IMPROVE

Aerosol Sampler

Operations Manual

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Standard Operating Procedures
Technical Information Document TI 201A

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INTRODUCTION

Summary of this manual

This document provides the site operator with a manual for the operation of the IMPROVE aerosol sampler. The site operator will also receive training when the field technician performs annual maintenance. The site operators are strongly encouraged to call the Lab Manager or Field Specialist at (916) 752-1123 whenever they have questions about or difficulties with the sampler. This manual provides documentation on sampler operation, repair, and audits, and is useful to refer to during phone conversations. Topics covered include weekly sample changing, troubleshooting, repairs, clock controller programming, and flow rate auditing procedures.

Weekly maintenance, or sample changing, is performed by the site operator, though any deviations from expected behavior should be reported to the Lab Manager or Field Specialist at (916) 752-1123. Weekly maintenance of the IMPROVE samplers involves recording the information requested on the site log sheets, replacing exposed filter cassettes with unexposed filter cassettes, and recording and reporting any potential problems with the samplers or the data.

Troubleshooting and repairs are performed whenever a problem that may affect the validity of the samples occurs. Troubleshooting guides are included in this document, though troubleshooting is generally a process involving the site operator and Field Specialist or Lab Manager. Small urgent repairs are generally performed by the site operator under instruction from the Field Specialist or Lab Manager. For small problems, the replacement part is mailed overnight to the site operator, along with specific instructions for installation. For catastrophic problems, the solution involves either sending a Field Technician to the site, or sending a replacement sampler. Site operator will not be asked to perform any potentially dangerous repairs. If a repair is requested that the site operator does not feel secure in performing, additional assistance will be arranged, or the repair will be assigned to a Field Technician.

Clock controller programming procedures are explained in this document due to the frequency of power outages, surges, and brown outs at the sites in the IMPROVE network. The clock controller is rugged, but continually unstable power can cause loss of the sampling programs and current day and time. This document provides information on the function and purpose of all the buttons and indicators on the clock controller. It also describes, in detail, the method for setting the current time and date, and for programming the clock controller for IMPROVE protocol sampling

Flow rate audits are performed biannually, for quality assurance purposes, and also whenever a problem with the system gauges or flow rate is suspected. Audits are performed to verify the calibration equations relating the magnehelic and small gauge readings for a module to the flow rate through that module. Due to the number of sites in the network that must be audited, all audits must be done in a timely manner. The audit devices are sent through the mail, and the audit is performed, in stages, by the site operator. After each stage, the operator is instructed to confer with the field specialist or lab manager at the Air Quality Group to determine whether the current information is adequate, or further data must be collected.

Summary of IMPROVE

IMPROVE (Interagency Monitoring of Protected Visual Environments) is a cooperative program of the National Park Service, Forest Service, Bureau of Land Management, Fish and Wildlife Service, and Environmental Protection Agency, whose primary purpose is the protection of visibility in Class I areas. The IMPROVE program monitors visibility (extinction or scattering) and particulate concentrations.

The standard IMPROVE particulate sampler consists of a PM_{10} module with Teflon filters, and three $PM_{2.5}$ modules, one with Teflon, one with nylon, and one with quartz filters. Each module has an independent air stream with a sizing device, a flow controller, and a pump, plus solenoids for exposing two filters between weekly sample changes. A programmable clock, in one of the filter modules or in a separate module, controls pump and solenoid switching for all filter modules. The pumps are housed separately.

Approximately 20% of the sites in the IMPROVE network operate with a single $PM_{2.5}$ module containing the programmable clock.

The filters are loaded into cassettes at the central laboratory. Two cassettes are loaded in each module during weekly site visits. The exposed cassettes are returned to the Air Quality Group laboratory for processing. The $PM_{2.5}$ Teflon filter deposits are analyzed for the concentrations of deposit mass and elements hydrogen and sodium to lead, and for an optical parameter, the coefficient of absorption. The nylon filters are analyzed for the concentrations of nitrate and sulfate, the quartz filters for the concentrations of organic and elemental carbon, and the PM_{10} Teflon filters for the concentration of deposit mass.

The particle sizing for $PM_{2.5}$ particles is accomplished with a cyclone operating with an ambient flow rate of 22.8 L/min. The flow rate is measured with a magnehelic gauge, using the pressure drop across the cyclone. A secondary measurement, using a pressure gauge behind the filter, provides a quality assurance check and ensures that the cassettes are properly seated. Flow control is maintained by a critical orifice between the filter and pump. The standard deviation of flow rates over a year is typically 2-3%.

Precision tests using collocated samplers typically indicate that the flow rate precision is 3%.

The IMPROVE sampler has been used in the field since 1988. Approximately one-half of the samplers operate without a shelter in extreme environmental conditions. The remainder are in air quality shelters, generally without air conditioning. The sampler has been very reliable, with losses due to sampler problems of approximately 1%. Almost all of these are associated with power outages and surges. Normally, routine sampler repairs are performed annually.

1.0 Weekly Maintenance Procedures

The procedures for weekly maintenance at an IMPROVE site involve these basic steps. First, data to calculate the flow rate and volume of air sampled must be recorded from the thermometer, elapsed time, magnehelic, and vacuum gauges. Next the exposed cassettes are removed and the appropriate clean cassettes installed. Finally, the elapsed time gauges are reset, and data to calculate the flow rate are recorded for each of the clean cassettes. In each step the site operator verifies the readings are within the range listed as acceptable, and the data are recorded for the correct cassette. Each procedure is described in the sections listed below:

1.1 Cassette labeling and installation protocols.
1.2 Initial procedures and sampler status checks
1.3 Recording of final data and removal of exposed cassettes.
1.4 Installation of clean cassettes and recording of initial data.
1.5 Weekly equipment checks.
1.6 Field blank procedures

1.1 Cassette Labeling and Installation Protocols.

Each cassette is designated for a specific sample date and module when loaded with a filter in the Air Quality Group Lab. The cassettes are color coded, one color to indicate the module, and black or white to indicate a Wednesday or Saturday sample respectively. The solenoids in the modules will be similarly color coded. Each cassette is also labeled with the sample date, module and channel on a white sticker label. The labeling protocol is described in Table 1 below.

Table 1 Cassette Labeling Protocol

Module	Channel	Sample Day	Filter Color Code	Label	Description
A	1	Wednesday	red, black	date-A1	25mm Teflo™
	2	Saturday	red, white	date-A2	
B	1	Wednesday	yellow, black	date-B1	25mm Nylasorb™
	2	Saturday	yellow, white	date-B2	
C	1	Wednesday	green, black	date-C1	25mm quartz
	2	Saturday	green, white	date-C2	
D	1	Wednesday	blue, black	date-D1	25mm Teflo™*
	2	Saturday	blue, white	date-D2	

Cassettes containing filters for the IMPROVE sampling network are mailed in sealed bags. Each bag is labeled with the Tuesday date of the week the cassettes must be installed, and contains one week of filter cassettes. Two weeks of filters are enclosed in each blue shipping box for mailing to and from the site.

The installation date printed on the outside of the blue box. The sampler must be changed on Sunday, Monday, or Tuesday under the IMPROVE protocol. If the sample change day is missed, the cassettes may be changed on Wednesday, Thursday or Friday, after advising the Air Quality Group of the situation. Changes on invalid days will preclude collection of a valid Wednesday sample, but will allow a valid Saturday sample.

1.2 Initial Procedures and Sampler Status Checks

1. LOCATE REQUIRED MATERIALS. Take the following materials to the site.
   - Blue shipping box containing the cassette shipping bag, the red filter protecting caps, and the log sheet for the exposed filter cassettes currently in the IMPROVE sampler.
   - Blue shipping box, labeled with the Tuesday date for the current week, containing the log sheet and unexposed filter cassettes for the current week for the IMPROVE sampler.
   - Writing implement.
   - IMPROVE Sampler Manual.

2. RECORD CURRENT SITE INFORMATION ON THE LOG SHEET. Remove the partially completed log sheet for the exposed cassettes from the shipping bag. On the log sheet, record the day of the week, the current date and time, the initials of the person doing the sample change, and the current temperature. The temperature, preferably in ºC, may be read on the thermometer installed at the site. If the sample change occurs on a day other than Sunday, Monday, or Tuesday, note this on the log sheet in the comments section, advise the Air Quality Group, and carefully follow the additional instructions for Wednesday or Saturday changes included in this section. Figure 1, Sample Log Sheet, shows a typical log sheet for the site BIBE1 to be used the week of 06/18/96.

