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UCD IMPROVE Standard Operating Procedure #226

Site Maintenance

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

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DOCUMENT HISTORY

Date Modified	Initials	Section/s Modified	Brief Description of Modifications
6/14/22	IVP	6,8	Added interference from spider webs. Added detail on packing lists.
6/14/22	IVP	10	We no longer upload site specific calibration constants from the flow check forms since transitioning to universal flow calibration constants.

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1. PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) details the procedures the field technicians must follow for routine maintenance of equipment in the IMPROVE sampling network. Prior to 2013, routine site maintenance occurred on a yearly basis. Starting in January 2013, sites will receive biennial maintenance; with half of the network receiving maintenance one year and the other half the next year. Routine maintenance is divided into "loops," with an average of ten sites visited on each loop. Maintenance is solely the responsibility of the Air Quality Research Center's field operations team, comprised of the field manager and field technicians.

2. SUMMARY OF THE METHOD

Prior to routine maintenance, the field technician will review and summarize the information collected at each site during the previous year(s) to characterize how well each site is functioning. The data recorded during weekly visits to the IMPROVE samplers by the operators, as well as any problems detected during quality assurance procedures, will be incorporated into the site summary. This reference will be used to determine whether extra maintenance or troubleshooting is required at each site. The Air Quality Research Center (AQRC) will establish and announce a rough maintenance schedule for the year.

Routine site maintenance will be performed by AQRC field technicians. During the site visits the cyclones, stacks, and inlets are cleaned; the electronics are checked; the pumps are flagged for replacement or repaired as needed; the sampler flow rates are checked; and calibration equations are verified. Operator training and review sessions as well as any sampler upgrades are also performed at this time.

3. DEFINITIONS

- Cassette: a plastic holder that contains a filter substrate or dummy.
- Dummy: a 25 mm or 37 mm piece of material used in cassettes that are not sampled.
- Cartridge: consists of a cartridge plate and 3-4 cassettes inserted in the cartridge plate.
- $PM_{2.5}$: Particulate matter, aerodynamic diameter of 2.5 micrometers or less.
- PM_{10}: Particulate matter, aerodynamic diameter of 10 micrometers or less.
- 1A module: one of four channels routinely run at every site in the IMPROVE network. Measures $PM_{2.5}$ with Teflon® as the filter medium and runs at 23 liters per minute.
- 2B module: one of four channels routinely run at every site in the IMPROVE network. Measures $PM_{2.5}$ with nylon as the filter medium and

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runs at 23 liters per minute.

- 3C module: one of four channels routinely run at every site in the IMPROVE network. Measures $PM_{2.5}$ with quartz as the filter medium and runs at 23 liters per minute.
- 4D module: one of four channels routinely run at every site in the IMPROVE network. Measures PM_{10} with Teflon® as the filter medium and runs at 16.9 liters per minute.
- 5X module: a duplicate of 1A or 2B or 3C or 4D module installed at selected site for quality assurance purpose.
- Cyclone: IMPROVE particle size separator based on aerodynamic equivalency diameter of 2.5 micrometers.
- Denuder: set of concentric aluminum tubes used to remove nitric acid from air stream.
- Ebox: Electronic box which houses pressure transducers and manifold drive relays.
- Rbox: Relay box which houses relays that turn on pumps.
- lpm: liters per minute
- Stack: inlet tube for module
- Inlet: cap over $PM_{2.5}$ stack with insect screen
- Magnehelic: device that measures differential pressure in mercury (Hg), used for flow checking modules.
- Sierra inlet: EPA Louvered PM_{10} Inlet
- EPA: Environmental Protection Agency

4. HEALTH AND SAFETY WARNINGS

Be aware that various stinging insects, venomous creatures, and large mammals (such as bears) can be found at many of the IMPROVE sites. Be cautious when stepping in tall grass surrounding a site or when opening pump boxes.

Maintenance requires cleaning of the stack inlets, which typically requires accessing the roof of a structure. Safety ratings are assigned to classify fall risk at each site. These ratings range from “None,” “Low,” “Medium,” to “High.” The field manager and technician will meet to discuss the fall safety plan determined for accessing and cleaning the inlets and stacks.

Inclement weather is often an issue at many IMPROVE sites. If severe weather is impending, wait it out in the vehicle or reschedule the site visit.

Always carry a first aid kit. Report any injuries to the field manager immediately.

Refer to TI 226G for more information.

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5. CAUTIONS

Many access roads to IMPROVE sites are locked after regular business hours. Be sure to communicate with necessary staff how long the visit is expected to take to avoid being locked in the area.

