __	__ __	__ __	__ __	__ __ __ __
		Mod A	__ __ __						
08/28/2004	0000 Sat			2	__ __	__ __	__ __	__ __	__ __ __ __
08/31/2004	0000 Tue			3	__ __	__ __	__ __	__ __	__ __ __ __
08/25/2004	0000 Wed			1	__ __	__ __	__ __	__ __	__ __ __ __
		Mod B	__ __ __						
08/28/2004	0000 Sat			2	__ __	__ __	__ __	__ __	__ __ __ __
08/31/2004	0000 Tue			3	__ __	__ __	__ __	__ __	__ __ __ __
08/25/2004	0000 Wed			1	__ __	__ __	__ __	__ __	__ __ __ __
		Mod C	__ __ __						
08/28/2004	0000 Sat			2	__ __	__ __	__ __	__ __	__ __ __ __
08/31/2004	0000 Tue			3	__ __	__ __	__ __	__ __	__ __ __ __
08/25/2004	0000 Wed			1	__ __	__ __	__ __	__ __	__ __ __ __
		Mod D	__ __ __						
08/28/2004	0000 Sat			2	__ __	__ __	__ __	__ __	__ __ __ __
08/31/2004	0000 Tue			3	__ __	__ __	__ __	__ __	__ __ __ __

After Finals Move Cassette to Hole in Next Cartridge Plate

Always Orient each Cartridge Plate as per Instructions on each Door

Lab Use Only
42.708 41.002
41.275 40.331
42.213 39.018

comments:

For Help Call (530) 752-1123

Figure 5-1. Field logsheet for sample cartridges with three cassettes (i.e., three sampling days). 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 flow rate readings for each used cassette, 2) remove the used cartridges, 3) install the new cartridges, and 4) collect the initial flow rate readings for each new cassette. This procedure must be repeated for all four sampling modules: A, B, C, and D.

For two of every three Tuesday sample changes, the modules will be 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. The dates when the sampling date is on Tuesday are given in Appendix I: Sample Collection Dates.

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.

