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UCD IMPROVE Technical Information #226A

Site Maintenance for Field Technicians

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

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DOCUMENT HISTORY

Revision	Release Date	Initials	Section/s Modified	Brief Description of Modifications
	04/22/2021	SRS	All	Separated TI: A-H doc into individual TIs
	5/17/2021	IVP	10,11, TOC	Filled in missing sections, fixed TOC
	6/14/2022	IVP	9	Removed notes on valve rotations and coupler fixes, as all sites have been upgraded at this point.
2.6	3/14/2024	IVP	9	Removed redundant information from section 9 that is better covered in TI-226C, TI-226B Added a refence to new flow control hardware

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1. PURPOSE AND APPLICABILITY

This technical information (TI) document 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 all of the information collected at each site during the previous year(s) in order 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 micrometers (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 mm or less.
- PM_{10}: Particulate matter, aerodynamic diameter of 10 mm 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 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.
- Cyclone: IMPROVE particle size separator based on aerodynamic equivalency diameter of 2.5 mm.
- 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 used for flow checking modules.
- Sierra inlet: EPA Louvered PM_{10} Inlet.

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.

5. CAUTIONS

Many access roads to IMPROVE sites are locked after regular business hours. Be sure to

communicate with any 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 vehicles and secure work and personal equipment while at the site.

6. INTERFERENCES

Occasionally, 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.

7. PERSONNEL DUTIES

The field manager will:

- Oversee and maintain records of site and sampler operation
- Organize and schedule maintenance loops
- Review flow rate checks and flow rate adjustments
- 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
- 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. Because of this and due to the extensive amount of supplies needed, equipment lists will not be reported within this TI. They can be located in Attachment 1, "Maintenance Packing Lists" of *UCD SOP #226: Site Maintenance.*

9. PROCEDURAL STEPS

Field technicians perform routine site maintenance, generally in the spring or summer. This visit to the site is an opportunity to flag non-vital sampler components for replacement, verify calibration equations, 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

Preparation for site maintenance involves contacting each site, scheduling visit dates and times, and creating a site flow check and maintenance kit. The field manager is responsible for scheduling maintenance trips and overseeing the training and supplying of the field technicians, both prior to leaving the AQRC and while in the field. The process to prepare for site maintenance is described below.

1) The field technician notifies the site operator of the impending visit two to four weeks prior to the scheduled date. The following topics are covered during operator notification:
    - The exact date and time of scheduled maintenance at the site.
    - Scheduling of operator training sessions or review. The operator should agree to meet for at least twenty minutes so that any changes to the site can be explained.
    - Details of site access, including keys, combinations, etc.
    - Current problems with the sampler, power, site, etc.
    - Past performance/collection rate of the sampler (if requested by the operator

or if the collection rate is low).

2) The field technician prepares the following documents:
   - Site access sheets.
   - Site information.
   - Site data.
   - Sample log sheets for each site.
   - Maintenance checklist (one for each site; tasks should be checked off on the checklist as they are performed).
   - Labels (for controller and electronics boxes).
   - Notes generated during maintenance preparation meeting with field manager.
   - History of all equipment replaced since last maintenance. Also, include any out of the ordinary troubleshooting that has occurred at the site that will provide insight on any other problems that may be encountered during the visit.
   - Maintenance loop schedule. Check with the field manager to see if any sites have time restrictions.
3) The field technician must prepare the flow check devices and flow adjustment cartridges. First, the field technician must select two complete flow check devices (one as primary and the other as backup). The field technician must also prepare two sets of cartridges: one set for the flow rate check (with old lot nylon filters) and the other set for flow adjustment (new lot nylon filters). Teflon® and quartz filters are typically very stable without significant changes from lot to lot, so the Teflon® and quartz filters can be loaded from the current open box of filters in the lab. Teflon® filters from the new lot are used for both 1A and 4D cartridges. Quartz filters are used for 3C cartridges. Nylon filters, however, vary in resistance significantly between each other. Many 2B filters of both the old lot and the new lot must be tested and the one with average resistance in each lot must be selected and loaded in the cartridges. The field technician must also bring extra filters, as each filter should not be used for more than three sites. Use the following equation to determine the number of additional filters to bring:

   (# of sites) ÷ 3 = (# of filters to prepare)
4) The field technician checks the calibration of the two flow check devices with the BIOS Definer 220. If the flow rates are not within 2% of the previous device calibration, the flow checking device is recalibrated.
5) The field technician assembles a tool kit and organizes a comprehensive parts kit. Parts and tools required for basic electrical and carpentry tasks should be included. At this time, the maintenance loop documents should be reviewed to

determine any extra work or suspected problems for which the technician must be prepared.

6) The field technician prepares clean, coated denuders to replace the used denuders in the 2B modules at each site. For instructions on how to clean and coat each denuder, please see TI 226D.

7) The field technician ships the maintenance gear before departing on the maintenance trip if applicable.

9.2 Operator Training and/or Review

Once at the site, the field technician should meet with the operator and discuss the following:

- Introduce any new hardware/software that will be installed. Talk about any changes the operator will see and leave behind an explanation letter, sample change SOP, site contact info update form, and site report.
- Ask about any concerns or pending problems at the site. Make sure that all of the problems are addressed before leaving the site. If a particular problem cannot be resolved, leave a note or call the operator and explain what the plan is to resolve it in the near future. Call the lab for assistance or equipment if needed.
- Explain the range of temperature values that the operators should expect.
- Show the operator where the AQRC lab number is located on each log sheet and on the controller door instructions.
- Stress the importance of reporting if the time on the controller drifts more than five minutes ahead or behind actual time. Also remind them that all IMPROVE network controllers should run on standard time, and that the operators should not adjust the controller to match DST. Controllers that are connected to an internet device should sync their time automatically, and should not need to be adjusted.
- Stress the importance of writing comments in the comment section of the log sheets for minor issues. These comments are vital in helping the AQRC lab determine when equipment has failed, been requested, and been replaced.
- In addition to writing comments, stress the importance of also calling the lab, especially if equipment seems to be malfunctioning or when equipment is replaced.

If there is a new operator for the site who has not received training, make sure to set aside extra time to train the operator on sample change procedures. Site operator training involves review of the materials covered in *UCD SOP #201: Sampler Maintenance by Site Operators*. The site operator must be trained to perform the following tasks:

- Recording of the final readings for exposed filter cassettes
- Removal of exposed filter cassettes
- Installation of clean filter cassettes

- Recording of initial readings for the clean filter cassettes
- SD card installation
- Shipping/mailing procedures for the return of exposed filter cassettes and log sheets
- Air Quality Research Center phone numbers
- 4 letter site name code
- Basic troubleshooting procedures
- Overview of the site flow rate check procedure, as operators are occasionally required to perform audits due to significant changes in flow, equipment, replacements, etc.
- Replace some of the basic components, including the controller, electronics boxes (Eboxes), and pumps
- Ability to disengage the manifold motors in case they stop working between maintenance visits

9.3 Site Maintenance

9.3.1 Pre-Maintenance Inspection at Site

Prior to maintenance of the sampler, inspect the site for any general repairs needed. Any repair or changes to the sampler or site should be noted. The following is a review of the suggested pre-maintenance procedures:

1) Determine the location of the breaker for power to the sampler.
2) Check the integrity of the sampler stand, noting any parts that require repair or replacement. Required repairs must be reported to the host agency as soon as possible.
3) Note the condition of the sampler modules (e.g. are they rusted?)
4) Visually inspect the sample cassettes. Note and correct any errors involving the sample change protocol.