Some IMPROVE sites are remote and require hiking to the site or driving off-road. Be sure to have detailed directions on how to get to a site that requires walking or off-road driving.

Many IMPROVE sites do not have cellular reception. Take this into consideration when planning site visits.

Wasps and rodents sometimes make nests in the inlets and the sampler enclosure. Check for this carefully, as this can cause issues during sampling and other health concerns. Report any infestations in the sampler to the field manager immediately.

There are several urban IMPROVE sites and care should be taken to lock vehicle and secure work and personal equipment while at the site.

6. INTERFERENCES

Due to weather conditions or the way a site is housed, the 4D module stack at a site may rub against the funnel. This situation results in the formation of a black powder, referred to as “anodizing dust,” that collects and falls down onto the filters. During site maintenance, check to make sure there is no sign of anodizing dust on any of the 4D module filters at the site before and during maintenance. If any anodizing dust is present on the filters, flag the site as a candidate for a stack-stabilizing tripod, take detailed pictures of the roof where the tripod will sit, and inform the field manager. If any anodizing dust is found in the funnel, locate the cause and flag any equipment that needs replacing.

The sampling inlet stacks ensure that air is sampled from a sufficient height to be representative of the region. The sampler has no sensors or electronic indication that the Inlet stack is all the way seated in the sampler or that the Tee plug that blocks the alternative calibration inlet is present. If the stack is not lowered or the tee plug is missing sampling data will be biased, but not obviously enough to catch in QC. Local operators and field technicians must visually verify that the stack is lowered all the way and the tee plug is present at each site visit.

Spiders commonly set up their webs near the inlets of the sampler, and especially on the 4D module, they make webs inside the sampling stack. Significant spider web coverage can act as a pre-filter for particulate matter being sampled and can decrease mass loading. Significant coverage is difficult to define quantitatively, so technicians should always photograph and document any spiderweb that could be blocking airflow.

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7. PERSONNEL DUTIES

The field manager will:

- Oversee and maintain records of site and sampler operation
- Organize and schedule maintenance loops
- Review initial flow rate checks and final flow rate checks
- Oversee the training of field technicians both at the AQRC and in the field
- Respond to any issues or concerns brought up by field technicians during maintenance

The site operator will:

- Note deviations from normal operations and inform AQRC personnel
- Attend site operator training and review sessions during site maintenance
- Replace equipment when requested by field operations
- Maintain a clean site

The field technician will:

- Perform routine site maintenance
- Perform site operator training and review sessions
- Maintain records on equipment repair and modification
- Update equipment inventory during site maintenance
- Report any issues or concerns in the field to the field manager

8. EQUIPMENT AND SUPPLIES

The equipment list for site maintenance trips will vary depending on the number of sites that will be visited and whether any new sites will be installed during the trip. There is much discretion given to the maintenance technician on what specific tools and equipment are needed on any given trip. Technicians will usually form their own packing lists, but the following equipment is always needed:

- Volumetric flow measurement device
- Scientific cleaning wipes and Paper Towels
- Isopropyl or ethyl alcohol (cleaning agents with detergents should not be used)
- Philips screwdriver, and a standard hex wrench set
- Spare sampler components

An example packing is located in Attachment 1, “Maintenance Packing Lists.”

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9. PROCEDURAL STEPS

Field technicians perform routine site maintenance, generally in the spring, summer, or fall. This visit to the site is an opportunity to flag non-vital sampler components for replacement, verify flow rates, replace or update obsolete equipment, thoroughly clean each sampling module, and test the vacuum systems. It also allows trained personnel to inspect the site to ensure compliance with EPA sampling regulations and provides an excellent opportunity for operator training.

9.1 Preparation for Site Maintenance Loop

Field technicians prepare for site maintenance by contacting each site, scheduling visit dates and times, and creating site flow check and maintenance kits. The field manager is responsible for organizing maintenance loops and overseeing the training and supplying of the field technicians both prior to leaving the AQRC and while in the field. Refer to TI 226A for more information.

9.2 Operator Training and/or Review

Once at the site, field technicians should meet with the operator to explain any new software and to ask about any concerns or pending problems at the site. Field technicians should ensure that each of the reported problems is addressed before leaving. If a site operator is new, the field technician will review the materials covered in *UCD SOP #201: Sampler Maintenance for Site Operators* with the operator to ensure that the operator understands how to perform sample changes at the site. The field technician should also show the operator how to replace some of the basic components in case equipment replacements are necessary before the next routine maintenance visit. For further details, see TI 226A.