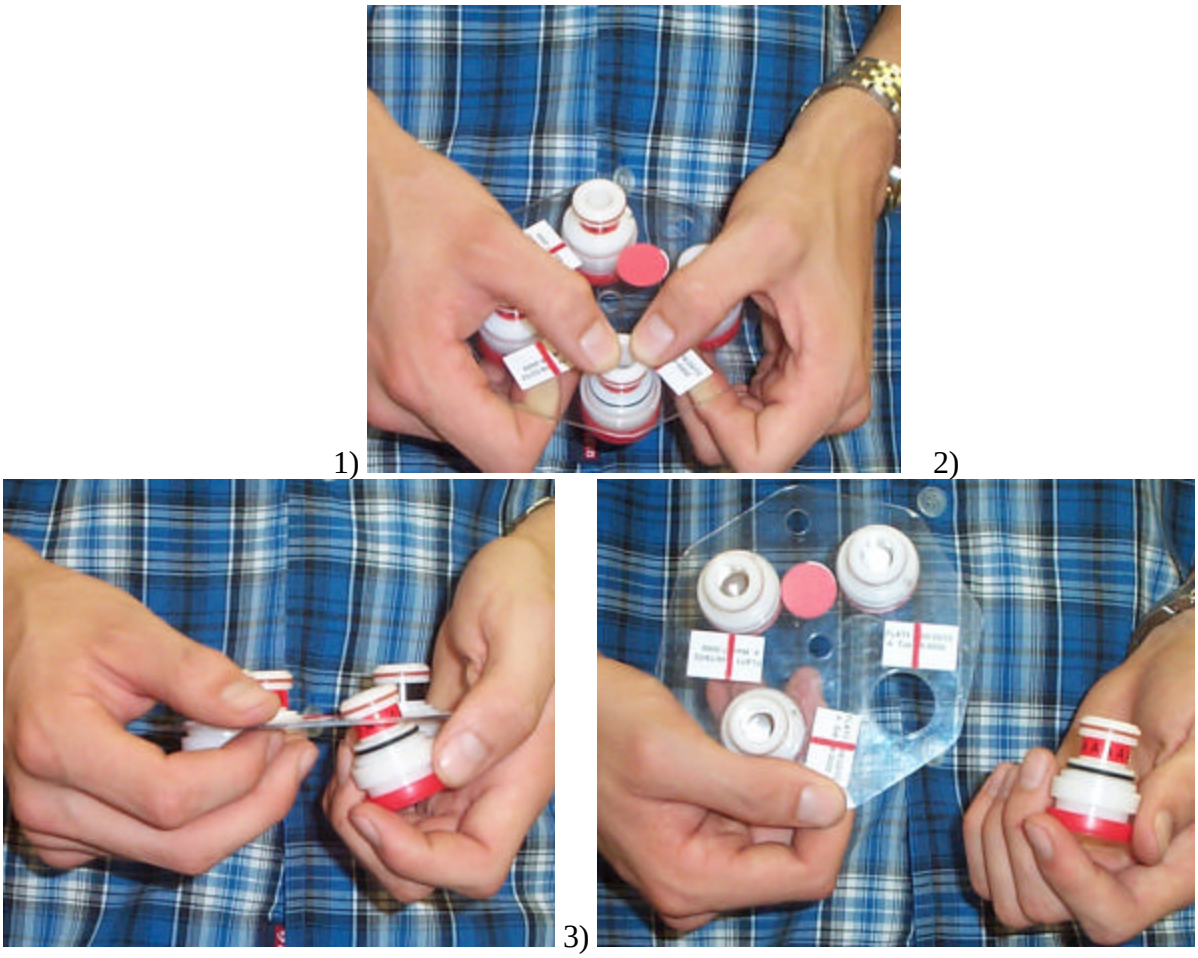


Figure 5-2. Photos illustrating the removal of the position 3 cassette (note black o-ring on removable cassette) from the cartridge.

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" thoughout 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 (Figure 5-3).

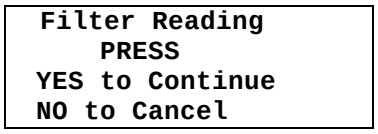


Figure 5-3. Continue screen.

6. Press the number corresponding to your initials, or press 4 and enter your initials (Figure 5-4).

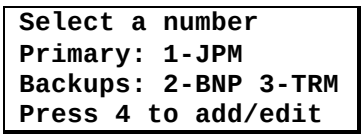


Figure 5-4. Select initials screen.

7. Record the temperature measurement, "T=" (95V in Figure 5-5), in the blank labeled "CurTemp" on the top right of the logsheet. (The temperature measurement is displayed in units of millivolts.)
8. Hit Enter.

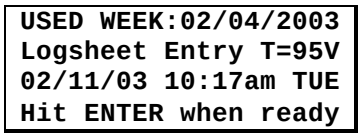


Figure 5-5. Current temperature screen.

9. Record the Final Readings (Vac, Mag, and ET) for each used cassette. Figure 5-6 shows the pressure readings (**Vac** & **Mag**) and elapsed time (**ET**) for the first cassette (**FIL 1**) in Module A.
10. 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).

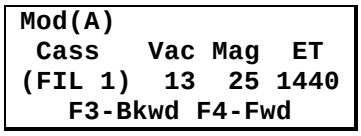


Figure 5-6. Flow rate readings screen.

11. When all the Final Readings are collected, check that all blanks on the log sheet are filled in.
12. Note any problems or mistakes made during the sample change procedures (e.g., dropped cartridge or cassette, touched filter with finger, etc.).
13. Also note any unusual events that occurred near the site (e.g., fires, construction, painting, power outages, lightening strikes, fireworks, high traffic, etc.).
14. If all the readings are acceptable, press the ® **F4** key (Figure 5-7). To redo the readings, press the ¬ **F3** key.

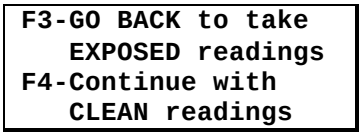


Figure 5-7. Continue screen.

15. 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).

16. 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.

17. Hit **ENTER** when you have the appropriate bag of filters.

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

Figure 5-8. Exchange cartridges screen.

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

    If this is <u>not</u> 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.

```
STANDARD change
Remove EXPOSED

        -  –
cartridges & insert
the CLEAN cartridges

Press ENTER if done
```

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

    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 (A,B, and C), the labels and the red, yellow, or green dot will be facing up (Figure 5-10). For the PM_{10} module (D), the labels and the blue dot will be facing down (Figure 5-11).