Take final readings on any samples that are complete and record them on the appropriate log sheet. If the blue box and log sheet are not available, make sure to record the information in the flow check/flow adjustment spreadsheet and transmit it to the sample-handling laboratory upon returning from maintenance.

If the controller is running upon arrival, the field technician needs to record the elapsed time of the running samples. Record the final PRES/ORI and FLOW/CYC values for the sample currently running and then take new initial readings for the sampler after the conversion and flow calibration. With this particular type of conversion, the calibration equations will be changed significantly and thus PRES/ORI and FLOW/CYC values for each section of data (before and after maintenance) are needed. Record these values on the log sheet.

Write them down in the flow check/flow adjustment spreadsheet if the log sheet is

unavailable, and transfer the values onto the log sheet when it returns from the field.

Write a note in the comment section of the log sheet (if available) mentioning the visit. For example, "Site maintenance performed on 9/5/2017 by JSG. ET stopped at 800."

9.3.2 Pre-Maintenance Checks

1) Perform the initial flow check. See TI 226B for step-by-step instructions on how to perform the flow check.
2) Review the flow check results. Compare the nominal values to the previous year's values. The errors generated through the flow check should be under 10%. If large errors occur, it is expected you investigate the cause of the discrepancy. Electronic box, controller replacements, or previous flow adjustments all may account for large errors. Obstructions or leaks in the valve may also lead to large errors. Document all troubleshooting steps and observations. On return from maintenance, large errors should be reported to the data quality team by way of a JIRA issue noting affected samples.
3) Perform the pre-leak check of all sampling modules. Make sure to first equilibrate the vacuum gauge. Use the plug and extension bar from the flow check probe to check the vacuum reading from each pump and module to ensure that the readings from each pump and its corresponding module are similar. If a difference between pump and module is greater than 2.0" Hg, a leak in the vacuum system was pre-existing. Fixing the leak is not necessary at this step, but locating the leak is very important in the next step. Leaks may arise from a bad alignment on the cyclone between the cyclone block and funnel, from loose valves, torn O-rings, or a cyclone that needs shimming.

9.3.3 Sampler Cleaning and Maintenance

9.3.3.1 Clean Cyclones

1) If you bring pre-cleaned cyclones with you for maintenance, you may skip the cleaning procedure. This can be useful in situations were poor site conditions make it difficult to clean the cyclones.
2) Remove the cyclones in the 1A, 2B, and 3C modules. Move the cyclones to an area where they can be cleaned comfortably and where there is low risk of dropping any tools or parts into dirt, water, etc.
3) As each cyclone is disassembled and reassembled, check each O-ring. If any O-ring is damaged or missing, replace the part or replace the O-ring with a vacuum-greased BUNA O-ring and report it in the site notes. When working with cyclone assemblies, use caution when using metal tools as they can damage the anodized surface. All internal

surfaces of the cyclone assembly should be cleaned with alcohol and laboratory wipes.

4) Clean the 4D module funnel. Note that this requires removing the lid.

9.3.3.2 Clean the Stacks, Inlets, Tees, and Stack Bottom Plugs

1) Remove the stack bottom plugs, checking the O-rings and replacing the entire plug if they are damaged. Clean the Tees with alcohol and laboratory wipes.
2) If you bring pre-cleaned inlet with you for maintenance, you may skip the cleaning procedure. This can be useful in situations where poor site conditions make it difficult to clean the inlets. This method is recommended for sites with poor roof access, as having pre-cleaned inlets will save time on the roof and improve safety.
3) Remove and clean the inlet caps from the top of the stacks. Check and replace the O-rings if necessary. Use laboratory wipes and alcohol to clean the screen and remove dust and any spider webs. Wasps and other stinging or biting insects sometimes build nests in the inlets, so use caution when removing them and notify the field manager if any wasp nests are found.
4) For the Sierra inlet, which is located on the 4D stack:
    - Unscrew the water trap bottle, either plastic or glass, from the metal cover.
    - Empty the bottle and wipe out any sediments or materials that have collected inside it or on the metal cover. Check for cracks or chips. If the cup is damaged in any way, replace it immediately. Inspect the water trap bottle gasket for damage or excessive wear.
    - Reinstall the water trap bottle.
    - Unscrew the four Phillips head screws on the underside of the louvered flaps of the inlet and remove the top plate. Clean the cone attached to the top plate and the inlet funnel with alcohol and a lint-free laboratory wipe.
    - Clean the exit tube for the inlet funnel with a cotton-tipped applicator and alcohol.
    - Reassemble the inlet. If any of the screws appear to be stripped, replace them. They are 8-32 x ½" Phillips head screws. Use anti-seize when replacing any screws and/or standoffs.
    - Hold the top of the inlet with one hand, grasp the pipe to the water trap bottle with the other hand, and unscrew the inlet top

from the body at the seam located 7½" above the base of the inlet.

- Clean the impaction surface thoroughly with lint-free cloths and alcohol.
- Clean all interior surfaces with lint-free clothes or cotton-tipped applicators and alcohol.
- Reassemble the inlet head.
- Check the O-rings inside the stack sleeve, replacing them if necessary. They are ethylene propylene O-rings size 200-026 and are easily removed using a knife blade.
- Coat the O-rings in the stack sleeve and exit funnel with vacuum grease.

5) Remove the denuder from the 2B module by raising the stack, then removing the denuder detent O-ring. The denuder will now drop out of the Tee, or it can be pulled out of the top of the module if the stack is removed.

6) Clean the inlet stacks using a stack brush. Clean each stack at least twice.

7) Use alcohol and a clean rag or laboratory wipes to clean the inlet Tee. Inspect and replace any damaged O-rings.

8) Reinstall the inlet caps

9.3.3.3 Clean the Interior of the Module and Check All Hoses, Wires, and Connectors

1) Brush out the bottom of the modules to eliminate fugitive dust and insects. Be sure the vents are clear of debris.

2) Remove the needle valve stems carefully using a ¾" wrench. Clean the inside of the valves with a cotton-tipped applicator and then reinstall them.

3) Check for cracked or aged hoses on the cyclone. Clip any damaged ends or, if the tubing is showing signs of wear, replace it with new tubing.

4) Use wire ties and anchors to keep wires out of the way of the site operator.

9.3.3.4 Pump Maintenance and Equipment Replacement

1) Listen to each pump to determine whether any of them are making unusual noises. If you have a spare pump with you replace these pumps.

2) Replace any version II 4D funnels with version I funnels. These version II funnels are now rare.
3) Replace any grommets on module cases that have weathered and cracked.
4) Replace any broken or cracked manifold motor couplers.
5) Replace the used denuder with a clean, coated denuder. Make sure to record the inventory number of the new denuder in the site notes.

9.3.3.5 Inspect the Sampler Stand or Structure and the Pump House/Area

Look for deterioration of the stand or structure and the pump house or area, recording any issues in the site maintenance notes. The modules should be securely attached to the mounting structure, and the stacks should be firmly seated. The pumps should be in an area that has enough airflow for effective cooling, and the area should be free from pest infestation. Inform the field manager if there are any issues that need to be addressed immediately.

9.3.4 Post-Leak Check All Modules

Return all equipment to its proper location and perform a leak-check of all the modules.