9.3 Pre-Maintenance Procedures at the Site

Prior to maintenance of the sampler, the field technician inspects the site for any general repairs needed. Any necessary repairs or changes to the sampler or site should be noted. If a problem that affects flow rate or system vacuum is identified, the technician will have to perform two flow checks: one with the existing problem and a second check once the problem is corrected.

The field technician prepares the sampler for maintenance by recording final readings and noting the elapsed times for each sample. The field technician visually inspects the sampling cassettes, noting and correcting any errors involving sample change protocol, and removes the sampling cassettes from the modules in preparation for the initial flow check. If it happens to be a sampling day, the technician should note this time on the log sheet as when the sampling was stopped. In these cases, maintenance should be performed in less than 6 hours to avoid invalidating the sample. For step-by-step instructions on these procedures, see TI 226A.

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9.4 Initial Flow Rate Check

The field technician performs a flow check using a digital magnehelic and probe. The flow check will serve to test current flow rates and equations to determine whether there has been any drift since the last maintenance visit. Further details on this procedure are located in TI 226B.

9.5 Pre-Leak Check of the Sampling Modules

Before cleaning the modules, the field technician performs a leak check of the sampling modules using the plug and extension bar from the flow check probe. The field technician checks the vacuum gauge reading from each pump and module to find possible existing leaks in vacuum system and weak pumps. If a difference between pump and module is greater than 2.0" Hg, the field technician pays close attention when cleaning the modules to identify where the leak is located and corrects it. If a pump vacuum is greater than -20" Hg, the pump is called "weak" and should be flagged for replacement soon. This is elevation dependent and remains a judgment call by the technician. A vacuum reading at a high elevation site may operate normally around -20" Hg. Step-by-step instructions for this procedure can be found in TI 226E.

9.6 Sampler Cleaning and Maintenance

The field technician thoroughly cleans the cyclones for the $PM_{2.5}$ modules (1A, 2B, and 3C) and the 4D module funnel with laboratory wipes and alcohol. The stacks, inlets, Tees, and stack bottom plugs are cleaned as well. The interior of each module is brushed to eliminate fugitive dust and insects. The valves are carefully removed and cleaned with cotton-tipped applicators and alcohol. The field technician checks for cracked or aged O-rings and hoses and makes repairs or replacements as needed. Refer to TI 226A for more information.

9.7 Detailed Inspection of Components and Housing

After cleaning, the field technician performs a detailed check of the site and the sampler. The field technician listens to each pump carefully to determine whether any of them are making unusual noises, and any pumps that need replacing are flagged. The stand/structure and the pump house/enclosure are examined for any signs of deterioration. The field technician confirms that the modules are securely attached to the mounting structure and that the stacks are stable and seated firmly. The field technician checks to confirm that the latest version of the software is installed. The technician also evaluates any issues with the controller and performs troubleshooting procedures to determine the cause if issues are found. After the inspection is complete, the field technician prepares the modules for a leak test. More details on these procedures can be found in TI 226A and TI 226F.

9.8 Post-Leak Check of the Sampling Modules

The field technician performs a leak check of the sampling modules using the plug and extension bar from the flow check probe. The field technician checks the digital magnehelic reading from each pump and module to ensure that the readings from each pump and its corresponding module are similar. Pump and module differences cannot be greater than 2.0" Hg. If a difference is greater than 2.0" Hg, the field technician performs

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troubleshooting procedures to identify where the leak is located and corrects it. Step-by-step instructions for this procedure can be found in TI 226E.

9.9 Final Flow Rate Check

The field technician checks the zero flow values for all modules. Pressure/Orifice readings will be 14.7 psi, and lower as elevation increases. Flow/Cyclone readings will be around 3.3. The field technician then verifies the flow rate on all of the $PM_{2.5}$ modules (1A, 2B, and 3C) run at a nominal rate of 23 lpm, and the PM_{10} module (4D) to run at a rate of 16.9 lpm. Any X module is verified to match the flow rate of its corresponding primary module. The techniques used to set nominal flow rate and check it against a standard are explained in TI 226C.

9.10 Post Calibration Verification and Documentation

After final flow rate check is complete, the field technician updates the controller's date, time, and GMT offset (if necessary) and verifies that all of the site configuration parameters are correct. All of the equipment is then labeled with colored tape in order to make it easy for an operator to replace equipment or to troubleshoot. The sampling cartridges are returned to their corresponding modules and the field technician prepares the controller to resume its normal sampling schedule. If the maintenance was performed on a sampling day, the time sampling is resumed should be noted on the log sheet.

