IMPROVE Standard Operating Procedure

SOP 151
Installation of Samplers

IMPROVE Program
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UCDAVIS CROCKER NUCLEAR LABORATORY

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1. PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) describes the procedures for installing new aerosol sampling sites according to IMPROVE sampling network protocol.

The IMPROVE aerosol monitoring program is designed to collect quantitative information on the composition and concentration of fine ($PM_{2.5}$) aerosol particles that reduce visibility. Aerosol data provide information to decision-makers and the public on the state of Class I area visibility, causes of visibility impairment, and trends in visibility for a region. Finally, elemental analysis of aerosol samples can identify tracers for emission sources.

An IMPROVE aerosol sampling site generally has a controller and four sampling modules. The modules run in parallel; the controller sends the same signals to each module. The four standard sampling module types are A, B, C and D. Module A collects fine particles (0 – 2.5µm) on a stretched Teflon® filter, and provides data on elemental composition of fine particles. Module B collects fine particles (0 – 2.5µm) on a nylon filter, has a denuder before the nylon filter to remove acidic gases, and is used to quantify particulate anions (nitrate, nitrite, sulfate, and chloride). Module C collects fine particles (0 – 2.5µm) on a quartz filter to measure organic and elemental carbon. Module D collects coarse particles (0 – 10µm) on a stretched Teflon® filter, and provides data on PM_{10} mass loading. Some sites have a fifth module for collocated precision measurements (called an X module), which can be a duplicate of an A, B, C, or D module.

Each module is independent, with a separate inlet, sizing device, flow measurement system, critical orifice flow restrictor, and pump. All modules are wired to a common controller which, for IMPROVE sampling, is programmed to collect a twenty-four hour sample every third day from midnight to midnight.

The design is simple and rugged to withstand ambient field conditions, and for ease of operation and maintenance.

The purpose of this standard operating procedure is to facilitate installation of IMPROVE aerosol samplers, to assure consistent, quality data, and to minimize data loss by installing aerosol monitoring systems according to design specifications and EPA requirements.

2. SUMMARY OF THE METHOD

The principal investigator, field manager, and local contact work together to find a suitable location and prepare housing for new IMPROVE monitoring sites. The procedures and criteria for selecting new site locations are provided in SOP 126, “Site Selection for IMPROVE.” Lab personnel prepare boxes of filters to initiate sampling at the site. A field technician is sent to the location to install and calibrate the sampler, train the new operator(s), and to complete documentation of the site.

3. RESPONSIBILITIES

3.1 Principal Investigator:

The principal investigator shall:

- Approve final site configuration materials including photographic documentation, maps, installation location, and site configuration specifications.

- Verify funding and approval of the final site configuration and location by contacting the agency(s) or program(s) responsible for the funding of the site.

3.2 Field Manager:

The field manager shall:

- Schedule the aerosol sampler installation.
- Make suggestions on construction of the support structure for the aerosol sampler based on the site photos and descriptions returned with the siting document.
- As required, review the determined site preparation and installation requirements with the local contact.
- Schedule an operator training session for all identified operators and the primary local contact.
- Enter the site documentation and configuration information into the site database.
- Review the site calibration equations derived by the field technician.

3.3 Field Technician:

The field technician shall:

- Install the sampling modules at the site.
- Clean and test the sampling modules.
- Calibrate the sampling modules.
- Take photographs of the site and final equipment configuration and complete on-site documentation.
- Produce detailed directions for access to the site and create any necessary maps of the site location.

3.4 Lab Technician:

The lab technician shall:

- Initiate the new site in the aerosol samples and analysis databases.
- Create site-specific filter and sampling date identification labels for the new site.
- Assemble cassettes, shipping boxes, and labels for shipping samples between Davis and the new site.
- Verify the address to which the samples will be shipped.
- Send out the filters to initiate sampling at the site, as scheduled by the field manager.

3.5 Local Contact:

The local contact shall:

- Review the determined site preparation and installation requirements with the field technician.

- Identify and contact local land owners, primary contacts, and site operators regarding site installation and routine maintenance requirements.
- Finalize contracts with land owners for site installation and power usage.
- Perform any necessary site preparation prior to the installation (e.g. tree or brush removal, access road maintenance, electrical re-wiring to meet power requirements, aerosol sampler support structure construction, etc.).
- Maintain communications with the field technician and local land owners to confirm scheduled installation requirements.
- Schedule operator training session with the field technicians and the field manager.
- Provide site access and installation assistance as needed.
- Verify site location and geographic reference specifications documented by the field manager.