Make sure to first equilibrate the vacuum gauge. Use the plug and extension bar from the flow check probe to check the vacuum 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, investigate to determine what is causing the leak. Leaks may arise from a bad alignment on the cyclone between the cyclone block and funnel. Adjust the play in the two mating pieces. Leaks may also arise because of a loose valve, torn O-rings, or a cyclone that needs realignment/shimming. Replacing the cyclone with a spare can often fix alignment issues because of differing machining tolerances. Refer to TI 226E for step-by-step instructions.

9.3.5 Record Zero Flows

The zero flows for all primary modules should be 14.7 psi at sea level for the PRES/ORI value and ~0.0 in H_2O for the FLOW/CYC value, depending on the individual sensor. X module values will match the primary module during flow adjustment. Please see TI226C for step-by-step instructions on how to perform the procedure.

Note: zero values are no longer manually adjusted.

9.3.6 Post-Maintenance Flow Rate Adjustment and Check

1) Adjust the flow rate on the modules by following detailed procedure in TI 226C.

2) Input the default pump speed values calculated in the previous step for PM2.5 modules running active flow control. From the Home Screen, go to **Menu**, then **Advanced Menu** and enter code **9051**. The pump speed menu option will be the last option.

9.3.7 Final Checks

3) Update the date and time on the controller if necessary. Do this by pressing **Menu** from the home screen, then selecting **Settings**. Ensure that the GMT is set correctly by selecting **Time Zone** from the same menu.

4) Verify that all of the site configuration parameters are correct. From the Home Screen, go to **Menu**, then **Advanced Menu** and enter code **1123**. The Site Config menu option will be the first option. There are several parameters to adjust within the Advanced Menu. Some of them are as follows:

   - Site: The four-letter site name followed by a number.
   - "UC Code": This is a four-digit number that is used as the site's inventory number. In most cases, it should match the last four digits under the barcode in the interior of the 1A module case.
   - SD Card: This will configure whether the controller asks for a new memory card every week (bag) or every three weeks (box).
   - Edit Schedule: Each site will be either "2-3-2" or a "3-2-2." If the blue box has a yellow sticker with the site code printed on it, the site is a "2-3-2." If the blue box has a green sticker with the site code printed on it, it is a "3-2-2." The IMPROVE calendar lists which week bag should be used on each Tuesday according to blue box schedule.
   - Server Settings: Enable or disable remote backup of flow data.

5) Verify that the advanced site configuration parameters are correct. From the Home screen go to **Menu**, then **Advanced Menu** and enter code **9051**. The Maintenance Menu will come up and some of the options are as follows:

   - Unlock Controller: This can be used in special cases to unlock the controller to sample the following week without performing the filter readings procedure.
   - Elapsed Times: This can be used to edit the amount of the time the controller reports sampling for. This feature is used by maintenance technicians to correct the elapsed sample times due to interruptions resulting from maintenance.
   - Edit Constants: This can be used to edit the calibration constants.

After 2018, this should no longer be necessary, and operator should never use this menu option.

- Config Modules: This screen will display one module per page and lists whether the module is online, what module type it is (1A, 2B, 3C, or 4D) and gives the option to edit the calibration constants.

6) Update operator initials if needed. Do this by pressing **Menu** from the Home Screen, then **Settings**, and **Operator Initials**.
7) Install the current sampling set of cartridges and run through Final/Initial readings by pressing **Filter Readings** from the Home Screen. Correct initial readings for any samples that have not yet run.
8) Fill out or update the site data sheet and note any equipment changes.
9) Leave any pertinent documents for operators either inside the controller or in the blue box if the documents cannot be given directly to the operator.
10) Make sure all equipment inventory numbers have been recorded. Most equipment labels are barcoded to make it easy to record numbers into the field laptop. If any equipment is missing an inventory label, the technician should come prepared with new labels. These include inventory numbers for:
    - Pumps
    - Controller/ Controller Configuration
    - Network device/ Network Configuration
    - Modules
    - Electronic boxes
    - Relay boxes
    - Flow Boards
    - Denuder (note this is engraved and is not barcoded)
    - Ruby Orifice (note this is engraved and is not barcoded)
11) Record breaker amperage and quantity.
12) Label all equipment with colored tape to make it easy for the operator to troubleshoot.
13) Tape 1A, 2B, and 3C Tee plugs to the Tees and add 1A, 2B, 3C, and 4D stack labels to the stacks. Use the appropriate color of tape (red for 1A, yellow for 2B, green for 3C, blue for 4D, or orange for 5X modules) for each module.
14) Take pictures of the following:
    - Eight inward views while standing approximately 30 yards away from the site; take pictures of the site looking N, NE, E, SE, S, SW,

W, and NW

- Four outward views while standing with back against the site and looking towards N, E, S, W
- All of the modules
- Pumps and relay boxes
- Source of power for controller and relay boxes (e.g., A/C outlets, power strip)
- Breaker, from a distance and up close
- Roof
- Stacks (include inlets)
- Sampler Overview
- Photos detailing any site hazards if applicable

15) Call lab for any necessary equipment.

10. DATA AND RECORDS MANAGEMENT

All equipment inventory records collected during site maintenance are maintained on a SQL server running on the UC Davis AQRC network. Technicians employ the use custom .Net software tools to assist the updating of records.

Notes about site visits, including accessibility of the site, recommended hotel accommodations, and detailed directions are stored in Microsoft word documents on the shared network drive.

Photos are also saved in the shared drive.

All data on network drives and SQL servers are periodically backed up and are stored indefinitely.

11. QUALITY ASSURANCE AND QUALITY CONTROL

The field maintenance team visiting the site on any given year is responsible for verifying that all the equipment is in good working order from the last maintenance visit to the present. This means any issue encountered must be documented and reported to the data validation group. Any change and/or issue could affect the sample. To prevent unreported issues from a previous maintenance, the lead technician visiting on any given year should be different from the previous maintenance.

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 PM2.5 modules and that the PM10 module stack has been lowered back into the funnel. 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

UCD SOP #226: Attachment 1, "Maintenance Packing Lists"

UCD SOP #226: Attachment 2, "Maintenance Checklist"

UCD SOP #201: Sampler Maintenance by Site Operators

TI 226B, "Audit"

TI 226C, "Calibration"

TI 226D, "Denuders"

TI 226E, "Leak Check"

UCD IMPROVE Technical Information #226B

Flow Check

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

March 14, 2024
Version 2.6

Prepared By: DocuSigned by: Ilia Potavin 46441F2308F14C2... Date: 3/12/2024

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DOCUMENT HISTORY

Revision	Release Date	Initials	Section/s Modified	Brief Description of Modifications
	04/26/2021	SRS	All	Separated TI: A-H doc into individual TIs
	5/17/2021	IVP	6,7,10,11	Added missing sections
2.6	3/14/2024	IVP	9.1	The preparation step procedure was changes with new flow-control pumps

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1. PURPOSE AND APPLICABILITY

The purpose of this technical information (TI) is to describe the flow check procedures used during field maintenance for all IMPROVE network sites.

2. SUMMARY OF THE METHOD

The field technician performs a flow check of the modules during field maintenance to test current flow rates and equations in order to determine if there has been any drift since the last maintenance visit. Flow rate values for each module are checked and recorded.