Figure 1 Sample Log Sheet

INSTALL BY --> BIBE1 06/18/96

INITIAL READINGS | FINAL READINGS CurTemp ____C

Operator's Initials ____ Date: ______ | Operator's Initials ____ Date: ______

Day: Sun Mon Tue Time _____ | Day: Sun Mon Tue Time _____

Sample Date	Start Time	Module	MaxVac ("Hg)	Cassette Color	SmGaug ("Hg)	Magn ("H2O)	SmGaug ("Hg)	Magn ("H2O)	ET
06/19/96	OOOO	RED Mod A	_ _	BLACK	_ _._	._ _	_ _._	._ _	_ _._
06/22/96	OOOO	RED		WHITE	_ _._	._ _	_ _._	._ _	_ _._
06/19/96	OOOO	YELLO Mod B	_ _	BLACK	_ _._	._ _	_ _._	._ _	_ _._
06/22/96	OOOO	YELLO		WHITE	_ _._	._ _	_ _._	._ _	_ _._
06/19/96	OOOO	GREEN Mod C	_ _	BLACK	_ _._	._ _	_ _._	._ _	_ _._
06/22/96	OOOO	GREEN		WHITE	_ _._	._ _	_ _._	._ _	_ _._
06/19/96	OOOO	BLUE Mod D	_ _	BLACK	_ _._	._ _	_ _._	._ _	_ _._
06/22/96	OOOO	BLUE		WHITE	_ _._	._ _	_ _._	._ _	_ _._

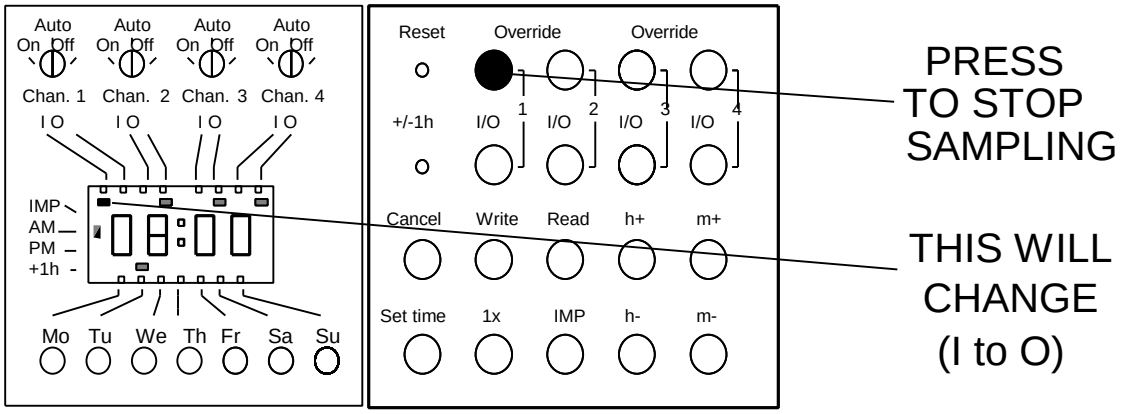
Lab Use Only | Comments

3. CHECK CURRENT DATE AND TIME. Verify that the current time and day displayed on the clock controller are correct. Make a note of any deviations from expected status on the log sheet. Following the procedures in Section 2.3.3 on setting the current time, correct the deviation if it is significant (for example if the wrong day of the week is displayed, or the time is off by one hour or more from the local time).
   a. At older sites, the clock controller will be inside the IMPROVE controller module, a non-sampling module containing only controller circuitry.
   b. At newer IMPROVE aerosol sampling sites, the clock controller is located inside the Controller Module A, a combination controller module and sampling module.
4. CHECK SAMPLING STATUS. Verify that the sampler status is correct. For assistance in reading the clock controller, review Section 2.3.1; Reading the clock controller display.
   a. For a normal change day, Sunday, Monday, or Tuesday, or for an incorrect Thursday or Friday change, the sampler should not be running. The indicator bars on the clock controller display under Chan 1 and Chan 2 should both be under the "O" or Off position.
   b. NOTE: For a change on a sampling day, Wednesday or Saturday, the sampler may be running. If the site has a lock out device, the solenoids and pumps will be prevented from re-exposing the filters. If not, the sampler will be running. The clock controller will indicate the following.
      - WEDNESDAY CHANGE: the indicator bars on the clock controller display will be under the Chan 1 "I" (On), and will be under Chan 2 "O" (Off).
      - SATURDAY CHANGE: the indicator bars on the clock controller display will be under the Chan 1 "O" (Off), and will be under Chan 2 "I" (On)

1.3 Recording of Final Data and Removal of Exposed Cassettes.

1. PREPARE FOR MANUAL OPERATION. Set the sampler in manual mode.
   A. WEDNESDAY CHANGE: SPECIAL INSTRUCTIONS. See Figure 2 Override Channel 1. Press the Channel #1 override button, in the top row of buttons on the clock controller, until the black rectangle on the clock display moves from being under Chan 1 "I" to Chan 1 "O". This turns off the Wednesday sample, the filter that would be currently running, so that it will not interfere with the sample change procedure.

Figure 2 Override Channel 1



A. SATURDAY CHANGE: SPECIAL INSTRUCTIONS. Press the Channel #2 override button, in the top row of buttons on the clock controller, until the black rectangle on the clock display moves from being under Chan 2 "I" to Chan 2 "O". This turns off the Saturday sample, the filter that would be currently running, so that it will not interfere with the sample change procedure. See Figure 2, but press the second button from the left in the top row of buttons on the controller. Instead of Chan 1 indicator changing, the Chan 2 indicator will move from "I" to "O".

II. SET FOR MANUAL OPERATION.

A. For an IMPROVE controller module, turn the 30 minute timer dial clockwise to 30 minutes to turn on the pumps and set the sampling modules to manual control. Note that if the 30 minutes expires before the sample change is completed, the pumps will turn off and the sampling modules will return to auto control. Once the pumps turn off, the vacuum in the system will prevent them from turning back on immediately. You may wait five minutes, or you can release the vacuum in the samplers by pressing the toggle switches on each sampling module to release the vacuum. Once the vacuum is released, you may restart the pumps and return to manual mode by turning the timer to 30 minutes.

B. For a Controller Module A, simply turn the pump override switch on the face plate to "on" or "manual".

I. COLLECT FINAL READINGS. Take final readings for the exposed cassettes in each sampling module. See Figure 3 for a labeled view of a sampling module.

A. Press the filter 1 toggle switch and record the small gauge and magnehelic gauge readings on the log sheet for each sampling module.

B. Repeat step a for filter 2.

C. Record the elapsed times (in tenths of hours) for each filter on the log sheet. Times of 24.0 hours are expected.

D. Zero the elapsed timers by pressing the reset button on the left side of the elapsed timer face. Note, you may need to press it several times to return the value to 00.00.

E. Note any unusual findings, circumstances, or problems with the previous week's sample, including local construction, fires, thunderstorms, power outages, etc. When finished, place the completed log sheet in the appropriate labeled shipping bag.

II. REMOVE EXPOSED FILTERS. To remove the exposed filter cassettes;

A. unscrew the knurled knob holding the cassettes on the cyclone enough to lift the filter hold down clamp and remove the cassettes.