4. EQUIPMENT AND SUPPLIES

The materials required to install an IMPROVE aerosol sampler depend on the type of installation; in an existing building, in a newly constructed sampler shed, or on an outdoors stand. Other factors include how many aerosol sampling modules are being installed; up to five sampling modules fit within standard protocol.

Information for the local contact on preparing existing buildings for sampler installation, constructing new buildings to house aerosol samplers, or constructing an outdoors stand for aerosol samplers is included in Section 4.1, Site Preparation and Communication Procedures. However, as the local contact at each site will encounter different problems, no general listing of the equipment required to site preparation prior to sampler installation will be made.

4.1 Sampler Installation Equipment

The installation of the aerosol sampler(s) by field technicians shall occur only after all site preparations are completed, including ensuring adequate power supply, preparing access roads, sampler stand with adequate roof access, or support structure construction, etc. Standard equipment and materials required for installation of aerosol samplers include:

- 1 aerosol sampler controller
- Module A ($PM_{2.5}$) sampler collecting samples for elemental analysis
- Module B ($PM_{2.5}$) sampler collecting samples to analyze for nitrate, nitrite, sulfate, and chloride ion
- Module C ($PM_{2.5}$) sampler collecting samples to analyze for carbon
- Module D (PM_{10}) sampler collecting samples for gravimetric analysis
- Module X (which can be A, B, C, or D) if applicable
- Vacuum tubing for each sampling module, long enough to run between the air sampling modules and pumps
- One pump for each sampling module
- One anodized aluminum inlet stack long enough to meet EPA requirements for each sampling module (see SOP 126 Figure 5). Modules with 2.5µm cut points ($PM_{2.5}$ samplers) require a pipe with 1/16” wall and outer diameter 1.5”; modules with

10µm cut points (PM_{10} samplers) require a pipe with 1/16" wall and outer diameter 1.25".

- 1 cleaned, coated aluminum denuder for the B module
- 1 inlet head for each $PM_{2.5}$ sampling module. Note that inlet heads for all $PM_{2.5}$ modules are identical
- 1 inlet head for each PM_{10} module being installed (Andersen Samplers Inc. 16.7 lpm low flow rate Sierra inlet)

4.2 Site Calibration Equipment

Refer to SOP 226, "Annual Site Maintenance," for a detailed list of equipment required to calibrate an IMPROVE aerosol sampler.

4.3 Sampling Initiation Materials

The following materials are necessary for site initiation:

a. 2 boxes of unexposed filter cartridges configured for the new site and sampling dates. Each box should contain the following:
   - 3 "A" module cartridges, labeled, quality-checked, and containing pre-weighed Teflon® filters
   - 3 "B" module cartridges, labeled, quality-checked, and containing nylon filters
   - 3 "C" module cartridges, labeled, quality-checked, and containing quartz filters
   - 3 "D" module cartridges, labeled, quality-checked, and containing pre-weighed Teflon® filters
   - 3 log sheets, each representing one week of cartridges for the sampler, for recording sampling data
   - 3 reclosable bags, each containing one week of cartridges for the sampler, to prevent contamination of the cassettes during shipment
   - 1 compact flashcard for recording data at the site
   - 1 UPS return label or business reply USPS label (depending on the site) for returning the box to the Air Quality Group lab

4.4 Site Documentation Materials

The following materials are required to complete the site documentation process:

- One camera for site documentation photos
- Photographs of the site and final equipment configuration
- On-site documentation by the field technician during installation
- Maps of the site location and directions for access

5. METHODS

This section describes site installation and documentation procedures and includes two major subsections:

5.1 Site Preparation and Communication Procedures

5.2 Installation and Calibration of Aerosol Samplers

5.1 Site Preparation and Communication Procedures

Prior to installation of an IMPROVE aerosol sampler, the local contact must ensure the site is prepared for sampler installation. The field technician shall inform the local contact of the site preparation and installation requirements determined to be necessary by the field manager and the principal investigator. The local contact shall then be responsible for ensuring the preparations are completed prior to the date set for site installation. The information communicated to the local contact shall include:

1) The selected site configuration, whether in an existing building, a newly constructed sampler shed, or on an outdoor stand. Samples of sheds (C76-NPS-2841, C76-NPS-2842) and outdoors stands (C76-IS-2430) for IMPROVE aerosol samplers may be found in the diagrams packet.
2) The basic requirements for the sampler module support structure are simple:
   a. The mounting surface on the structure should consist of two horizontal 2x6 studs separated by 18" center to center.
   b. The top of the lower 2x6 stud should be positioned roughly 52" above the floor to ensure the cyclones are at or near eye level.
      - For an indoors site, the distance between the top of the upper stud and the top of the roof must be reported to the field manager for calculation of the required inlet stack length.
      - For an outdoors site, unless there are unusual circumstances, the inlet stacks shall be 6 feet long.
   c. The mounting structure must be stable to avoid vibration or shifting of the sampler modules after installation.
   d. The mounting structure must be strong enough to support the weight of the sampler module(s). A complete IMPROVE set-up, with a controller and four modules, would weigh 209 lbs.
   e. The mounting structure must be long enough to support all of the modules, which is generally 96 inches long. An optimal spacing of the modules is roughly 24", between stack to stack. The preferred installation has all the modules along one wall, but if there is not enough space, other walls may be used as well, pending approval from the field manager.
   f. For an indoors site, the mounting structure must be constructed in a location where holes may be drilled vertically through the roof above the modules once mounted.
   g. Preparations for installation of samplers in pre-existing concrete and/or metal structures may be quite complicated. Careful discussion of sampler mounting options with property managers is required, as is assistance from the local contact and maintenance workers. Damage to structural integrity is possible, and on-site supervision of installation by personnel responsible for the structure is required. In these situations, for insurance purposes, the Air Quality Group requires the property managers to approve, oversee, and hire the appropriate personnel to attach the support structure, drill the holes for the stacks, and re-seal the roof once the samplers are installed. Due to these

constraints, installation in pre-existing concrete or metal structures does not generally occur.

h. Each shelter must be equipped with a safe means of accessing the roof and stacks. A permanent staircase or ladder is preferred, but as a secondary option, a lean-to ladder that can be hooked to the structure may be kept at the site. The roof must be accessible year-round.

i. Pump enclosures are required for outdoor sites and recommended for indoor sites. Outdoor enclosures must be big enough to allow at least two cubic feet per pump and must be well ventilated. Indoor pump enclosures are generally constructed by sectioning off a portion of the shelter from the main area that houses the modules in order to prevent heat from the pumps affecting the modules. The sectioned-off pump area must be well ventilated to prevent overheating.

3) The number and type of modules to be installed.
   a. The exact location to install the sampler modules:
      - Which wall or surface will the sampler be mounted on? Note that if on an outdoor stand, the sampling modules are mounted facing north.
      - Where will each module be mounted on the wall or support structure? The modules are general mounted roughly 52" above the floor or ground to put the cyclones in the modules at eye level. Also, the modules cannot be mounted closer than 5" from a corner in order to allow the doors to open freely.
4) The power requirements for the sampler. The IMPROVE aerosol sampler uses 110V, 60Hz electrical power during normal use. The sampler requires two 20 amp breakers or one 30 amp breaker. A minimum of four outlets is necessary, preferably two for each of the 20 amp breakers.
5) Obstructions to air flow, such as trees or bushes, which must be removed or trimmed.
6) Necessary site access path or road maintenance.
7) What assistance, in terms of tools and equipment (e.g. four wheel drive vehicles, concrete, etc.), will be necessary for the field technicians to complete installation of the sampler.

5.2 Installation of Aerosol Samplers

The IMPROVE aerosol samplers are installed on walls or stands according to site requirements. The basic configuration requirements are that all modules and inlets are located with the same air mass, as required by EPA siting documents, and the cyclones are mounted vertically for optimal efficiency. Installation procedures for IMPROVE aerosol samplers are described in the following subsections:

5.2.6 Sampler Function Check

5.2.1 Attachment of Aerosol Sampler to the Support Structure

The local contact, prior to site installation, shall have constructed a support structure for the sampler modules. The support must meet the requirements specified by the field manager for strength and stability. Any special arrangements, such as installing the samplers in a pre-existing building, shall have been made so that the installation process can proceed smoothly.

The modules are attached to the 2x6 studs. The modules are checked during mounting to insure the cyclones are vertical. The cyclones should be at or near eye level.

The modules are installed in alphabetical order from left to right and along one wall, if possible. There must be enough space between modules to allow the door to stay open. A spacing of 24" between stacks is optimal.