3. DEFINITIONS

- 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 mm or less.
- PM_{10}: Particulate matter, aerodynamic diameter of 10 mm 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 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.
- Stack: Inlet tube for module.
- Inlet: Cap over $PM_{2.5}$ stack with insect screen.
- Magnehelic Probe: Custom device that measures differential pressure across an arbitrary restriction created for the purpose of flow measurements.
- NIST: National Institute of Standards and Technology
- Sierra inlet: EPA Louvered PM_{10} Inlet.

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.

5. CAUTIONS

Make sure that the magnehelic is set to zero when vertical and that the tubing for the device is straight and not kinked before beginning the flow check.

6. INTERFERENCES

The magnehelic probe device relies on an accurate measurement of atmospheric pressure on one leg of the pressure tube. On windy days the wind will cause pressure fluctuations on the open end and lead to an inaccurate flow measurement. Using the wind damper device shown in Figure 3 prevents measurements from the effect.

7. PERSONNEL QUALIFICATIONS

Flow checks should be performed by trained field technicians who have experience with the procedure and have a good understanding of the fundamentals of sampler operation. In extraordinary circumstances, a local operator might be asked to perform this check with the remote assistance of a field technicians closely following printed instructions and/or and instructional video.

8. EQUIPMENT AND SUPPLIES

A black, hard-cased flow check kit should contain the following:

- Magnehelic and probe
- One flow check cartridge for each module being checked, four maximum
- One 5/32” hex key
- NIST-certified thermometer

The field technician should also have a prepared, site-specific flow check sheet.

9. PROCEDURES

9.1 Preparing the Modules and Controller for the Flow Check

1) Open the controller door and press the **Home** button if the display is not on main screen, which will bring up the main menu.
2) Remove the sampling cartridges from the modules. Make sure that final readings have already been taken.
3) Insert each flow check cartridge into its corresponding module.
4) Access pump and solenoid control through the **Flow Adjustment** option of the Maintenance Menu. From the Home Screen, Press **Menu**, **Advanced Menu**, enter code **9051**, press Submit, press **More** and **Flow Adjustment** will be the second menu option.
5) Make sure that active flow corrections are turned off for each module by pressing the "**flow**" button and selecting "**off**" (note this setting is reset when you exit the advanced menu)
6) Click "**back**" and then click "**solenoid**" on module 1 and press "**s1**" to open solenoid 1
7) If the module is a PM2.5 module that has active flow-control hardware, you will need to set the pump speed prior to checking the flow. After solenoid 1 is open, go "back" and select "**pump**" option to edit pump speed. Turn pump "**on**" and use buttons **+1%** and **– 1%** to adjust the pump speed until a nominal flow rate of 22.6 is met. After this is complete, note down the value in your notes and turn the pump back off.
8) Repeat steps 5,6, and 7 for all modules. Please note, if you leave the flow adjustment page all the values will be reset and these steps need to be redone.

9.2 Recording Temperature, Max Orifice, and Zero Values

1) In the flow check device case, there will be a NIST-certified thermometer. Please take the thermometer out of the case and place it in the shade next to the 3C module. Turn the power switch to the "On" position and the unit switch to "°C." Disconnect the temperature probe from the 3C module and place the tip of the probe next to the thermometer. Allow the thermometer to equilibrate for approximately five to ten minutes.
2) To take the temperature reading from the probe, look at the temperature displayed in the upper right corner of the Home Screen. Record this value in cell C16 of the sheet titled "Site and Device Data". Then, record the value reported by the thermometer in cell C15.
3) To take Vac/Max Orifice (or MxORI) values, enter the Flow Adjustment Mode. For each module turn on its pump and no solenoids. Record the values for each module in cell B8 for each module specific sheet.

4) To take zero values for the Pres/ORI and Flow/CYC of each module, go to the Flow Adjustment menu option. Note that if the system was sampling upon arrival, the pump must be stopped before measuring zero flows. With the pump off and at least one solenoid open, the controller display will show the zero values for the 1A module. Enter the CYC Zero and ORI zero values in cells B9 and B10, respectively, of the 1A module sheet. Navigate through each module by pressing the > button and record the values in the appropriate sheets and cells. When finished with the last module, press the **Home** button to exit the Flow Adjustment Menu.

9.3 Preparing the 1A Module and Magnehelic

1) Place the magnehelic on the inside of the module 1A door. Note that it is digital so orientation doesn't matter. The magnehelic has a magnet on the back, so it will stay attached. Make sure that the magnehelic reads "0.000," when turned on. If not, hold the "Zero" button to reset the value to zero.
2) Inside the 1A module, locate the stack plug and the black plastic cap. Remove the cap by pushing down on it from the top, and remove the plug by pulling down on the brass fitting.
3) Place the probe into the Tee. Do this by pushing the probe (hose end down) through the bottom of the module and up into the Tee until the probe bottoms out.
4) On a windy day, the magnehelic reading may fluctuate. To keep the reading stable, use the PVC cylinder included in the Flow Check Kit. If no PVC cylinder is included, wrap the open end of the Tygon tubing with a piece of laboratory wipe, making sure not to block or restrict any of the holes on the probe or pressure hoses.

Figure 1. Removing the plastic cap and stack plug.

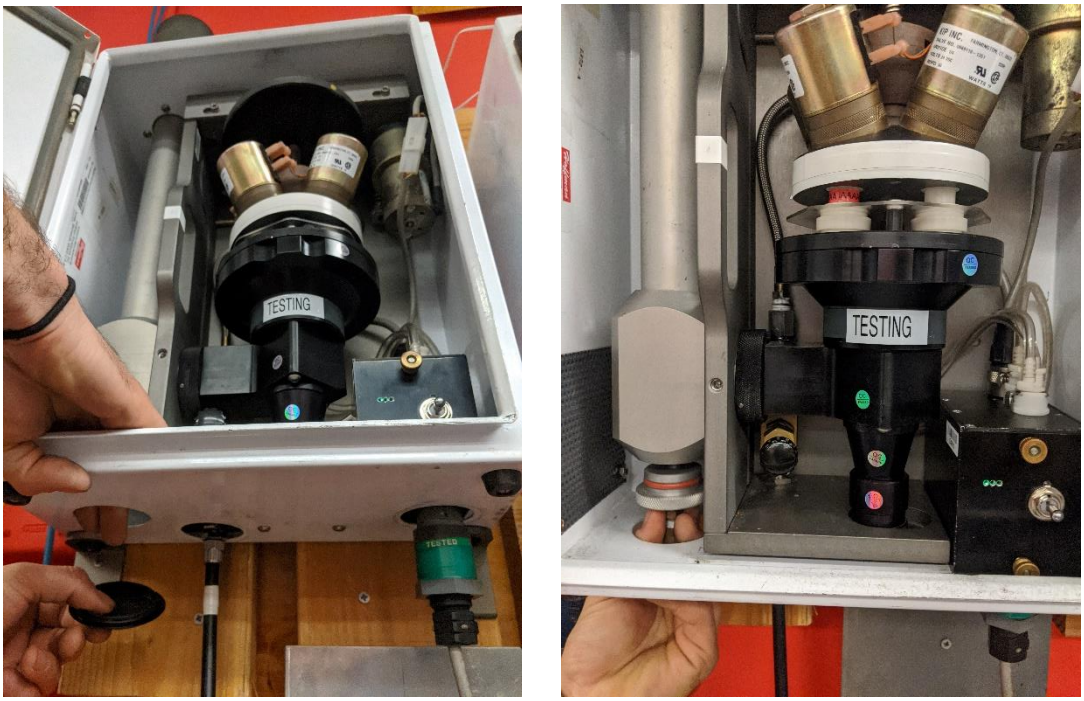


Figure 2. Inserting the probe into the tee.