B. Install the protective red caps on the cassettes.

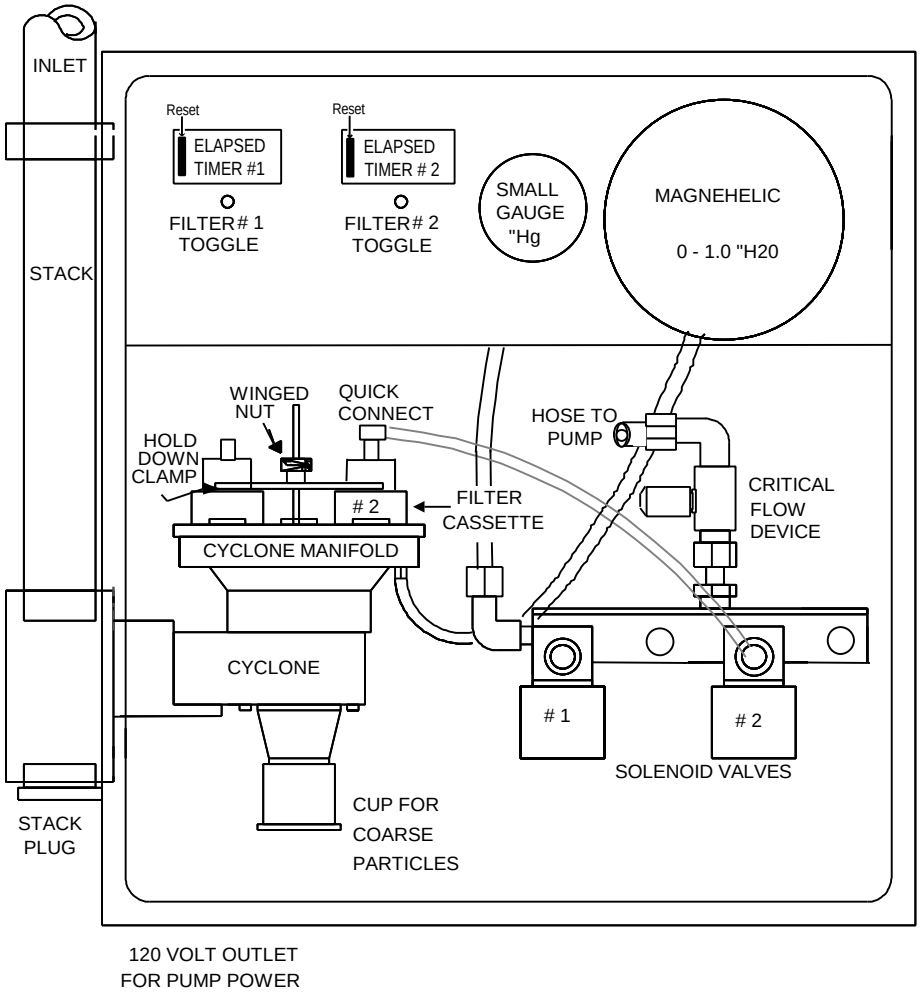
C. Remove the cassettes from the sampler by pressing the quick disconnect button (gray) and gently pulling the cassette away from the hose to the solenoid.

D. Place the exposed cassettes in the shipping bag with the corresponding log sheet.

E. Seal the shipping bag and return it to the appropriate blue shipping box.

F. Check the blue shipping box. If both weeks of cassettes in the blue box have been used, close the box, and reverse the mailing label to send it back to the Air Quality Group.

Figure 3 Labeled Diagram of IMPROVE Sampling Module



1.3 Installation of Clean Cassettes and Recording of Initial Data.

1. CHECK NEW FILTERS. Remove the blank log sheet from the current week's shipping bag. Check the date on the box and log sheet to verify the correct week of cassettes is being used. If the date is wrong, find and use the correct week of filters. If the correct week cannot be found, or are inaccessible, use the incorrect box, but note the substitution, and call the Air Quality Group immediately to advise them of the changes.

2. FILL OUT LOG SHEET. Record the current date, time, and the operators initials on the log sheet. If the current day is a Wednesday or Saturday, note this on the log sheet and carefully follow the additional instructions in sample change steps listed below.

3. SORT CASSETTES. Select the two cassettes for each sampling module, recalling the color coding duplicated below from Table 1, or following the labels on the tags.

Module	Channel	Sample Day	Filter Color Code	Label
A	1	Wednesday	red, black	date-A1
	2	Saturday	red, white	date-A2
B	1	Wednesday	yellow, black	date-B1
	2	Saturday	yellow, white	date-B2
C	1	Wednesday	green, black	date-C1
	2	Saturday	green, white	date-C2
D	1	Wednesday	blue, black	date-D1
	2	Saturday	blue, white	date-D2

4. INSTALL THE CASSETTES. Install the cassettes in the sampling modules.
   A. Remove the protective red caps, storing them in the shipping bag, and place the cassettes on the open ports on the cover plate of the cyclone.
   B. Tighten the hold down clamp onto the cassettes using the knurled knob. Be sure the cassettes and cyclone port caps are securely seated on the o-ring fittings on the cover plate.
   C. Connect the quick connect on the hose from solenoid #1 (the solenoid on the left side of the manifold, labeled with Wednesday sample colors) to the Wednesday cassette on the cyclone. Verify the hose connection has clicked and locked into place on the cassette fitting.
   D. Connect the quick connect on the hose from solenoid #2 (the solenoid immediately to the right of solenoid #1 on the manifold, labeled with Saturday sample colors) to the Saturday cassette on the cyclone. Verify the hose connection has clicked and locked into place on the cassette fitting.

NOTE: while most IMPROVE sites have only two solenoids, a few that were used for special studies may have four solenoids. Generally, in A, B, or C module samplers with four solenoids, the Wednesday and Saturday solenoids are solenoid 1 and 2 respectively (solenoids are numbered from left to right in the sampler). Solenoids 3 and 4 are not used. In D module samplers with four solenoids, generally, solenoids #1 and #4 are used.

5. RECORD INITIAL DATA. Record the initial readings for the clean cassettes in each module.
   A. Press the filter 1 toggle switch and record the initial small gauge and magnehelic gauge readings in the corresponding columns on the log sheet. Verify the readings are within the range indicated with a colored marker pen on the face of each gauge.
      - If the readings are out of range, verify the cassettes are securely seated on the cyclone, and the hoses are locked into position on the cassettes.
      - If the readings remain out of range, check the troubleshooting guide in this manual for potential causes.
      - If the readings remain out of range, and no cause is found, call the Air Quality Group for further instructions.
   B. Repeat step a. for filter 2.

C. Verify the elapsed time indicators for each channel read 00.00. If not, zero the elapsed timers by pressing the reset button on the left side of the timer face. Note, you may need to press it several times to return the value to 00.00.

D. Record the vacuum gauge reading with no toggle switches held "on" in the Max Va. column for each sampling module. It should read between 18" Hg and 29" Hg depending on the elevation of the site (higher elevations will have lower Max Vac readings.)

E. Place the completed log sheet in the appropriate labeled shipping bag with the protective red caps, and replace the bag in its blue shipping box.

6. PREPARE FOR AUTOMATIC SAMPLING. For Wednesday or Saturday sample changes, return the sampler to its correct configuration for IMPROVE protocol sampling.

   A. WEDNESDAY CHANGE: SPECIAL INSTRUCTIONS. press the Channel #1 override button, in the top row of buttons on the clock controller, until the black rectangle on the clock display moves under Chan 1 "I". This turns on channel #1, the channel scheduled to be running, since the clock controller can only switch this channel to "ON" at the time and date programmed into the clock, namely 12:00am on Wednesday.

   B. SATURDAY CHANGE: SPECIAL INSTRUCTIONS. press the Channel #2 override button, in the top row of buttons on the clock controller, until the black rectangle on the clock display is under Chan 2 "I". This turns on channel #2, the channel scheduled to be running, since the clock controller can only switch this channel to "ON" at the time and date programmed into the clock, namely at 12:00am on Saturday.

7. RETURN TO AUTOMATIC SAMPLING. Return the sampler to auto mode in preparation for IMPROVE protocol sampling.

   A. For an IMPROVE controller module (non-sampling module containing controller circuitry), turn the 30 minute timer to 0 minutes to turn off the pumps and return the sampler to automatic mode. Then, close the door to the controller and all sampling modules.

   B. For a Controller Module A (a Module A sampler containing controller circuitry, used instead of a separate controller module at new sites), turn the pump override switch on the faceplate from "ON" or "MANUAL" to "OFF" or "AUTO" to return the sampler to automatic sampling mode. This will switch control of the pumps back to the sampler.

8. SECURE SITE. Close the sampling module doors, and return the cassettes to a safe location.

1.4 Monthly Equipment Checks.

Some of the IMPROVE aerosol sampling equipment requires regular checks and occasional maintenance. The following checks should be made at monthly intervals.

1.4.1 Emptying the Water Bottle on the Sierra PM_{10} Inlet.

If the site has a Sierra PM_{10} inlet on the D module stack, extra maintenance is required. Sierra inlets have plastic or glass bottles attached to them to catch the water that condenses in or is blown into the PM_{10} inlet. This prevents the particle trap filling with water and overflowing to run down the stack onto the filter.