5.2.2 Installation of Inlets and Inlet Stacks

Following the mounting of the aerosol sampler modules, the inlet stacks must be installed. The procedures for installation are listed below:

- Mark the location of the center hole for each stack on the ceiling using the special IMPROVE module mounting template.
- Drill a 1¾ hole (1½ for D module) centered on the marks made on the ceiling.
- For modules A, B, and C, slide the 1.5" stacks through the holes in the roof and into the stock collars on top of the modules. Twist the stacks into the aluminum T-connectors as far as they will go.
- For the D module stack, slide the 1.25" stack through the hole in the roof and in the top of the D module. Twist the stack into the top of the black funnel inside the module until it rests on the O-ring seat inside the funnel. Then, lock it into place with the stack brace.
- For the B module only, install the denuder in the stack.
  a. Remove the stack bottom plug from the base of the stack Tee.
  b. Push the denuder up into the stack above the Tee, and then place the O-ring detainer inside. Allow the denuder to rest on top of the O-ring detainer.
- Slip a loose fitting roof jack over each stack, lay a bead of silicone caulk between the roof jack and roof, nail or screw in the roof jack at each corner, and seal around the edges of the roof jack and the roof with silicone caulk. Place a tight-fitting second roof jack over each stack.
- Install the inlets at the tops of the stacks by twisting them on.

5.2.3 Wiring the IMPROVE Aerosol Sampler to Power

The IMPROVE controller module is the only module containing control circuitry. The controller's power cord should be connected to a surge protector. The surge protector should be exclusive to the controller. Each sampling module not having controller circuitry should be connected to the controller by the twelve conductor wiring harness. Two relay

boxes and a temperature probe are also connected to the controller module. Two pumps are plugged into each relay box. Each relay box has a power cord. If two breakers are available, plug one relay box into each.

5.2.4 Connecting Pumps to the Aerosol Sampler

The aerosol sampler uses external pumps, switched on by the circuitry in the relay boxes to produce the appropriate flow rate. External pumps reduce the weight of the sampler modules, and are easier to maintain or replace. The procedures for installing pumps are as follows:

1) Set vacuum pumps upright in selected location.
2) Plug the pumps into the two relay boxes connected to and switched on by the controller module. Follow the color code when plugging in the pumps.
3) Connect the vacuum tubing from each module to the pump plugged into the outlet labeled as switching on that module. Follow the color code.
4) Verify the functioning of the pumps.
   a. Using the controller keypad, go to the main menu and press the number 2. Make sure the pumps turn on in sequence in alphabetical order. The max orifice values should be at nominal values for that site.

5.2.5 Sampler Function Check

Once the sampler has been installed, validation procedures to verify the correct wiring and functioning of the sampler components are necessary. The following are instructions for sampler validation checks:

5.2.5.1 Verify Module Values

1) Insert audit cartridges into their matching modules. On the controller display, in the main menu, select “F3” for the Advanced Menu. Enter the code ‘1123.’ Do not press “Enter” after typing in the code. Now select “F1” for calibration.
2) The pump for module A should turn on. The display will show two values (ORI and CYC). Check to make sure the flows are reasonable and confirm that the pump is running. Press the “F4” key to move to the next position. Do the same checks for the values and continue to positions #3 and #4.
3) Repeat step 2 for the B, C, and D modules (as well as for the X module, if applicable).

5.2.5.2 Verify Integrity of the Vacuum System

1) From the main menu, press “F3” to enter the Advanced Menu. Type in the code “9051.” Do not press “Enter” after typing the code.
2) From the Advanced Menu, press “F2.” This will display the zero values for the ORI and CYC of each module. Cycle through by pressing “Enter.” Record the values for each module. Press “Enter” to return to the Advanced Menu.

3) Return to the Main Menu by pressing "Enter." Then press "2." All of the pumps should turn on. After running for a few seconds, MxORI values will appear for each module. Record these values.

5.3 Calibration of the Modules

Before the site can begin running samples, the field technician must calibrate the modules. Detailed instructions on how to perform sampler calibrations can be found in SOP 226, "Annual Site Maintenance."