Figure 3. Attaching the PVC dampener.

9.4 Begin the Flow Check

1) Return to the controller's display. From the Advanced Menu enter **9051** and press **Submit**. Press **More** and then **Flow Adjustment**.
2) The module 1A sensor data will be displayed. Turn on solenoid 1 by pressing **S1: Off**. Turn the pump on by pressing **Pump: Off**. The magnehelic pressure gauge will move from the 0" H2O position to a value greater than 0.

9.5 Filling in the Flow Check Sheet

1) Check the magnehelic value. Enter the displayed number into cell C8 of the flow check sheet, making sure to place a decimal before the number.
2) Look at the controller display. It will show two values for position 1, the Flow/Cyclone (CYC) and the Pres/Orifice (ORI) sensor values. Enter these in cells D8 and E8, respectively. If either of the values is unstable, note the full range of values in the comments section on the bottom left of the flow check sheet.
3) Once these values are recorded, press the **S1: On** button and then the **S2: Off** button to move to the second position of the flow check cartridge. The buttons should now read "S1: Off" and "S2: On." Record the magnehelic and CYC/ORI values in cells

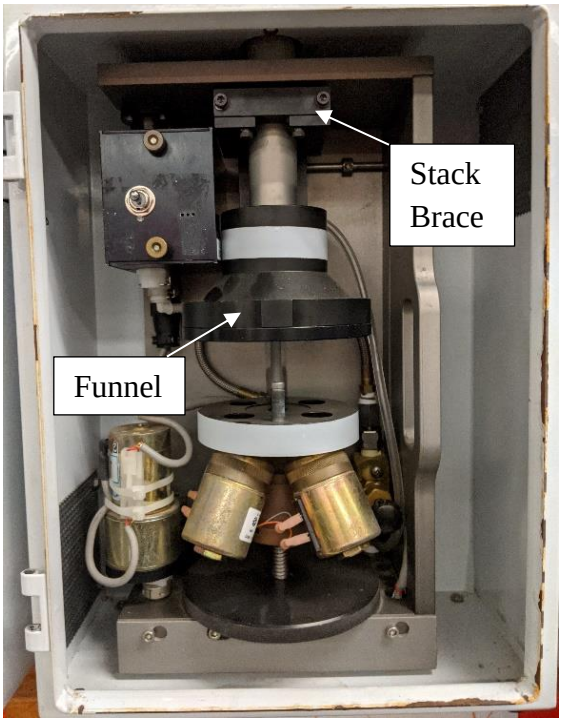
D9-E9. Repeat the previous steps 1 and 2 for each of the four positions, making sure the correct solenoid is open and record the values in the appropriate cells.

4) Repeat steps 1-3 for modules 2B and 3C.

9.6 Preparing Module 4D

1) In order to flow check module 4D, first raise the stack to accommodate the flow check probe. There are two things that need to be loosened before the stack can be raised. First, loosen the locking collar on top of the module by turning it counterclockwise. Then, take the 5/32" hex key and loosen the four screws of the 4D brace. Do not remove the screws.
2) Slide the stack up approximately four inches or until it is above the 4D brace. After moving the stack, retighten the locking collar to temporarily secure the stack.

Figure 4. Module 4D.



9.7 Preparing the Magnehelic Probe

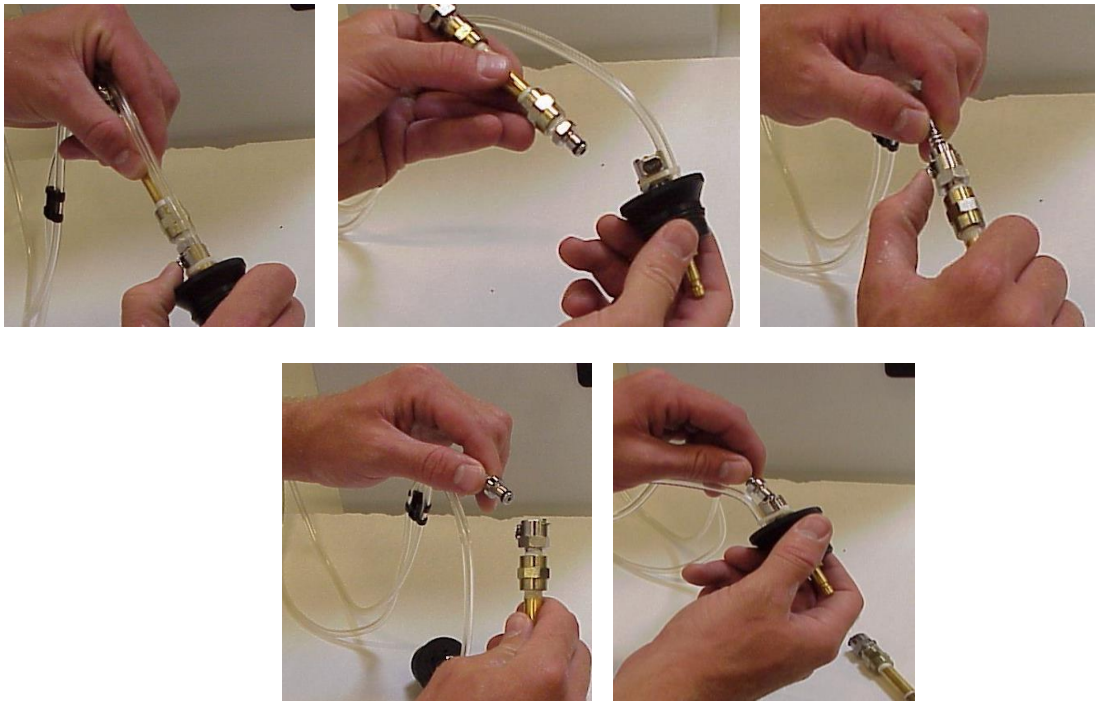
In order for the probe to fit into the funnel of the 4D module, it is necessary to make two modifications to the probe itself:

- First, locate the spring-loaded coupler, which is between the probe and the probe plug. Push this coupler's outer sleeve down (toward the hose). This will release the probe plug.

- Second, locate the 3-inch brass extender bar, which is attached via quick connects. To remove this extender bar, disengage the quick connects by pushing on the buttons and gently pulling the bar away. After removing the extender bar, attach the quick-connect fitting on the hose to the probe quick-connect.

Figure 5. Releasing the probe plug.

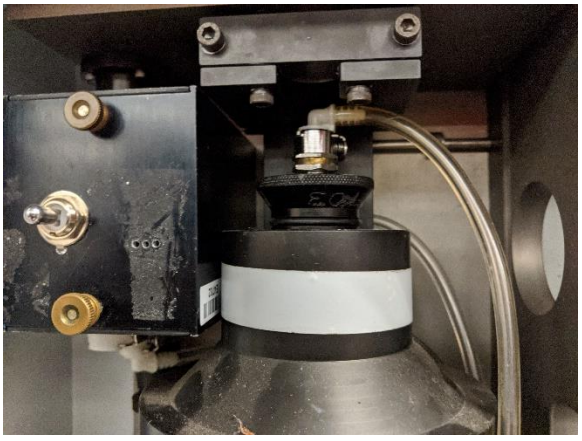
Figure 6. Modifying the probe.