1. Unscrew and drain the plastic or glass bottle on the Sierra PM_{10} inlet whenever it begins to fill with water. It should be drained whenever the bottle approaches half full.
2. When the bottle is drained, check it for cracks or chips that could allow air to leak into the inlet through the bottle. If chips or cracks are found, call the Air Quality Group to request a replacement.
3. Reinstall the bottle, tightening it snugly into place.

1.4.2 Verify the Integrity of the Stand.

1. The gauges on the samplers are sensitive to vibration. Make sure that the pumps or other equipment are not causing undue vibration of the samplers. If there is vibration, the cause should be moved or insulated.
2. The D module inlet can be blown around excessively in the wind. If this movement is extensive, guy lines to the inlet cap should be installed or tightened.
3. The IMPROVE aerosol sampler is not fragile, but if the stand on which it is mounted falls over, it could be damaged. If the stand or mounting surface seems shaky, repair or brace it.

1.4.3 Verify the Integrity of the Filter Mounting Ports.

1. There should be four cassette mounting ports on each cyclone cover plate. If not, check the inside of the module, and the recently removed cassettes to determine whether the port may have accidentally popped out of the cover plate. If the port cannot be found, call the Air Quality Group for a replacement.
2. Each mounting port should have an o-ring. If the o-ring is missing, the port will leak resulting in the loss of data.
3. Two of the ports should be covered by cyclone port covers. These covers should fit snugly on the mounting ports as if they are loose, they will leak, resulting in invalid data. If the covers are loose, verify that the o-ring on the mounting port is intact. If not, replace the o-ring. If the port covers are at fault, call the Air Quality Group and request replacements.

1.5 Field Blank Procedures.

For quality control, roughly 2% of the filters in the IMPROVE network are field blanks. Field blanks are collected to determine the amount of material, the artifact, picked up by the filter cassettes during the shipping, installation, removal, and laboratory processing procedures.

Field blank cassettes are not treated differently than normal sampling cassettes, except that field blanks do not have air drawn through them. The Air Quality Group keeps records of when field blanks were sent to each site, and maintains a balance of types and frequency of blanks collected.

When a field blank is sent to a site, the normal blue shipping box will have a page of instructions and one extra cassette marked with a purple band of tape . The field blank cassette will also have the standard color bands and identification stickers to indicate in which module it should be installed. Keep the field blank with the filter cassettes having the same sample date.

To install the field blank in the indicated module, remove a cyclone port cover from an unused port on the cyclone cover plate and mount the field blank as a "third" cassette. The blank cassette is sealed and does not need a quick connect hose.

Upon completion of sampling, during your next weekly service, remove the field blank cassette and place it in the shipping bag with the other exposed cassettes bearing the same sample date labels. Reinstall the cyclone port cover in its correct position. Seat the port cover firmly on the O-ring port fitting to assure an air-tight seal.

2.0 Operator Assisted Determination and Repair of Malfunctioning Samplers

The procedure for determining and repairing potential malfunctions at an IMPROVE site involves three basic steps. First, the site operator or Air Quality Group personnel determine a problem may exist. Next, using troubleshooting procedures, the problem is diagnosed. Finally, if urgent, the problem is resolved by the site operator. Malfunctions that may result in loss of data, or increased error bars in the final data set are considered urgent. Site operators are instructed by Air Quality Group personnel on the performance of urgent repair procedures when necessary. Non-urgent repairs are noted in site logs for repair by field technicians during the next annual maintenance trip. The troubleshooting procedure is described in the sections listed below:

2.1 Determination of Sampler Malfunction.

2.2 Troubleshooting and Repair Procedures.

2.1 Determination of Sampler Malfunction.

Determination of sampler malfunction is not always a simple task. The site operator should watch for the following during the weekly sample changes.

1. Unusual elapsed time readings
2. Low readings on the vacuum gauge (small gauge) with no solenoids open.
3. Pumps not starting or hesitating for long periods of time before starting.
4. Incorrect time or date displayed on the clock controller
5. Incorrect or missing programs in the clock controller
6. Out of range or unusual readings on the gauges when the solenoids are open
7. Physical damage such as burned wires or transformers

2.2 Troubleshooting and Repair Procedures.

When a problem is suspected, the following tables may be used to determine the cause of commonly seen malfunctions and the procedures required to correct them. In the event of a suspected problem, the Air Quality Group should be notified. The Lab Manager, Field Specialist, or Lab Technicians are trained to provide assistance in determining the cause and effecting the solution to common sampler malfunctions.

The following materials are those most commonly required for sampler repairs.

- IMPROVE Aerosol Sampler Operations Manual.
- Parts and/or instructions from Air Quality Group personnel
- Voltmeter (AC)
- Crescent wrench
- Screwdrivers, both Phillips and Standard
- Needle nose pliers
- Wire clipper and crimping tool
- Note paper and pencil or pen to record action taken and results to forward to the Air Quality Group.

Table 2 Elapsed Timer Diagnostics

Display Problem	Check	Possible Diagnosis	Remedy
0000.00-0000.05	The filter has a visible deposit	The time indicator dials are stuck in position. OR	reset and replace if the problem repeats
		The connection to the terminal strip is loose.	check connections
	The filter does not appear to have collected a sample.	There is a clock controller program error. OR	check the programs in the clock controller.
		There is a loose wire between the clock controller and the terminal strip, or on the relays.	Turn off the power and check the wire connections
Elapsed times are less than 24.00	The time is short on all channels.	There was a power outage at the site during the sampling period.	check the fuses and breakers, and verify the clock controller is functioning.
	The time is short in subsequent weeks.	The clock controller program is in error. OR	Verify the programs in the clock controller.
		There is a loose wire connection to the clock controller or to the relays.	Turn off the power and check the wire connections.
	The time is short on only one channel.	The time indicator dials are sticking in position.	Reset the elapsed timer; replace it if the problem repeats.
Elapsed times are more than 24.00	The time is exceeded on only one channel.	The operator did not or could not reset the elapsed timer	Confirm no operator error occurred. Send replacement timer if necessary.
	The time is exceeded on all channels.	There may be a clock controller program error.	Verify the programs in the clock controller.
Cannot reset the elapsed timer to zero.		The reset mechanism is gummed up or corroded.	Spray graphite lubricant into the reset button slot. Press the button several times to work in the lubricant.

General Information on Elapsed Timers: Elapsed times other than 24.00 may result from a number of operator errors. It is generally necessary to look at the logs from several weeks of sampling to determine if there is really a malfunction and diagnose it. If the remedies listed above do not work for problems involving an individual timer it should be replaced.

Table 3 Pump Diagnostics

Problem	Diagnosis procedure	Remedy	Effect on samples
Low maximum vacuum (Max Vac) reading.	Tap the pressure gauge to determine whether the vacuum gauge indicator needle is sticking. IF NOT, THEN:	Call the Air Quality Group for a replacement vacuum gauge. Unscrew the vacuum line between the gauge and the manifold. Unscrew the two clamps holding the gauge in place. Remove the old gauge and install the new one. Reattach vacuum line and test for leaks.	None, but vacuum gauge data prior to the repair is labeled as questionable, and an audit must be sent to the site for a new vacuum gauge calibration.
	Check the system for vacuum leaks (listen for air leaks). IF NONE, THEN:	Tighten or replace leaking connections. Replace damaged lengths of vacuum hose.	The samples are bad if the flow rate was not critical.
	Replace the pump.	Call the Air Quality Group for a new pump. Unscrew the vacuum line from the old pump and unplug the pump from power. Tighten the vacuum line fitting onto the new pump and plug it into the power plug used by the old pump. Ship the old pump back to the Air Quality Group.	The samples are bad if the flow rate was not critical during a sampling period.
The Maximum Vacuum (Max Vac) reading is decreasing through time.	Replace the pump.	See the description above.	The data are questionable if the flow rate was not critical during a sampling period.
A pump will not start.	Check whether the vacuum gauges indicate there is vacuum in line. IF NOT, THEN:	Press one of the toggle switches in each module to release the vacuum.	No effect on the samples if corrected.
	Verify the pump is plugged in and has power. IF YES, THEN:	Use a voltmeter to check for power at the outlet when the sampler is in manual mode (the pumps are on).	Verify previous weeks filters collected samples. If not, they may be invalid.
	Replace the pump.	See the description of pump replacement four rows up.	The samples are bad if the flow rate was not critical during a sampling period.
The pump is very noisy.	Check whether the mufflers are broken or missing. IF NOT, THEN:	Call the Air Quality Group for replacement parts, then remove the broken mufflers and replace them with new ones, or with brass nipples.	No effect on the samples.