5.4 Operator Training

The operator training session is run by the field technician and generally lasts about one hour (depending on the number of people being trained and their level of experience). The session involves reviewing SOP 201, "Sampler Maintenance by Site Operators," and answering any questions the operator may have about sampling. Supervised hands-on training is also provided. The subjects covered include:

- Overview of the function and operation of each sampler module
- Pump functioning
- Procedures for data recording prior to and following sampling
- Filter cassette installation/removal
- Troubleshooting
- Phone numbers to call if problems arise

5.5 Site Documentation

Site documentation for the IMPROVE modular aerosol sampler involves completion of the Site Information Sheet (Form 1). This information is filed with the site documentation data collected during the siting procedure.

Details required to complete the site configuration form are described in detail in the following summaries:

Site Code: Record the 5 letter side code (e.g., BAND1 or THSI1).

Site ID: Record the four digit University of California Inventory ID number.

Date/Initials: The date the site was installed and the initials of the field technician who installed it.

Shelter and Roof: List the type of shelter, its dimensions and materials used to build it, as well as a description of the shelter's ventilation.

Controller and Modules: List the configuration/order of the modules and controller, the location and height of the modules, the sampling cycle of the site, the filter specs, the length of the module cables, stack information, the location of the temp probe, E-box versions, and the E-box cyclone zeros.

Pumps: List the location of the pumps and the distances from the pump to the relay boxes, from the relay boxes to the electrical outlets, and from the relay boxes to the controller. Note the dimensions of the pump box (if applicable) and anything used to control the climate in the pump area.

Power: List information regarding any surge suppressors and circuit breakers. Describe where the electrical outlets are and what equipment is plugged into each. List the distance between each outlet and the controller.

Surroundings: Describe the source of any potential contamination (within 300 yards of the site) and any clearance violations or issues.

After site documentation has been completed, the field technician must take pictures of the following:

- Modules
- Pumps
- Power
- Breakers
- Roof
- Stacks (inlets)
- Inward views facing the site (N, NE, E, SE, S, SW, W, NW)
- Outward views facing away from the site (N, E, S, W)

6. REFERENCES

SOP 126, "Site Selection for IMPROVE"
SOP 201, "Sampler Maintenance by Site Operators"
SOP 226, "Annual Site Maintenance"

Form 1. Site Information Sheet

IMPROVE Aerosol Monitoring Site Information Sheet

Please change any information that is not current and fill in all blank fields.

SITE CODE: _____ **SITE ID:** _____ **DATE/INITIALS:** _____

SHELTER AND ROOF:

Type:

Climate control:

Wall Dimensions (height x width x depth):

N: E:

S: W:

Wall Material (of ecto or shed):

Roof Material (material and shingle style):

Door Dimensions (type of door and dimensions):

Roof Style (shape and peak):

Roof Peak Heights (peak 1,2,3 floor to peak):

Ventilation:

Wall	Size, Type and X,Y coordinates (0,0)=bottom left of wall
N:	
S:	
W:	
E:	

CONTROLLER AND MODULES:

Sample Configuration:

MOD Location (e.g. N Wall inside):

Filter Specs:

A (M1/M0):

B (size):

C (prim/sec):

BLBX Sequence:

Daylight Savings:

Cable lengths:

A: C:

B: D:

Stacks:

PM10 inlet type:

Anodized:

Length:

Braces or guide lines:

Clearances:

Program Version:

A-B:
B-C:
C-D:

MOD Height:
Floor to top of MOD:
Top of MOD to roof:

24V Source:
Temp Probe in MOD:
D Funnel Ver:

EBOX Ver:
A: B: C: D:

E BOX Mag Zero's: (5 or 10)
A: B: C: D:

Pumps:

Pump Location:

Pump Area Climate Control:

Dimensions of Pump Box:

Pump to RBOX distances:
A/B:
C/D:

RBOX to Outlet Distances:
A/B:
C/D:

Leak Check	A	B	C	D	Avg
MOD:					
PUMP:					

Power:

Surge Suppressor:
Circuit Breaker:
Size (e.g./ 20A):
Location:
Outlets/Equipment:

Outlets:

Wall	Type, Distance to CNTRLR and X,Y coordinates (0,0) = bottom left of wall
1	
2	
3	
4	

Surroundings:

Contamination (within a 300 yd. Range):

Source (equip., unpaved roads, VC, etc.)	Distance from site: (straight line distance)	Direction: (due from site)	Frequency run: (days, times, avg. cars)
1			
2			

3
4

Clearance Violations/Issues

	Object (trees, buildings, equipment)	Distance from site: (straight line distance)	Direction: (due from site)	Height: (height of object)
1				
2				
3				
4				