9.8 Conducting the Flow Check on Module 4D

1) Place the probe into the top of the funnel (where the stack was previously) and gently push down until it bottoms out.
2) With the flow check probe in the funnel of the 4D module, the 4D module flow check can now be completed. Repeat the steps in section 5.4 for the 4D module.

Figure 7. Inserting the flow check probe into the 4D Module.



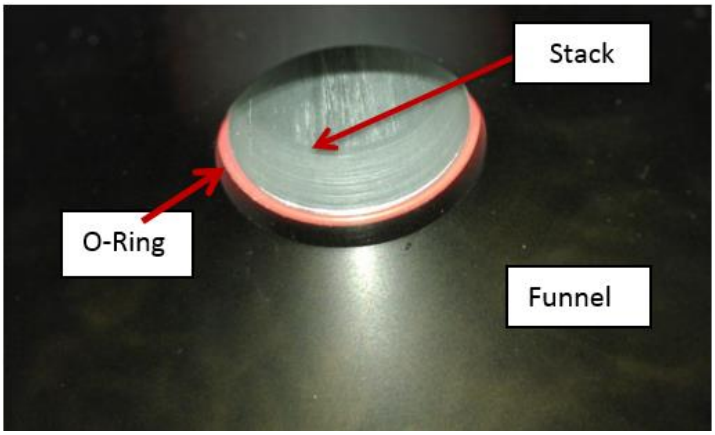
9.9 Re-installing the 4D Stack

1) Remove the 4D funnel's bottom lid. Using both hands with thumbs on the recessed channels of the funnel, pull downwards to separate the bottom lid from the rest of the funnel (Figure 8). Sometimes it is necessary to use a soft mallet to gently tap the bottom lid to separate the two pieces.

Figure 8. Removing the bottom lid of 4D Module funnel.

2) Gently lower the stack back to its original position, making sure that the stack is fully seated into the black funnel. It should rest on an orange (or black) O-ring as in Figure 9.
3) While the 4D funnel's bottom lid is still removed, verify that the 4D stack O-ring is securely in place and uniformly positioned between the silver stack and the retaining lip of the 4D funnel.

Figure 9. 4D O-Ring between stack and funnel.



4) Tighten the sleeve collar by turning it clockwise and then tighten the four screws on the 4D brace to secure the stack.
5) Replace the 4D funnel's bottom lid.
6) If the modules are not being flow adjusted, perform the following steps:
    - Double-check that all black plastic caps and stack plugs are in their proper position for modules 1A, 2B, and 3C.
    - Reassemble the magnehelic probe to its original configuration.

- Place all of the flow check components back into the flow check kit.
- Reload the modules with the exposed sampling cartridges. If a sample change needs to be performed, do it now. Record final readings for all modules, install clean sampling cartridges, and take initial readings.

9.10 5X Modules

Some sites have a fifth module for collocated precision measurements, referred to as an X module or 5X. The X module is a duplicate of a 1A, 2B, 3C, or 4D module. The A, B, C, or D designation after the 5 determines what filter media and particle size is used for the 5X module. If there is fifth X module, present, determine what type of module it is and perform the flow check accordingly.

10. DATA AND RECORDS MANAGEMENT

Data recorded from the flow check is stored on am excel spreadsheet. When technicians return from maintenance, they are responsible for storing this spreadsheet on the network drive in a folder of all flow checks performed at this site.

11. QUALITY ASSURANCE AND QUALITY CONTROL

If the flow measurement is outside 10% of nominal values, the discrepancy must be reported to the data validation group for proper flagging. In these circumstances the technician should do their best to explain the reason for the discrepancy as the reason will help narrow down when the sampler failure was likely to occur in the preceding 2-year period leading up to site maintenance. Technicians carry a backup Magnehelic device for these situations. Verify any out of specification measurements with the backup device by creating a copy of the flow check excel spreadsheet labeled accordingly. When returning back from maintenance both, primary and backup Magnehelic device are audited for accuracy and will inform the technician on what data is valid.

12. REFERENCES

Not applicable.

UCD IMPROVE Technical Information #226C

Flow Adjustments

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

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Version 2.6

Prepared By: DocuSigned by: Ilia Potanin 46441F2308F14C2... Date: 3/12/2024

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DOCUMENT HISTORY

Revision	Release Date	Initials	Section/s Modified	Brief Description of Modifications
	05/04/2021	SRS	All	Separated TI: A-H doc into individual TIs.
	5/17/2021	IVP	6,7,10,11	Added missing sections
	6/14/2022	IVP	5,8	Added a caution for the T-plug and stack. Clarified that Magnehelic guage is now digital.
2.6	3/14/2024	IVP	9	Modified Flow adjustment procedure for new active flow-control modules.

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LIST OF FIGURES

1. PURPOSE AND APPLICABILITY

The purpose of this technical information (TI) is to describe the calibration procedures used during field maintenance for all IMPROVE network sites.

2. SUMMARY OF THE METHOD

The field technician performs a flow adjustment of the modules after completing a flow check and general cleaning of the equipment. The flow adjustment corrects current flow rates and equations in the event of any drift since the last maintenance visit due to equipment malfunction or new equipment installation.

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 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

Not applicable.

5. CAUTIONS

Make sure to zero the Magnehelic pressure gauge and that the tubing for the device is straight before beginning the flow adjustment.

On finishing the flow check, it is critical to replace the T-plug for the $PM_{2.5}$ modules and to re-lower the stack on the PM_{10} modules. Failing to do so will likely bias the PM measurement as air will not pull from the free air stream but from ground level or inside a shelter. There is no change in flow rate measurements if this happens and is not observable in QC.

6. INTERFERENCES

The magnehelic probe device relies on an accurate measurement of atmospheric pressure on one leg of the pressure tube. On windy days the wind will cause pressure fluctuations on the open end and lead to an inaccurate flow measurement. Using the wind damper device shown in Figure 2 prevents measurements from the effect.

7. PERSONNEL QUALIFICATIONS

Flow adjustments should be performed by trained field technicians who have experience with the procedure and have a good understanding of the fundamentals of sampler operation. In extraordinary circumstances a local operator might be asked to perform this check with the remote assistance of a field technicians closely following printed instructions and/or and instructional video.

8. EQUIPMENT AND SUPPLIES

A black, hard-cased audit kit should contain the following:

- Magnehelic pressure gauge and custom flow restriction Probe
- One flow adjustment cartridge for each module, four total
- One 5/32" hex key
- NIST-certified thermometer

The field technician should also have a prepared, site-specific flow check/ flow adjustment sheet.

9. PROCEDURAL STEPS

9.1 Preparing the Modules and Controller for the Flow Adjustment Check

1) Open the controller door and press the **Home** button, which will bring up the main menu.
2) Insert each flow adjustment cartridge into its corresponding module.
3) Access pump and solenoid control through the **Flow Adjustment** option of the Maintenance Menu. From the Home Screen, Press **Menu**, **Advanced Menu**, enter code **9051**, press Submit, press **More** and **Flow Adjustment** will be the second menu option.
4) Make sure that active flow corrections are turned off for each module by pressing the "**flow**" button and selecting "**off**" (note this setting is reset when you exit the advanced menu)
5) Click "**back**" and then click "**solenoid**" on module 1 and press "**s1**" to open solenoid one which should be the clean filter position and lick on the **"pump:off**" button to toggle the pump on
6) Adjust the Flow rate to the nominal value (**22.6 lpm** for PM2.5 and **16.9** for PM10)
    - If the module does not have active flow-control hardware you will adjust the valve in the module clockwise for up and counterclockwise for down until flow rates are nominal.
    - If the module has active flow-control hardware, the flow is adjusted through the **default pump speed**. To do this, go "**back**" on the menu and select the "**pump**" option to edit pump speed. Use the buttons **+1%** and **– 1%** to adjust the pump speed, until the nominal flow rate is met. After this is complete, note down the value in your notes and turn the pump back off. This value will be needed for completing your final maintenance checks.
7) Repeat steps 5 and 6for all modules. Please note, if you leave the flow adjustment page, all the pump speed values will be reset and these steps need to be redone.