	Replace or repair the pump during the next scheduled maintenance trip.	See the description of pump replacement six rows up.	No effect on the samples.

Table 4 Clock Controller Diagnostics

Display	Diagnosis Procedure	Remedy	Effect on samples
blank display screen or slow response to command input	Check for power at the modules using a voltmeter. IF HAVE POWER, THEN:	Return power to the site. Then, press the reset button on the clock controller face, reset the current day and time, and reprogram the clock controller, following the instructions in Section 2.3	No samples were collected from the time of the outage since the programs were lost.
	If the temperature of the clock controller is below zero, the display will go black. Verify the heater in the module with the controller is working.	The clock will be fine when it warms up, but at cold sites the heater is necessary. Turn off the power and check for loose wires. Call the Air Quality Group for specialized instructions.	The samples are probably fine, only the clock display is affected.
flashing or "weird" display	Probable cause was a power outage at the site. The internal battery in the clock controller should hold the programs for a week without power, but the batteries occasionally fail. Generally, the display will show a current time of 12:00 when this occurs.	Press the reset button on the clock controller face, then reset the current day and time and reprogram the clock controller. If the power outage causing the problem was short (less than 1 day), or it is a recurring problem, the Air Quality Group will send a replacement clock.	No samples were collected from the time of the outage since the programs were lost.
incorrect time	The clock controller displays the wrong current time. NOTE: current time is always local time. In states running daylight savings time, the clock time must be reset twice per year.	Reset the current time, check the programs, and reset/reprogram if necessary, following the instructions in Section 2.3	Samples will be collected, but at incorrect times.
lost program	A clock controller program is missing. Either the elapsed times for channel 1 or channel 2 in all modules is 00.00, or is much greater than 24.00.	Reprogram the clock, following the instructions in Section 2.3	Samples on the affected channel are invalid.
incorrect program	The elapsed times for channel 1 or channel 2 are not 24 hours, and one of the clock controller programs is found to be incorrect.	Reprogram the clock, following the instructions in Section 2.3. Attempt to determine when the program was last checked.	Samples collected since the last program check are flagged as questionable.

General information: Clock battery can be checked by powering down sampler at breaker or pulling controller fuse and waiting at least 20 minutes. If time and program are retained, battery is OK. If above measures fail to restore normal operation, the controller should be replaced.

The following is an IMPROVE sampler flow anomaly diagnosis list. For the following list, "high" magnehelic means a reading higher than normal which corresponds to a perceived higher flow. "High" small gauge means a reading higher than normal, which corresponds to a perceived lower flow.

Table 5 A, B, C Module Flow Anomaly Diagnosis List

Magnehelic	Small Gauge	Problems	Things to check
High	High	Sticky small gauge (vacuum gauge) and a damaged or missing filter. OR:	Tap vacuum gauge. If the reading drops, the gauge is sticking and should be lubricated following the procedures in the first row of Table 3.
		Flow rate set too high	Call and request a flow rate audit.
	Norm	Multiple channels open simultaneously.	Read the indicator on the clock controller to see what channels are on. If more than 1 is on, turn the extra ones off. Then, check the clock controller program.
		For modules having small gauge readings (vacuum gauge) typically less than 1" Hg, there may be an obstructed magnehelic line. For modules having small gauge readings typically greater than 1" Hg, see the cases where Magnehelic = High, Small Gauge = Low	Remove and clear magnehelic hoses, and use a piece of wire to check the nipples on the cyclone and gauge are clear.
	Low	Damaged or missing filter OR:	Remove the cassette and look at the filter. If it is damaged or missing, make a note on the log sheet, and call the Air Quality Group for further instructions.
		Multiple channels open simultaneously.	Read the indicator on the clock controller to see what channels are on. If more than 1 is on, turn the extra ones off. Then, check the clock controller program.
Norm	High	Sticky small gauge (vacuum gauge)	Tap the small (vacuum) gauge before recording readings. If the problem is serious, the gauge should be lubricated following the procedures in the first row of Table 3.
	Norm	Great	
	Low	Sticky small gauge (vacuum gauge)	Tap the small (vacuum) gauge before recording readings. If the problem is serious, the gauge should be lubricated following the procedures in the first row of Table 3.
		Operator not reading the small gauge properly	Send operator gauge diagrams with correct readings displayed.

Table 5 A, B, C Module Flow Anomaly Diagnosis List (continued)

Low	High	If seen during initial readings, a double filter was installed in the cassette.	Call the Air Quality Group for further instructions.
		If seen during final readings, the filter in the cassette is clogged.	Should only be seen with heavily loaded filters.
	Norm	Blocked or leaking magnehelic hose or nipple	Remove and clear magnehelic hoses, and use a piece of wire to check the nipples on the cyclone and gauge are clear.
		Missing cyclone cover plate insert o-rings.	Remove cyclone port caps and cassettes. Check the cover plate inserts, the fittings the cassettes and caps mount on, to verify they are not missing. If they are missing, check the cassettes removed last to verify the insert is not stuck in the cassette. If the insert is missing, a new one will be sent. Verify each insert has an o-ring installed. If not, replacement o-rings will be sent.
		Loose cyclone port cap.	Remove cyclone port covers.
		Missing cyclone throat	Remove lower catch cup on cyclone (pull down.) Unscrew the lower cyclone funnel (2 to 4 pan head screws) and remove it. The cyclone throat is a black metal tube with an o-ring groove. It is approximately 1½ " long, and ½ " in diameter. It should be fitted up inside the cyclone. If it is loose inside the lower funnel, check the o-ring, wiping it with a lint free cloth to remove any dirt or excess lubricant, and re-install it in the cyclone. If the o-ring is damaged or missing, a replacement will be sent. Be sure to re-attach the lower funnel and catch cup.
		Cyclone cup or bottom funnel loose, or missing o-rings.	Verify the cyclone is completely assembled. If the problem persists, contact the Air Quality Group, then take the cyclone apart looking for locations that should have o-rings but do not. Replacement o-rings will be sent.
	Low	The pump may be failing IF NOT, THEN:	Swap the pump with one from another module (unscrew and exchange the vacuum lines) to see if the vacuum improves. If the pump is bad, call the Air Quality Group for a replacement.
		There may be a leak somewhere between cassette and pump. If the Max Vac reading is normal (closed solenoid vacuum reading) IF MAX VAC IS LOW, THEN:	The leak is in a cassette, hose or connector. Check for loose or damaged hoses, cassettes, and fittings and replace with spares if possible. Call the Air Quality Group for replacement parts or instructions.
		Leak is somewhere between the solenoid and the pump. IF STILL LOW, THEN	If the Max Vac reading is low, then the leak is in the pump line. Check for damaged vacuum tubing, loose fittings, etc.
		Have a clogged critical orifice. OR:	Call the Air Quality Group for a replacement.
		The flow rate is set too low	Request a flow rate audit.

If the magnehelic zero remains high after sampling is terminated, check the procedures for Low-Norm above.
Note: These problems can occur in any combination which could complicate diagnosis.

The following is the IMPROVE D-module flow anomaly diagnosis list. For the following list, "high" magnehelic means a reading higher than normal which corresponds to a perceived higher flow. "High" small gauge means a reading higher than normal, which corresponds to a perceived lower flow.

Table 6 D-Module Flow Anomaly Diagnosis List

Magnehelic	Small Gauge	Problems	Things to check
High	High	Sticky small gauge (vacuum gauge) and a damaged or missing filter. OR:	Tap vacuum gauge. If the reading drops, the gauge is sticking and should be lubricated following the procedures in the first row of Table 3.
		The flow rate is set too high.	Request a flow rate audit.
	Norm	Small leak in high pressure magnehelic hose	Look for leaks in high pressure magnehelic hose. A replacement hose will be sent if necessary.
		For sites at which the small gauge reading is normally <1.0" Hg, multiple channels may be open simultaneously.	Check the clock controller display to determine whether multiple channels are open. Use override switches to turn off extraneous channels. Verify the programs are correct.
	Low	Damaged or missing filter installed in a cassette.	Look at the filter. If it is damaged or missing, call the Air Quality Group for further instructions.
		Multiple channels open simultaneously. (check for flow through more than one solenoid simultaneously) IF NOT, THEN:	Check the clock controller display to determine whether multiple channels are open. Use override switches to turn off extraneous channels. Verify the programs are correct.
		Check for a leak in the high pressure magnehelic hose. IF NOT, THEN:	Check for leaks in the magnehelic hoses. If the ends are split, clip them off and re-install the hoses, or request replacements.
		Check for a crack in the magnehelic faceplate.	If the faceplate is cracked, request a replacement.
Normal	High	Sticky small gauge	Tap vacuum gauge. If the reading drops, the gauge is sticking and should be lubricated following the procedures in the first row of Table 3.
	Normal		
	Low	Sticky small gauge (vacuum gauge)	Tap the small (vacuum) gauge before recording readings. If the problem is serious, the gauge should be lubricated following the procedures in the first row of Table 3.
		Operator not reading the small gauge properly	Send operator gauge diagrams with correct readings displayed.