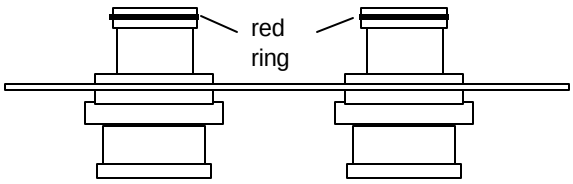


Figure 5-10. $PM_{2.5}$ cassette orientation.

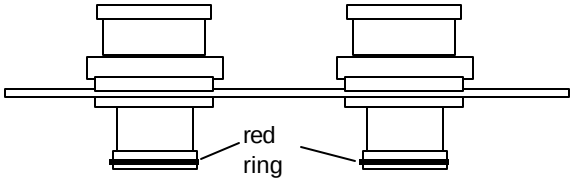


Figure 5-11. PM_{10} cassette orientation.

---------- 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.

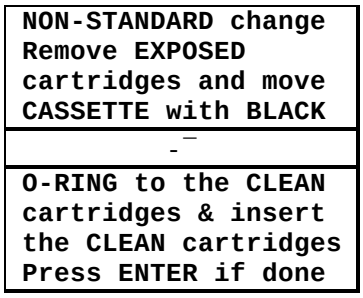


Figure 5-12. Active sampling Tuesday sample change.

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 (A,B, and C), the stickers and the red, yellow, or green dot will be oriented upwards. For the PM_{10} module (D), the labels and the blue dot will be facing down.

19. Repeat Step 18 for modules B (yellow), C (green), and D (blue), making sure to install the appropriately colored cartridge in each module.

20. Press the **ENTER** key when all the new cartridges are installed.

21. 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 ziplock 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.

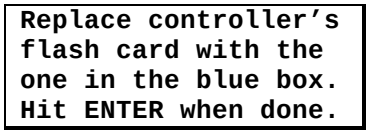


Figure 5-13. Replace flash card screen

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

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

Figure 5-14. No flash card warning

22. The screen shown in Figure 5-15 shows the Initial Readings for the new filter in the first cassette position in Module A.

```
Mod(A)
 Cass  MxVac Vac Mag
(FIL 1)  40   12  32
   F3-Bkwd  F4-Fwd
```

Figure 5-15. Clean filter readings screen.

23. Record the Initial Readings (MxVac, Vac, and Mag) for each new cassette on the new logsheet. Note that only one MxVac 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. The program will proceed to Figure 5-15. Note that the low flow message may appear for all in the cartridge.

```
      WARNING
LOW FLOW DETECTED
check Module (A) for
proper installation
```

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

Figure 5-16. Low flow through cyclone warning.

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.

```
WARNING: Cartridge
may be UPSIDE DOWN
check Module (A) for
proper installation
```

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

Figure 5-17. Cartridge upside down warning.

24. Use the ® **F4** key to move to the next cassette.

25. 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).

Figure 5-18. Final filter readings screen.

26. 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

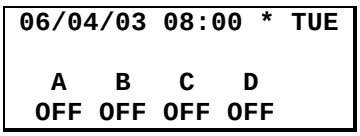


Figure 5-19. Current status, idle screen

---------- 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.

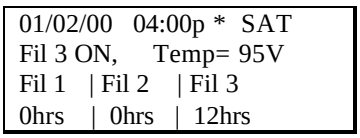


Figure 5-20. Current status, filter on

27. Make certain that a current status is showing on the screen before you leave.

28. Close the doors of the modules.

29. If you have any problems during a sample change, contact UC Davis at (530) 752-1123.

30. If this is the last (third) bag of samples in the Blue Box, return the box to Davis as soon as possible. Simply reverse the mailing label in the plastic pocket and send the box through the U.S. mail.

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) 752-4107, e-mail fieldops@crocker.ucdavis.edu). If possible, call from the site to facilitate troubleshooting.

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. Check the power strip that the sampler and pumps are plugged into (this may be located inside the pump enclosure). There should be a lighted switch on the power strip. If it is not lit up, turn the switch off and then on again.

iii. Check the power cord for the sampler. This black cord runs from the base of the control module to the power strip. If it is unplugged, reconnect it.

iv. If you are still not sure if power is on:
   (a) Unplug one of the pumps from its outlet box.
   (b) Disconnect the silver vacuum hose connecter from the top of the pump.
   (c) Plug the pump cord directly into the power strip. 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 and allow it to warm up.

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 A 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 one of the pumps from its outlet box.