9.11 Update Equipment Inventory

Document the inventory numbers of controllers, Eboxes, modules, pumps, and Rboxes. For efficiency technicians are encouraged to use a computer with a barcode reader to quickly log all equipment at the site. Replace inventory labels if they are damaged or missing from the equipment. The inventory database will be verified and updated upon the field technician's return to AQRC.

9.12 Take Photos of the Sites and Equipment

Various photographs are taken of the sampler components and the site itself, as well as the area surrounding the site. These photographs are taken to verify that the sampler and all of its components were left in the same condition as they were found or better, as well as to provide AQRC staff with a way to view site configurations remotely when troubleshooting with an operator over the phone. The photographs of the surrounding areas are used to ensure that there is no vegetation encroaching on the sampling cone or impeding access to the site.

Once all of these tasks are done, field maintenance is complete.

10. DATA AND RECORDS MANAGEMENT

Site flow checks excel forms are stored in a shared drive after the field technician returns from the site maintenance trip that is periodically backed up.

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Site photographs and notes are stored in site-specific folders on a different shared network drive. Due to folder size limitations the photo's folder is not backed-up as often as the text-based documents.

Any issue discovered on site that has the potential of effecting sampling should be written up in a JIRA issue (a web-based ticket tracking system). Notify the QA team directly of these issues, so they can start the process of flagging all relevant samples.

11. QUALITY ASSURANCE AND QUALITY CONTROL

The field maintenance team focuses on several areas to limit sources of possible contamination, to prevent equipment failure during maintenance, and to ensure that site maintenance has been performed correctly. These areas include cleaning and inspection of components, equipment replacement, taking pictures of site equipment prior to departure, and closely monitoring the data from a site for several weeks after maintenance was performed.

11.1 Cleaning and Inspection of Components

During site maintenance, field technicians thoroughly clean components with alcohol and laboratory wipes to reduce or eliminate any possible contaminants. Field technicians also inspect components for spider webs and other signs of pest infestation present in the modules and in the inlets. 4D modules are scrutinized to ensure that no anodizing dust is present due to the stack rubbing against the funnel or against the roof. If signs of anodizing dust are found, the field manager is notified immediately. If the issue causing the anodizing dust cannot be fixed during maintenance, the site is flagged for any equipment necessary to resolve the problem.

11.2 Equipment Replacement

Because of the potential for equipment failure, the field maintenance crew no longer rebuilds or repairs pumps in the field. Instead, field technicians examine flow data for the sites that they will be visiting prior to departing on the maintenance trip and determine what equipment may need replacing in the field. Field technicians bring enough spare equipment to meet any needs that can be identified through both the flow data and through speaking with the site operators before the visit.

If a piece of equipment is showing signs of impending failure at the site, field technicians will either change it out with the spare equipment they brought with them, or the equipment is flagged for replacement. This reduces risk of equipment failure due to less than optimal working conditions.

11.3 Documenting the Site with Photographs

Prior to departing the site, field technicians photograph all of the equipment. This documents that the site was left in the same or better condition than it was found and that the sampler has been completely reassembled after maintenance. Photographs of the modules are taken to show that the stacks have been lowered back into the Tees for the $PM_{2.5}$ modules and that the PM_{10} module stack has been lowered back into the funnel.

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Photographs are also taken of the roof to document that the inlets were placed back on top of the stacks and that the stacks were properly seated.

In addition to documenting the complete reassembly of the site, the photographs are useful for assisting AQRC staff with troubleshooting over the phone with operators, as the photographs allow the field technician to view the site configuration remotely.

11.4 Data Monitoring

The flow data returning from the site shortly after maintenance is scrutinized to ensure that the final flow rate check was performed properly and that the resulting flow data are valid, as well as to confirm that any replaced equipment is working appropriately. Action is taken immediately if any equipment appears to be malfunctioning or if any of the flow data differs significantly from what was expected.

12. REFERENCES

Attachment 1, "Maintenance Packing Lists"
Attachment 2, "Maintenance Checklist"
UCD SOP #201: Sample Maintenance by Site Operators
UCD SOP #226: Technical Instruction –

- TI 226A: Site Maintenance for Field Technicians
- TI 226B: Flow Check
- TI 226C: Flow Adjustment
- TI 226D: Denuders
- TI 226E: Leak Check
- TI 226F: Controller Repair
- TI 226G: Field Safety Plan
- TI 226H: Calibration of Flow Check Devices