Table 6 D Module Flow Anomaly List (continued)

Low	High	If seen during initial readings, a double filter was installed in the cassette.	Call the Air Quality Group for further instructions.
		If seen during final readings, the filter in the cassette is clogged.	Should only be seen with heavily loaded filters.
	Normal	Blocked or leaking magnehelic hose or nipple OR:	Remove and clear magnehelic hoses, and use a piece of wire to check the nipples on the cyclone and gauge are clear.
		Small leak in the low pressure magnehelic hose.	Check for leaks in the magnehelic hoses. If the ends are split, clip them off and re-install the hoses, or request replacements.
	Low (or nominal, if nominal is typically <1.5" Hg.)	The pump may be failing IF NOT, THEN:	Swap the pump with one from another module (unscrew and exchange the vacuum lines) to see if the vacuum improves. If the pump is bad, call the Air Quality Group for a replacement.
		There may be a leak somewhere between cassette and pump. If the Max Vac reading is normal (closed solenoid vacuum reading) OR:	The leak is in the cassette, and the Air Quality Group should be called for further instructions.
		May have a leak in the low pressure magnehelic hose. OR:	Check for leaks in the magnehelic hose. If the ends are split, clip them off and re-install the hose, or request a replacement.
		Probably have a clogged critical orifice.	Call the Air Quality Group for a replacement.

Other reading problems not related to sample flows:

1. Magnehelic zero remains high after sampling is terminated.

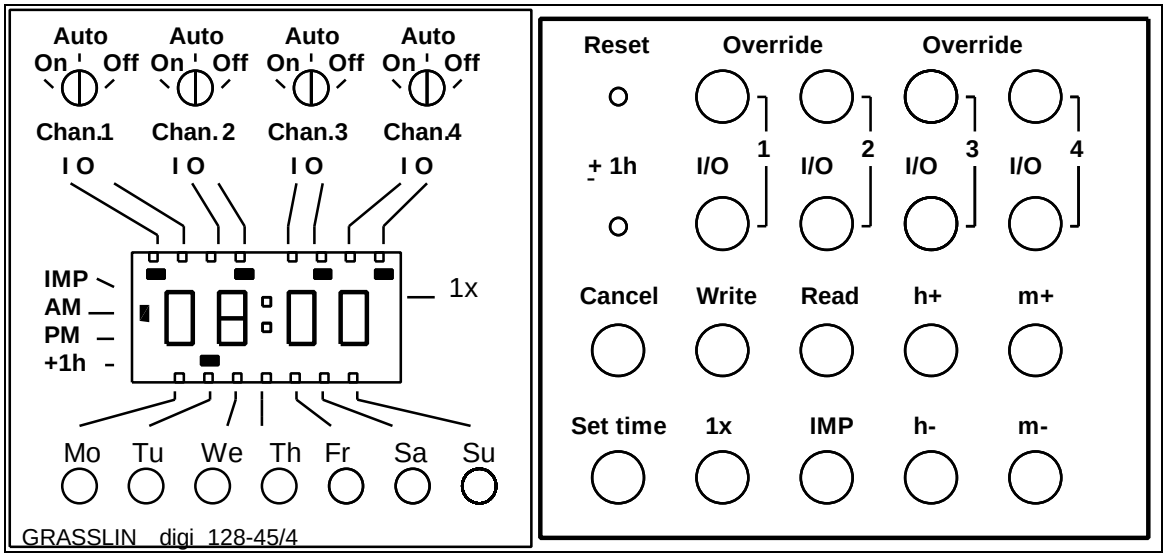
Check: Same as Low-Norm above.

Note: These problems can occur in any combination which could complicate diagnosis.

2.3 Programming the Clock Controller.

The controller clock operates the pumps and the filter solenoids. The clock has four time channels, each controlling its own solenoid valve. Channel 1 corresponds to Filter 1, Channel 2 to Filter 2, etc. Each one of the four channels is independently programmable on a weekly cycle. The left side of the clock contains the clock and status lights. The right side contains the override and programming buttons. The clock has a four to seven day battery backup; if this is exceeded, the clock goes blank or reads 12:00 a.m., and the time and memory will have to be reset. The clock has a specified operating range of -4° to +120°F. Figure 2 shows the clock face and the program buttons. These buttons are normally covered by a protective cover plate, on the back of which is printed programming procedures.

Figure 4 Clock Controller with Cover Plate Removed



2.3.1 Reading the Clock Controller Display

The clock uses 12-hour notation, with the hour and minute indicated directly and the a.m./p.m. shown by a black rectangle to the left of the time display. The day of the week is indicated by a black rectangle on the bottom of the time display. The status of each of the four output channels is indicated by black rectangles at the top of the time display. A black rectangle under "I" indicates the channel is ON (open) and a black rectangle under "O" indicates the channel is OFF (closed). When channel #1 is on, the solenoid for filter #1 is open, the vacuum pump is on, and a sample is being collected. The status shown in figure 5 is Tuesday, 8:00 a.m., with channel 1 on, and channels 2,3, and 4 off.

2.3.2 Clock Controller Settings and Buttons

The following section describes the default settings used in IMPROVE protocol sampling, and the purpose of the buttons on the clock controller. Procedures to use the described buttons will follow in sections 4.3.3 and 4.3.4.

OVERRIDE SCREWS.

The four screws above the clock display should all be set to auto. Each screw represents the channel above which it is located. Setting a screw to "on" will force that channel to be always on. Similarly, setting a screw to "off" will force that channel to be always off. Since we want to use programs to turn channels on and off, the screws must be set to "auto".

RESET BUTTON.

The reset button is a recessed button to prevent it's being used accidentally. This button clears and erases all programs and time of day settings, but also clears internal errors in the clock that may be caused by power surges.

TOP ROW OVERRIDE BUTTONS.

The override buttons in the top row can be used to reverse the status of any respective channel (on to off, off to on). This effect continues until canceled either by pressing an override button or by commands from a program in the controller. The override button is used to interrupt or restart current sampling. As an example of its use, imagine the cassettes were not changed until 8:10 am on the Wednesday sample date. The modules will not be collecting samples before the change due to the lockout device, but Channel #1 will be on. It must be turned off using the override button before making the change, then, after the change, it must be turned back on to collect the Wednesday sample. The clock controller will not turn channel #1 on except at 12:00 am on Wednesday. It does not check what condition each channel should currently be in, it only turns channels on or off at the programmed time.

± 1h BUTTON.

The "± 1h" button is not used at any time. If a rectangle appears on the display to indicate the ± 1h function is being used, it should be turned off immediately by using a pen or pencil to press the "± 1h" button. If, after several attempts, the function will not turn off, use a pen to press the reset button, then reprogram the clock controller.

SECOND ROW OVERRIDE BUTTONS.

The override buttons in the second row, labeled "I/O", are used in programming the status of each respective channel (on, off, or not indicated). Programming the clock controller is covered in Sections 2.3.3 and 2.3.4.

CANCEL BUTTON.

The "cancel" button is a programming button. It is used to delete an existing program. To use the cancel function, press the "read" button until the program to be deleted appears, then press the "cancel".

WRITE BUTTON.

The "write" button is a programming button. It is used to store the current information on the display screen in memory as a program. Use of the write button is covered in the programming section, Sections 2.3.3 and 2.3.4

READ BUTTON.

The "read" button is a programming button. It is used to review programs stored using the "write" button. It will always read the programs in the same order.

h+ BUTTON.

The "h+" button advances the time displayed on the clock by 1 hour each time it is pressed. Similarly, the "h-" button sets the time back by 1 hour each time it is pressed. When it is pressed while the "set time" button is being pressed, it will change the current time display. For programming, it is used without pressing the "set time" button.

m+ BUTTON.