      (b) Plug the pump cord directly into the power strip (make sure the power strip is receiving power). 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 3-11 and for the PM_{10} module is shown in Figure 3-13. 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 PM_{10} module (D) except the motor is upside down compared to the $PM_{2.5}$ modules. 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, module type and daylight saving settings.

```
F1 = Calib
F2 = Site Config.
F3 = Get Zero Flows
ENTER = Main Menu
```

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

```
Enter SAMPLER INV#
  Then press ENTER
SAMPLER INV#: 1138
```

Protocol: Select "Normal" or "Urban" sample collection protocol. Selecting Normal sets the sampler to collect an uninterrupted sample for 24 hours. Selecting Urban will sets the sampler to collect a sample 15 minutes out of every hour for 24 hours. This is to reduce the chance of clogging.

```
Select protocol
*Normal   Urban
F3&F4 to change
Press ENTER to save
```

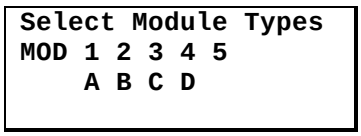
Time average: Enter the time interval, which the data will be reported to the serial flash card. Typically the value will be 15 minutes.

```
Enter time avg(mins)
  Then pres enter
  Max: 1440 min
 15 minutes
```

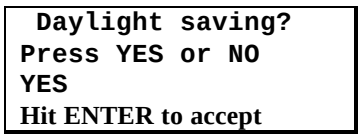
Change day: This is the day that the sample changes are performed. This will always be set to Tuesday unless otherwise specified by UCD.

```
Change Day ON:  TUE
F1&F2 Select Weekday
For Change Day
Press ENTER to save
```

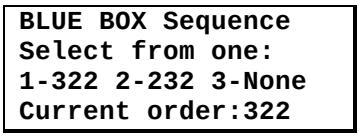
Module types: This screen is used to specify the number and type of modules operating at the site. If the current information is correct, press **ENTER** to save. Otherwise, enter the correct information and press **ENTER** to save.



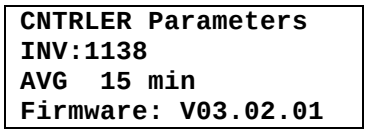
Daylight Saving: If the site observes daylight saving time, select yes. If the site does not (AZ, HI, parts of Indiana), select no. If the current setting is correct, press **ENTER** to accept the current setting.



Blue Box sequence: This screen allows the user to specify the cartridge sequence of the Blue Boxes. There are two choices: 1) 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 2) 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). If the user presses **ENTER**, the existing cartridge sequence is selected.



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



APPENDIX I: SAMPLE COLLECTION DATES

Table AI-1. Sample collection dates for 2004 through 2008. Tuesday sample collection dates are underlined.