9.2 Recording Temperature, Max Orifice, and Zero Values

1) In the flow check device case, there will be a NIST-certified thermometer. Please take the thermometer out of the case and place it in the shade next to the 3C module.

Turn the power switch to the "On" position and the unit switch to "°C." Disconnect the temperature probe from the 3C module and place the tip of the probe next to the thermometer. Allow the thermometer to equilibrate for approximately ten minutes.

2) To take the temperature reading from the probe, record the temperature from the upper right corner of Home Screen. Record this value in cell C18 of the "Site and Device Data" sheet. Then, record the value reported by the thermometer in cell C17.

3) To take Vac/Max Orifice (or MxORI) values, access the Flow Adjustment Mode, as described previously, or use the Vacuum Test option from the Equipment Tests menu. All the pumps should turn on in Vacuum Test mode. If in Flow Adjustment mode, turn on the pump, and make sure all solenoids are off. After running for a few seconds, MxORI values will appear for each module. Record the values for each module in cell D20 for each module-specific sheet.

4) To take zero values for the Flow/CYC and Pres/ORI of each module, access the Flow Adjustment Mode, open a single solenoid and make sure the pump is off. Note that if the system was sampling upon arrival, the pump will be running and will need to be turned off by pressing **Pump: On** so that it will read "Pump: Off". The controller display will show the zero values for the 1A module. Enter the values in cells D21 and D22 of the 1A module sheet. Cycle through the modules by pressing > and record the values in the appropriate sheets and cells, making sure that no pumps are running during the measurement. When finished with the last module, press the **Home** button to exit the Flow Adjustment Menu.

9.3 Preparing the 1A Module and Magnehelic

1) Place the magnehelic on the inside of the module 1A door. Note that the magnehelic is digital so orientation doesn't matter. Make sure the magnehelic reads "0.000" when on. If not, hold the "Zero" button on the magnehelic until it reads zero. The magnehelic has a magnet on the back, so it will stay attached to the door. If it is windy out, it is necessary to try to shelter the ambient pressure hose from the wind, without plugging it. This is best accomplished by attaching the ambient hose end to the PVC dampener included in the kit (Figure 2).

2) Inside the 1A module, locate the stack plug and the black plastic cap. Remove the cap by pushing down on it from the top, and remove the plug by pulling down on the brass fitting.

3) Place the probe into the Tee. Do this by pushing the probe (hose end down) through the bottom of the module and up into the Tee until the probe bottoms out.

4) On a windy day, the magnehelic reading may fluctuate. Remedy this by attaching the ambient hose end to the PVC dampener included in the kit (Figure 2) as mentioned above.

Figure 1. Removing the plastic cap and stack plug and inserting the probe into the tee.

Figure 2. Attaching the PVC dampener.

9.4 Preparing Module 4D

1) In order to flow adjust module 4D, first raise the stack to accommodate the flow check probe. There are two things that need to be loosened before the stack can be raised. First, loosen the locking collar on top of the module by turning it counterclockwise. Then, take the 5/32" hex key and loosen the four screws of the 4D brace. Do not remove the screws.
2) Slide the stack up approximately four inches or until it is above the 4D brace. After moving the stack, retighten the locking collar to temporarily secure the stack.

Figure 3. Module 4D.

9.5 Beginning the Flow Adjustment Check

1) Return to the controller's display. From the Home Screen, press the **Menu** button, then **Advanced Menu**, enter code **9051**, press **Submit** press the **More** button, and press **Flow Adjustment**.
2) Note that zero flows are no longer set for each module. The zero flow measurements are actual pressure measurements and reflect environmental conditions. The Flow/CYC sensor should be very close to zero (± 0.02) and the Pres/ORI sensor will be around 14.7 psi at sea level and reducing linearly with elevation.
3) The flow adjustment cartridge has a filter in its first position, and physical restrictions of increasing resistance in each consecutive position. Open the first solenoid by pressing **S1: Off** so that it reads "S1: On". Turn on the pump by pressing **Pump: Off** so that it reads "Pump: On".

9.6 Filling in the Flow Adjustment Sheet

1) The display will show two values (CYC and ORI). The magnehelic will indicate a value as well.
2) If the sampler does not have active flow control hardware, the flow rate will need to be fine adjusted at this stage. If the sampler has active-flow-control skip to step 3.

Look at the number in cell D23 ("Set Flow"). If there is no number listed, enter the device constants into cells C10 and C11 of the "Site and Device Data" sheet (which are located on the flow check device case) and a number should be generated. The number in cell D23 will be around 23.0 LPM, depending on temperature. This will be the value that you will adjust the flow rate to, as displayed by the controller screen. To achieve this flow rate, manipulate the valve located at the bottom center of the module (use the black knob on the needle valve, left of the cyclone, facing outward from the module) until the controller displayed flow rate value (to the right of the CYC pressure reading measured in " H_2O matches that of the value in D23.

3) Record the value reported by the magnehelic for that position in cell E20.
4) Look at the controller display. It will show two values for position #1, the Cyclone (CYC) and the Orifice (ORI). Enter these in cells F20 and G20, respectively. If either of the values is unstable, note the full range of values in the comments section on the bottom left of the calibration sheet.
5) Once these values are recorded, press the **S2: Off** and **S1: On** button to move to the second position of the calibration cartridge and close the first solenoid. The buttons should read "S1: Off" and "S2: On". Record the magnehelic and CYC/ORI values in cells F21 and G21. Repeat the previous steps for positions #3 and #4, recording the values in the appropriate cells.
6) Repeat steps 1-3 for all four positions for modules 2B and 3C.

9.7 Preparing the Magnehelic Probe for PM10 sampler

In order for the probe to fit into the funnel of the 4D module, it is necessary to make two modifications to the probe itself:

- First, locate the spring-loaded coupler, which is between the probe and the probe plug. Push this coupler's outer sleeve down (toward the hose). This will release the probe plug.

Secondly, locate the 3-inch brass extender bar, which is attached via quick connects. To remove this extender bar, disengage the quick connects by pushing on the buttons and gently pulling the bar away. After removing the extender bar, attach the quick-connect fitting on the hose to the probe quick-connect.

Figure 4. Releasing the probe plug.

Figure 5. Modifying the probe.