The "m+" button advances the time displayed on the clock by 1 minute each time it is pressed. Similarly, the "m-" button sets the time back by 1 minute each time it is pressed. When it is pressed while the "set time" button is being pressed, it will change the current time display. For programming, it is used without pressing the "set time" button.

SET TIME BUTTON.

The "set time" button is held in when the current time is being set, or pressed to return the clock more rapidly from programming mode to the current time display status. It is used only to set the current time, not during programming for sampling.

IMP AND 1x BUTTONS.

The "1x" and "IMP" buttons are not used at any time. If a rectangle appears on the display to indicate the 1x or IMP functions are being used, it should be turned off immediately by pressing the respective button, or pressing the reset button and reprogramming the clock controller following the procedures in sections 2.3.3 and 2.3.4.

The clock display, except while the controller is being programmed, should always show the current time and day of the week. If it does not, press the "Set time" button and wait for twenty seconds. If the current time is still not displayed, the controller may be suffering from a malfunction. In this case, use a pen to press the reset button, then reprogram the clock controller following the procedures in sections 2.3.3 and 2.3.4.

2.3.3 Setting the Current Time

1. With one finger, hold in the "**set time**" button.
2. With the other hand, select the day of the week by pressing the button under the correct day until the black indicator rectangle appears. Figure 4, as an example, shows the current day of the week to be Tuesday.
3. If you select the wrong day, press the button under the indicated day to de-select it. The black rectangle will disappear, and the correct day may be selected by pressing the appropriate day button.
4. Set the current time, local standard time, by using the **h+, h-, m+, m-** buttons to set the hour and minute respectively. Recall that the clock shows twelve hour time, so a.m. and p.m. must be correct. Note also, 12:00 am is midnight while 12:00 p.m. is noon.
5. When the current time and date have been set and are correct, release the "set time" button. The : in the time display will blink on and off if the operation was done correctly.
6. If the colon is not blinking, verify that the date and current time are indicated on the display. If not, hold in the "set time" button and enter the missing information.

Set time (Example: Monday 8:38 AM)

Hold	"Set time"	button depressed
Press	"Mo"	button -- bar shows above Mo
Press	"h+"	button until 08:__ AM shows in display and bar shows next to AM
Press	"m-"	button until 08:38 shows in display
Release	"Set time"	button -- seconds dot flashes

2.3.4 Entering IMPROVE Protocol Programs

Each program consists of the following three elements:

1. 1 to 7 days of the week
2. time of day
3. on/off command for each of channel 1, 2, 3, 4 (open/close solenoid 1, 2, 3, or 4) using the second row of override "I/O" buttons.

To enter a program into the controller, enter the above three elements, and then press the "write" button. Continue until all programs have been entered. If you hesitate longer than 15 seconds between button-pushing, the clock reverts back to the time output mode and the program is not entered. To turn a channel on, press the I/O button in the second row once. To turn a channel off, press the I/O button twice. A third press of the I/O button will return the program line to its original blank state (results in no action for that channel). Every command is registered immediately with a black rectangle or as hour: minute.

You may cancel a program completely or modify one or more elements. Press the "read" button until the desired program is reached. To cancel completely, press "cancel." To change one or more elements, press the appropriate buttons and then press "write."

For standard IMPROVE protocol sampling, the programs in Figure 5 must be entered.

Figure 5 IMPROVE Clock Controller Programs

Program One (Channel 1 ON, Wednesday at midnight)

Press	"We"	bar shows above We
Press	"h +"	until 12:_ _ AM shows in display
Press	"m+"	until 12:00 AM shows in display
Press	channel 1 "I/O"	until bar appears in display below I for Chan. 1
Press	"write"	for program entry

Program Two (Channel 1 OFF, Thursday off at midnight)

Press	"Th"	bar shows above Th
Press	"h+"	until 12:_ _ AM shows in display
Press	"m+"	until 12:00 AM shows in display
Press	channel 1 "I/O"	twice until bar appears in display below 0 for Chan. 1
Press	"write"	for program entry

Program Three (Channel 2 ON, Saturday midnight)

Press	"Sa"	bar shows above Sa
Press	"h +"	until 12:_ _ AM shows in display
Press	"m+"	until 12:00 AM shows in display
Press	channel 2 "I/O"	until bar appears in display below I for Chan 2
Press	"write"	for program entry

Program Four (Channel 2 OFF, Sunday at midnight)

Press	"Su"	bar shows above Su
Press	"h+"	until 12:_ _ AM shows in display
Press	"m+"	until 12:00 AM shows in display
Press	channel 2 "I/O"	twice until bar appears in display below 0 for Chan 2
Press	"write"	for program entry

Program Five (Channel 3 ON, Sunday at midnight)

Press	"Su"	bar shows above Su
Press	"h +"	until 12:_ _ AM shows in display
Press	"m+"	until 12:00 AM shows in display
Press	channel 3 "I/O"	until bar appears in display below I for Chan 3
Press	"write"	for program entry

Program Six (Channel 3 OFF, Sunday at 12:01 A.M.)

Press	"Su"	bar shows above Su
Press	"h+"	until 12:_ _ AM shows in display
Press	"m+"	until 12:01 AM shows in display
Press	channel 3 "I/O"	twice until bar appears in display below 0 for Chan 3
Press	"write"	for program entry

2.3.5 Installing or Removing the Clock Controller.

If the clock controller has been determined to be malfunctioning, the Air Quality Group will send a replacement. When the replacement has arrived, you will need a flat head screwdriver to remove the old clock controller and install the new one.

To remove the clock controller:

1. Turn off the power to the sampler.
   - If it is a site with a separate controller module, carefully remove the fuse in the lower right hand corner of the controller module. Or, turn off the power to the site at the breaker.
   - If the site has an A module controller (the clock controller is inside a sampling module), turn the switch in the lower right hand corner of the module on the heater panel to the off position, or turn off power to the site at the breaker.
2. Unscrew the flathead screw holding the clock controller to the back plate on the module door. The screw runs through a hole between wire positions 8 and 9 on the bottom of the clock. The screw cannot be completely removed as it is part of the clock controller. It should be loosened until it moves freely up and down.
3. Gently, grasp the top of the clock and pull out and down until it comes off from the back mounting plate on the module door. If it doesn't come off relatively easily, check that the screw is adequately loosened.
4. Place the removed clock controller in a safe location, being careful to avoid damaging the circuit board or the parallel metal electrical contact plates on the back of the clock controller.

To install a new clock controller:

1. Remove the replacement clock controller from the protective wrapping material.
2. Carefully line up the metal plates on the back of the clock controller with the slots in the back mounting plate. Press the clock controller into place. It should fit snugly and line up perfectly with the back mounting plate.
3. Tighten the screw to hold the new clock controller in place on the back plate.
4. Return power to the site.
   - If it is a site with a separate controller module, carefully reinstall the fuse in the lower right hand corner of the controller module. Or, if the power was turned off at the breaker, turn it back on.
   - If the site has an A module controller (the clock controller is inside a sampling module), turn the switch in the lower right hand corner of the module on the heater panel to the on position, or, if the breaker was turned off, turn it back on. When the power is returned, you will hear a loud click. This is normal.
5. Check the clock controller display. It should come up after a few seconds and display a flashing 12:00 as the time.
6. Press the reset button on the clock controller using the tip of a pen or pencil.
7. Set the current time on the clock following the procedures of section 2.3.3
8. Program the clock controller following the IMPROVE protocol programs listed in section 2.3.4.
9. Return the old clock controller to the Air Quality Group in the box provided.

2.4 Sampler Leak Check

The operator may be asked to check for leaks in the vacuum system. This will occur if the Field Specialist determines that one of the modules is performing abnormally. Figure 6 shows the locations of the parts referred to below.

1. Check if the critical orifice holder junction has become loose. Figure 6 shows the location within the sampler. If the junction is loose, tighten with an adjustable wrench or an 11/16 inch open end wrench.

2. Check the magnehelic pressure hoses (see Figure 6). These may have become loose or cracked at either end. To check them, follow each hose with your hand to the ends where they attach to barbed connectors at the back of the magnehelic gauge and cyclone or orifice meter. When you reach the end, feel for cracks and pull on the hose to see if it is loose. If the hose comes off of the barb easily inspect the end for excessive stretching or swelling, cut off the damaged part with a knife or scissors as needed, and re-attach it securely.