2004			2005			2006			2007			2008		
1/1	5/3	9/3	1/1	5/1	9/1	1/2	5/2	9/2	1/3	5/3	9/3	1/1	5/3	9/3
1/4	5/6	9/6	1/4	5/4	9/4	1/5	5/5	9/5	1/6	5/6	9/6	1/4	5/6	9/6
1/7	5/9	9/9	1/7	5/7	9/7	1/8	5/8	9/8	1/9	5/9	9/9	1/7	5/9	9/9
1/10	5/12	9/12	1/10	5/10	9/10	1/11	5/11	9/11	1/12	5/12	9/12	1/10	5/12	9/12
1/13	5/15	9/15	1/13	5/13	9/13	1/14	5/14	9/14	1/15	5/15	9/15	1/13	5/15	9/15
1/16	5/18	9/18	1/16	5/16	9/16	1/17	5/17	9/17	1/18	5/18	9/18	1/16	5/18	9/18
1/19	5/21	9/21	1/19	5/19	9/19	1/20	5/20	9/20	1/21	5/21	9/21	1/19	5/21	9/21
1/22	5/24	9/24	1/22	5/22	9/22	1/23	5/23	9/23	1/24	5/24	9/24	1/22	5/24	9/24
1/25	5/27	9/27	1/25	5/25	9/25	1/26	5/26	9/26	1/27	5/27	9/27	1/25	5/27	9/27
1/28	5/30	9/30	1/28	5/28	9/28	1/29	5/29	9/29	1/30	5/30	9/30	1/28	5/30	9/30
1/31	6/2	10/3	1/31	5/31	10/1	2/1	6/1	10/2	2/2	6/2	10/3	1/31	6/2	10/3
2/3	6/5	10/6	2/3	6/3	10/4	2/4	6/4	10/5	2/5	6/5	10/6	2/3	6/5	10/6
2/6	6/8	10/9	2/6	6/6	10/7	2/7	6/7	10/8	2/8	6/8	10/9	2/6	6/8	10/9
2/9	6/11	10/12	2/9	6/9	10/10	2/10	6/10	10/11	2/11	6/11	10/12	2/9	6/11	10/12
2/12	6/14	10/15	2/12	6/12	10/13	2/13	6/13	10/14	2/14	6/14	10/15	2/12	6/14	10/15
2/15	6/17	10/18	2/15	6/15	10/16	2/16	6/16	10/17	2/17	6/17	10/18	2/15	6/17	10/18
2/18	6/20	10/21	2/18	6/18	10/19	2/19	6/19	10/20	2/20	6/20	10/21	2/18	6/20	10/21
2/21	6/23	10/24	2/21	6/21	10/22	2/22	6/22	10/23	2/23	6/23	10/24	2/21	6/23	10/24
2/24	6/26	10/27	2/24	6/24	10/25	2/25	6/25	10/26	2/26	6/26	10/27	2/24	6/26	10/27
2/27	6/29	10/30	2/27	6/27	10/28	2/28	6/28	10/29	3/1	6/29	10/30	2/27	6/29	10/30
3/1	7/2	11/2	3/2	6/30	10/31	3/3	7/1	11/1	3/4	7/2	11/2	3/1	7/2	11/2
3/4	7/5	11/5	3/5	7/3	11/3	3/6	7/4	11/4	3/7	7/5	11/5	3/4	7/5	11/5
3/7	7/8	11/8	3/8	7/6	11/6	3/9	7/7	11/7	3/10	7/8	11/8	3/7	7/8	11/8
3/10	7/11	11/11	3/11	7/9	11/9	3/12	7/10	11/10	3/13	7/11	11/11	3/10	7/11	11/11
3/13	7/14	11/14	3/14	7/12	11/12	3/15	7/13	11/13	3/16	7/14	11/14	3/13	7/14	11/14
3/16	7/17	11/17	3/17	7/15	11/15	3/18	7/16	11/16	3/19	7/17	11/17	3/16	7/17	11/17
3/19	7/20	11/20	3/20	7/18	11/18	3/21	7/19	11/19	3/22	7/20	11/20	3/19	7/20	11/20
3/22	7/23	11/23	3/23	7/21	11/21	3/24	7/22	11/22	3/25	7/23	11/23	3/22	7/23	11/23
3/25	7/26	11/26	3/26	7/24	11/24	3/27	7/25	11/25	3/28	7/26	11/26	3/25	7/26	11/26
3/28	7/29	11/29	3/29	7/27	11/27	3/30	7/28	11/28	3/31	7/29	11/29	3/28	7/29	11/29
3/31	8/1	12/2	4/1	7/30	11/30	4/2	7/31	12/1	4/3	8/1	12/2	3/31	8/1	12/2
4/3	8/4	12/5	4/4	8/2	12/3	4/5	8/3	12/4	4/6	8/4	12/5	4/3	8/4	12/5
4/6	8/7	12/8	4/7	8/5	12/6	4/8	8/6	12/7	4/9	8/7	12/8	4/6	8/7	12/8
4/9	8/10	12/11	4/10	8/8	12/9	4/11	8/9	12/10	4/12	8/10	12/11	4/9	8/10	12/11
4/12	8/13	12/14	4/13	8/11	12/12	4/14	8/12	12/13	4/15	8/13	12/14	4/12	8/13	12/14
4/15	8/16	12/17	4/16	8/14	12/15	4/17	8/15	12/16	4/18	8/16	12/17	4/15	8/16	12/17
4/18	8/19	12/20	4/19	8/17	12/18	4/20	8/18	12/19	4/21	8/19	12/20	4/18	8/19	12/20
4/21	8/22	12/23	4/22	8/20	12/21	4/23	8/21	12/22	4/24	8/22	12/23	4/21	8/22	12/23
4/24	8/25	12/26	4/25	8/23	12/24	4/26	8/24	12/25	4/27	8/25	12/26	4/24	8/25	12/26
4/27	8/28	12/29	4/28	8/26	12/27	4/29	8/27	12/28	4/30	8/28	12/29	4/27	8/28	12/29
4/30	8/31			8/29	12/30		8/30	12/31		8/31		4/30	8/31	

APPENDIX II: ELEVATION FACTORS

Table AII-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 III: MODULE DOOR QUICK REFERENCE SHEETS

Version II IMPROVE Sampler

(Firmware 03.03)
designed and built by
Crocker Nuclear Laboratory
University of California, Davis

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

Procedures for Sample Changing.