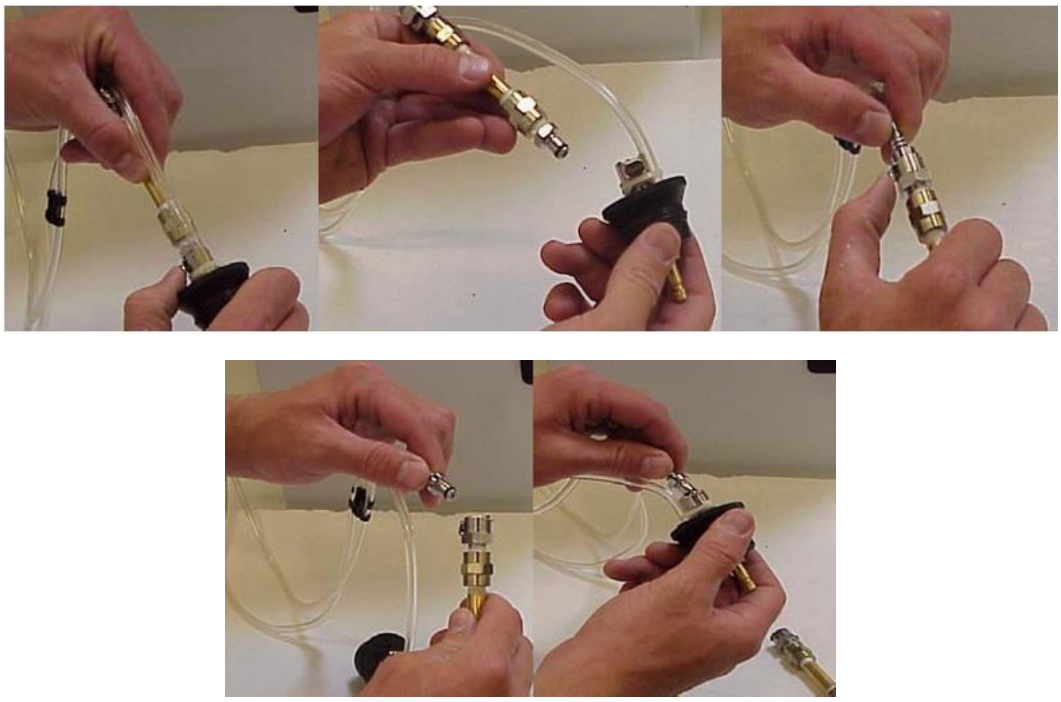
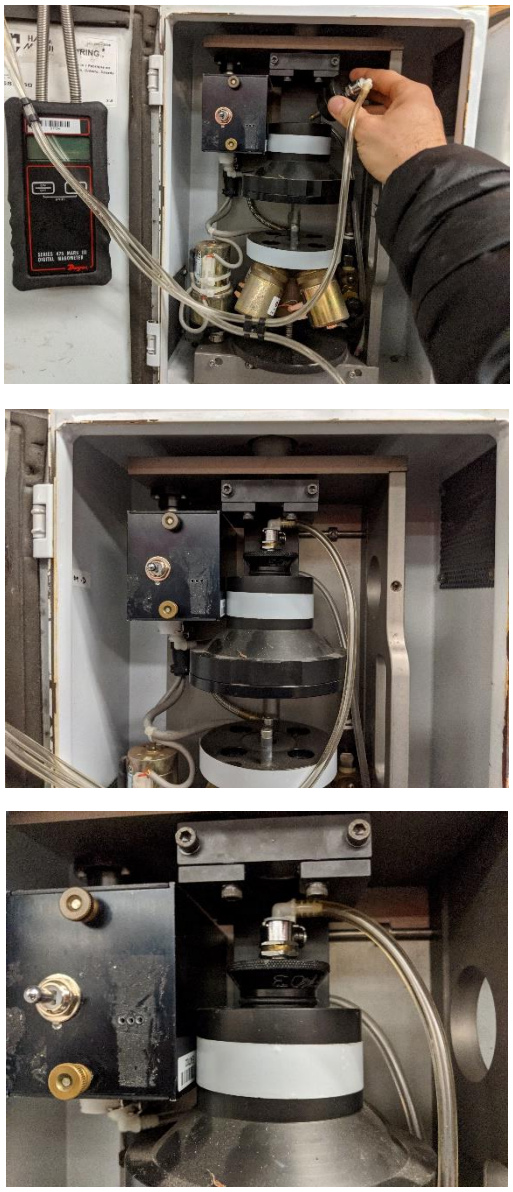


Figure 6. Placing the probe in Module 4D.



9.8 Flow Adjusting Module 4D

1) Place the probe into the top of the funnel (where the stack was previously) and gently push down until it bottoms out.
2) With the flow adjustment probe in the funnel of the 4D module, the 4D module flow adjustment can now be completed. Repeat the steps in 5.4 for the 4D module with a couple of exceptions. The number listed in cell D23 (“Set Flow”) will be different than the one used for the previous modules. This is because 4D modules run at a different flow rate. The value in cell D23 should be around 16.9 LPM. The 4D module does not have a functioning CYC, so only the magnehelic and orifice values

need to be recorded for each position.

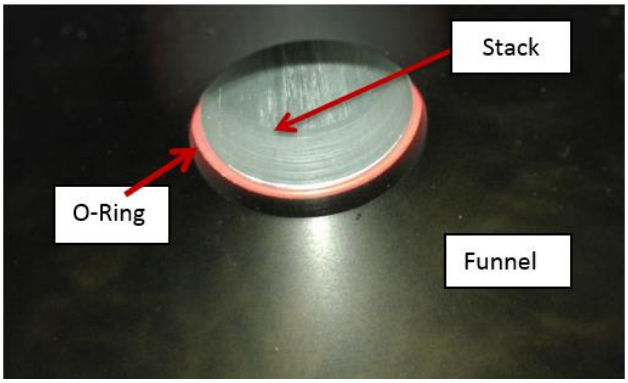
9.9 Re-installing the 4D Stack

1) Remove the 4D funnel's bottom lid. Using both hands with thumbs on the recessed channels of the funnel, pull downwards to separate the bottom lid from the rest of the funnel (Figure 7). Sometimes it is necessary to use a soft mallet to gently tap the bottom lid to separate the two pieces.
2) Gently lower the stack back to its original position, making sure that the stack is fully seated into the black funnel. It should rest on an orange O-ring as shown in Figure 8.
3) While the 4D funnel's bottom lid is still removed, verify that the 4D stack O-ring is securely in place and uniformly positioned between the silver stack and the retaining lip of the 4D funnel.
4) Tighten the sleeve collar by turning it clockwise and then tighten the four screws on the 4D brace to secure the stack.
5) Replace the 4D funnel's bottom lid.
6) Perform the following steps once flow adjustment is complete:
    - Double-check that all black plastic caps and stack tee plugs are in their proper position for modules 1A, 2B, and 3C.
    - Reassemble the magnehelic probe to its original configuration.
    - Place all of the flow adjustment components back into the flow check kit.

Reload the modules with the exposed sampling cartridges. If a sample change needs to be performed, do it now. Record exposed (final) readings for all modules, install clean sampling cartridges, and take clean (initial) readings.

Figure 7. Removing the bottom lid of Module 4D.

Figure 8. 4D O-Ring between stack and funnel.



9.10 5X Modules

Some sites have a fifth module for collocated precision measurements, called an X or 5X Module. The X is a duplicate of an A, B, C, or D module. If there is an X module present, determine what type of module it is and perform the flow adjustment accordingly.

10. DATA AND RECORDS MANAGEMENT

Data recorded from the flow check is stored on am excel spreadsheet. When technician returns from maintenance, he is responsible for storing this spreadsheet on the network drive in a folder of all flow checks performed at this site.

11. QUALITY ASSURANCE AND QUALITY CONTROL

Flow accuracy displayed on the controller is important for the proper function of the sampler. This accuracy is checked periodically by external EPA audits, and by the next visiting field technicians.

12. REFERENCES

Not applicable.