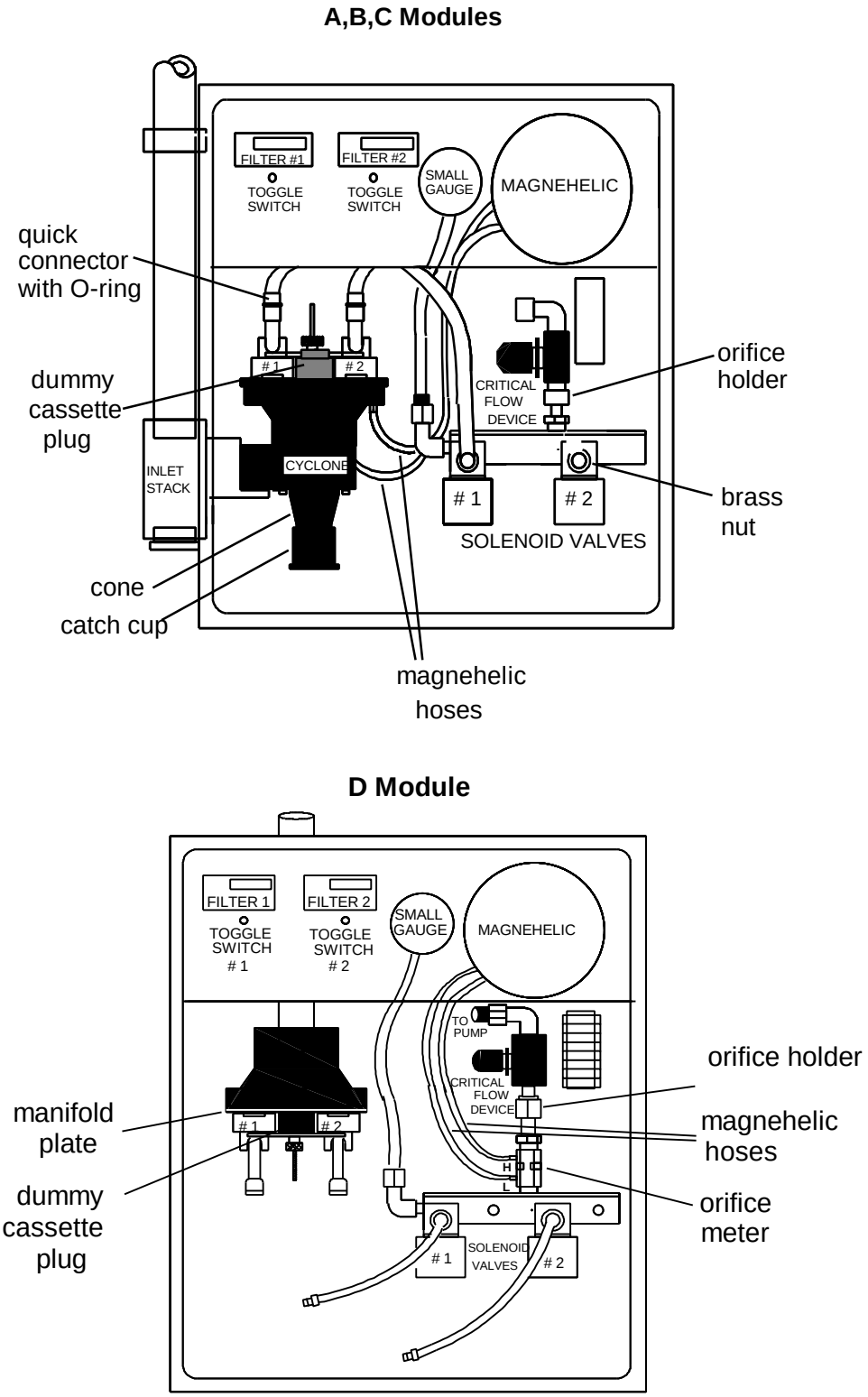
3. Check the filter cassette hoses. Make sure that the brass nuts which attach both filter cassette hoses to the respective solenoid valves are properly tightened. If the hose moves in and out of the brass nut when you pull on it unscrew the nut and re-attach the hose using a wrench if necessary. Also inspect the white plastic connector on the other end of the hose for cracking or damage to the black O-ring. Replace the hose with a spare if needed. (You should have a spare hose. Call the Air Quality Group laboratory if you have none.)

4. Check the top of the cyclone where the filter cassettes attach. Each port on top of the cyclone should have an insert with an O-ring on it, including the ones under the two dummy cassette plugs. If an insert is loose or missing call the Air Quality Group immediately.

5. Check the cone and catch cup at the bottom of the cyclone (see Figure 6). These two parts are connected by O-ring seals. Push on them to make sure they are properly attached.

6. For the D module, make sure the manifold plate is attached to the black inlet funnel so that there is no gap between the two parts.

Figure 6 Check Points for Sampler Leaks



3.0 Flow Rate Audits by the Site Operator

The site operator will be asked to perform a flow rate audit of the samplers in two cases: (a) to restore one of the modules in the sampler with an abnormal flow rate, and (b) as a routine Quality Assurance check of a normally operating sampler. In both cases, the site operator will be sent the necessary equipment and an instruction form. The instruction form includes spaces for all necessary information.

The procedures for site audits and calibrations are as follows.

3.1 Samplers with Anomalous Flow Rate Readings

3.2 Biannual Flow Rate Audit

3.1 Samplers with Anomalous Flow Rate Readings

The sampler gauge readings recorded on the log sheet by the site operator are evaluated at the Air Quality Group Laboratory. If these readings appear to be anomalous, or the flows derived from the two gauges do not agree, the site is marked as having a suspected flow problem. The Lab Manager or Field Specialist will telephone the site operator to discuss the problem. The initial step is to determine if the module has a leak. The site operator will be asked to check for leaks in the system (section 2.4) before performing the audit. The site operator will telephone these results to the Air Quality Group.

The site operator may be asked to make changes in the operation of the problem module. The necessary equipment and instruction letter will be sent to the site operator. The first step is a four-point flow rate audit to determine the current conditions (section 3.1.2). The site operator will telephone or FAX these results to the Air Quality Group. If this flow rate audit determines that the nominal flow rate is incorrect, the site operator will be asked to adjust the nominal flow rate (section 3.1.2) and repeat the flow rate audit (section 3.1.3).

The site operator should make a note of any changes on the normal field log sheet.

3.1.1 Initial Flow Rate Audit

The supplied equipment includes an audit device, four audit cassettes, and an instruction form. Instructions on how to assemble the audit device are included. The first step is to perform an audit of the current status of the sampler, called an initial audit. This data is vital as it will show whether the flow rate calculated from the sampler gauge readings is correct. Once the initial audit is performed, the data must be phoned or faxed to the Air Quality Group. The Lab Manager or Field Specialist will use this information to determine whether the site operator needs to perform any of the other steps on the form. The site operator should not adjust the nominal flow unless instructed to do so by Air Quality Group personnel.

3.1.2 Adjust Nominal Flow Rate

If the Field Specialist instructs the operator to change the flow rate through the sampler, the operator will be given the nominal audit device reading. The operator must adjust the critical flow device in the sampler until this reading is achieved on the audit device. Then, the operator must lock the critical flow device to prevent it changing flow rate. If the critical flow device is not locked in place at the appropriate flow rate, it may drift, resulting in bad data and a repeat of the audit procedure.

3.1.3 Final Flow Rate Audit

Once the operator adjusts the critical flow device, the operator must perform the final flow rate audit and phone or fax the results in to the Air Quality Group. The operator should keep the equipment until the Field Specialist certifies the results and requests their return. Occasionally, the equations from the audit are unsuitable and the audit must be repeated.

3.2 Biannual Flow Rate Audit

Flow audits are sent to randomly selected sites roughly six months following a site maintenance visit. The equipment sent will include an audit orifice meter, an extra funnel for the PM_{10} Module (D), and an instruction form. The audit is to be performed at the next normal weekly sample change. The operator will make a nominal flow rate check using the two clean cassettes for the next two sampling periods. The site operator will perform the listed steps and enter the results on the instruction letter. The operator will communicate the results to the Air Quality Group Lab Manager either by telephone or FAX. If the Lab Manager is satisfied with the results, the equipment will be returned to Davis by pre-paid mail.