1. Press the **ENTER**, - **F1**, and **YES** keys.
2. Select operator initials by pressing a number. If necessary, edit to add operators.
3. Record the temperature, date, time and operator's initials onto the logsheet and press **ENTER**.
4. Record the Vac and Mag readings and Elapse time for each exposed filter on to the logsheet. Press ® **F4** to move to the next filter.
5. To retake exposed readings, press ← **F3**. If okay, press ® **F4**.
6. Change the cartridges in each module.
7. If finished with third bag in Blue Box, remove the memory card from the controller and place it in the pouch of the old Blue Box. Remove flash card from new box and place in controller. If there is no flash card in new box, leave old card in controller. Press **ENTER**.
8. Record MxVac, Vac and Mag 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**. The sampler will return to the AUTO MODE

1
```
Select a number
Primary: 1-PHW
Backups: 2-ABC 3-XYZ

Press 4 to add/edit
```

2
```
USED WEEK:02/04/2003
Logsheet Entry T=95V
02/11/03 10:17am TUE

Hit ENTER when ready
```

3
```
Mod(A)
 Cass   Vac Mag  ET
(FIL 1)  12  23 1440
F3-Bkwd   F4-Fwd
```

4
```
F3-GO BACK to take
   Exposed readings
F4-Replace EXPOSED
   filters w/ CLEAN
```

5
```
USE WEEK:02/11/2003
Logsheet Entry T=95V
02/11/03 10:17am TUE

Hit ENTER when ready
```

6
```
Remove EXPOSED
cassettes and
insert CLEAN ones.
Hit ENTER when done.
```

8
```
Mod(A)
 Cass  MxVac Vac Mag
(FIL 1)  40   12  23
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

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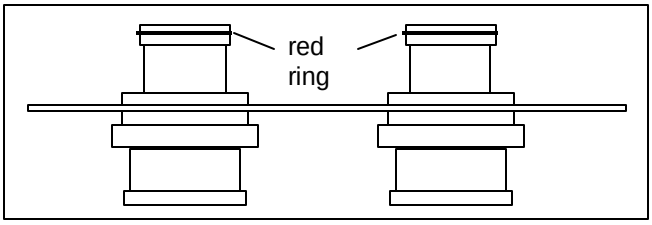
Cassette Orientation
Labels and Red O-ring UP



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

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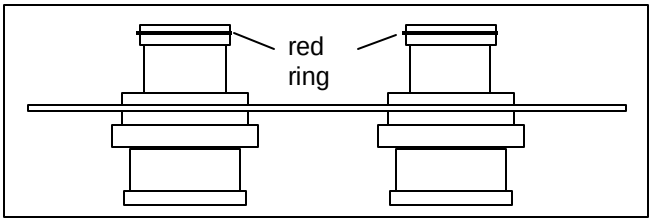
University of California, Davis

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

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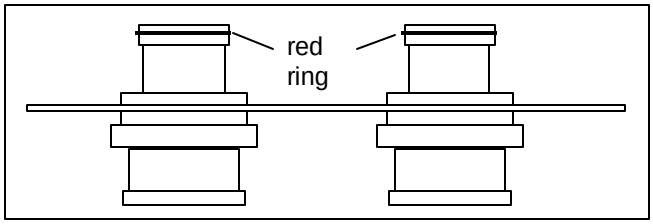
University of California, Davis

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 (PM_{10} inlet)—Blue Dot on Cartridge

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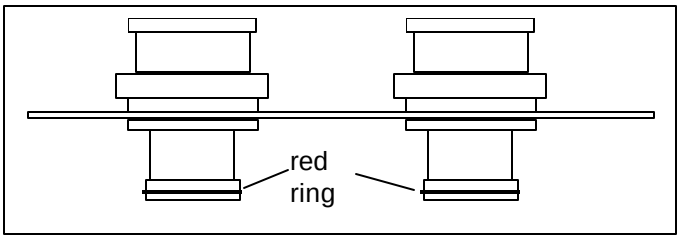
Cassette Orientation Reversed
Labels and Red O-ring DOWN



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